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Meta-synthesis of global cases for the adaption stages of artificial intelligence systems into university practices

Baris Uslu[1,2*] and Liudvika Leišytė[3*]

*Correspondence:
Baris Uslu
barisuslu@comu.edu.tr
Liudvika Leišytė
liudvika.leisyte@tu-dortmund.de
[1]Department of Educational Sciences, Canakkale Onsekiz Mart University, Canakkale, Türkiye
[2]College for Social Sciences and Humanities, University Alliance Ruhr, Essen, Germany
[3]Professorship of Higher Education, Center for Higher Education, Department of Business and Economics, TU Dortmund University, Dortmund, Germany

Abstract

The transformative potential of Artificial Intelligence (AI) in universities is simply extending beyond instructional applications to include administrative and strategic domains in university management. This study aims to explore how AI could be integrated into university practices by addressing three core questions: to what AI technologies are being employed, which integration stages support their implementation, and what kind of ethical risks need to be considered for AI usage in universities. To respond to these questions, the researchers a meta-synthesis approach to qualitatively analyse selected studies. Based on a systematic search protocol, they selected 49 empirical cases from different parts of the world; then, analysed them using thematic analysis through data reduction, data display, and conclusion drawing/verification. The findings were categorised into a three-layered framework capturing various purposes of AI usage, technical and institutional integration steps, and the components of ethical AI regulations in universities. The analysis shows that higher education authorities, university leaders, and techno-experts initially decide the purpose(s) of AI usage, regarding teaching, research, engagement, and administration. Then, as a structured roadmap, they can follow eight steps identified for the technical and institutional AI integration: 1. AI System Design, 2. AI Algorithm Development, 3. Data Management-Preprocessing, 4. AI System Integration, 5. Strategic Management Policies, 6. Operational Management Roles, 7. Curriculum-Pedagogical Design, and 8. Evaluation-Performance Monitoring. Lastly, ethical regulations could be organised combining sub-themes of Data Ethics, Algorithmic Ethics, Human-AI Interaction and Social Impact, Academic Integrity and Responsible Use, and Institutional and Managerial Ethics.

Keywords Artificial intelligence, University management, Technical structures, Institutional strategies, Ethical regulations

1 Introduction

Artificial intelligence (AI) is a rapidly evolving field that has made considerable advancements in recent years in terms of algorithmic sophistication, enhanced data-processing capabilities, and improved predictive accuracy. Especially, after OpenAI launched

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ChatGPT on November 30, 2022, the popularity of AI-tools gained momentum, and ChatGPT had over 100 million users at the beginning of 2025 (https://www.semrush.com/). Notably, 65% of AI-users come from the Generation Z group, and more than half of those aged 18–25 express a preference for specializing in AI technologies [23]. Beyond this largest user group falling within the higher education (HE) age-cohort, a growing number of academics and administrative staff have begun to benefit from AI tools in their daily professional practices. Therewith, the technical and institutional integration of AI technologies become a strategic priority within university management to foster effective and ethical use of AI in their teaching, research, engagement, and administrative activities.

The use of computers and algorithms to accomplish tasks that normally require human intelligence, such as learning, reasoning, and problem-solving, is referred to as AI [4]. The origins of studies in the field of AI can be traced back to the Turing test developed by Alan Turing in 1950 to answer the question "can machines think?" [27]. Since then, many studies reported the various technical advancements in AI technologies (e.g., Natural Language Processing (NLP), Large Language Models (LLMs), and artificial neural cells and networks [7]. After all such developments in terms of the increasing availability of data, powerful computing resources, and complex algorithms, universities also started to explore the potential applications of AI in teaching, research, engagement, and administration. Despite its potential to significantly improve students' learning outcomes, researchers' productivity, and administrative efficiency, the use of AI in HE has also brought various technical challenges such as data security, process transparency, and potential biases [18, 32]. Parallelly, many recent studies have focused on ethical dimensions of AI usage in teaching and learning and provided examples of ethical regulations for student privacy and data protection, as well as faculty's grading and cheating prevention in AI-adapted teaching environments (e.g., [15, 26]). Likewise, some studies presented field-based data to reveal how academics can benefit from AI-tools in their research, for example, through the use of large language models in academic writing, data analysis, and findings visualisation (e.g., [2, 16]).

At the same time, there are no clear clues how university management ensures privacy and security of students' data in AI-assisted teaching and learning environments or establishes frameworks to evaluate the cases of students' misuse of AI for cheating. As another issue, it is unclear how university management deals with plagiarism cases among academics when confronting their non-original, AI-generated publications, or proceed with IPRs (in terms of patents, licenses, copyrights, etc.) acquisition within AI-generated experimental formulas and material designs. Further, many studies outlined potential use of AI tools in different administrative tasks such as AI-supported student services from student enrolment to financial aids, internal resource allocation, faculty workload organisation, performance appraisal and rewards, and even data curation and reporting for quality enhancement, rankings, and sustainability development goals [9, 14, 30]. Rather than drawing on potential assumptions, field-based examples can provide well-established and comprehensive strategies for university managers to be able to effectively manage the technical, practical, and ethically integration of AI technologies in their institutions. Therefore, the purpose of this research is to examine actual cases of AI adaptation in university practices from different parts of the world. For this purpose, the research questions are:

1. To what purposes are AI technologies used in universities?
2. What are the technical and institutional management processes to adapt AI technologies in universities?
3. How are AI technologies regulated to foster ethical use of these technologies in universities?

2 Benefits of AI technologies in universities, but what are the challenges?

In the reviewed literature, there are more than 5,000 papers including 'AI and higher education' within their topical areas (see details in the Methodology). While some of these studies focus on technical design and testing of various AI tools within HE settings, most studies reported theoretical results through students', academics', and to some extent from administrative staff's perceptions towards AI use in HE. Additionally, there are quite extensive reviews outlining the benefits of AI technologies, as well as discussing the challenges against effective and ethical use of AI in HE institutions (as cited in [29], pp. 225–226). According to these reviewed studies regarding AI usage in universities, potential benefits and various challenges are summarised below.

2.1 Personalised learning

Through the application of AI-driven algorithms, educational environments can offer personalised learning experiences that respond to the distinct preferences, cognitive patterns, and styles of individual learners. For example, AI technologies can generate customized academic programs aligned with each student's specific needs and goals. Hence, AI platforms will enable flexible learning pathways that allow learners to progress at their own pace, concentrate on areas of personal or academic interest, and bypass content they have already mastered [31].

2.2 Enhanced predictive analytics

AI algorithms can play a critical role in universities by offering advanced predictive analytics to be able to identify students at risk of academic underperformance. Through the analysis of extensive datasets, AI systems are capable of detecting patterns and trends that inform projections of student outcomes and emerging concerns [11]. For example, such systems can detect students who consistently miss classes or fail to submit assignments, and these kinds of behaviours may signal underlying academic difficulties or personal challenges requiring timely intervention.

2.3 Improved student support

AI technologies can enrich student support services within universities. A notable implementation of this potential is the integration of AI-based chatbots, which offer students immediate and tailored assistance; therewith, alleviating the administrative burden on university staff and contributing to enhanced service delivery. These AI-powered chatbots can be systematically designed to respond to frequently asked questions and provide structured guidance across multiple domains, including enrolment procedures, financial aid options, admissions processes, and academic requirements [19].

2.4 Increased efficiency

AI provides transformative potential for the HE sector by streamlining routine tasks (e.g., grading and feedback) which, in turn, enables academics to allocate more time to core responsibilities in teaching and research [22]. Additionally, by processing and analysing student performance data, AI-driven algorithms can detect patterns in learner strengths as well as necessary areas for improvement; thereby, equipping educators with the insights necessary to personalise instruction and implement targeted interventions aimed at enhancing student learning outcomes.

2.5 Cost savings

The integration of AI into university management offers significant potential for achieving cost efficiencies through multiple mechanisms. By harnessing data related to student enrolment patterns, course scheduling logistics, and workload distribution of academic and administrative staff, AI can facilitate the optimization of resource allocation—thereby supporting more informed decision-making processes and minimizing institutional losses. Beyond this optimization function, AI is also capable of detecting operational inefficiencies, contributing further to cost reduction strategies within HE institutions [17].

In addition, several studies also underlined further benefits of AI technologies in universities. These include 'Enhanced Accessibility to HE', 'Increased Flexibility in Learning', 'Improved Student Engagement', 'Improved Learning Outcomes', 'Enhanced Scientific Productivity', and 'Better Decision-Making in University Management' [29], pp. 229–230. To ensure such diversified benefits, universities need to employ different AI technologies in teaching, research, engagment and administration (see Fig. 1). Besides its potential benefits, naturally, the use of AI technologies within university settings also includes a variety of challenges. Some of these challenges are shortly listed below:

2.6 (Non-)Adoption and implementation

The adoption and implementation of AI within universities constitutes a multifaceted and demanding processes. The effective integration of AI technologies into institutional systems and academic procedures necessitates substantial investment in technical expertise, infrastructure, and specialized software solutions. Moreover, the process of AI integration requires sustained coordination between technical administative staff and academic staff, which is time consuming and entails significant organizational effort [33].

2.7 Integration with existing systems

The complex and deeply embedded structure of university administrative systems are often developed and refined over extended periods of time. Sometimes, such existing technostructures will cause an important challenge to the incorporation of emerging technologies. Consequently, the implementation of AI systems within such institutional frameworks may face delays and entail considerable financial investment [1]. Furthermore, the successful deployment of AI technologies may also demand extensive datasets, which could require storage in alternative formats or new data storage systems, which complicates data interoperability with existing institutional databases.

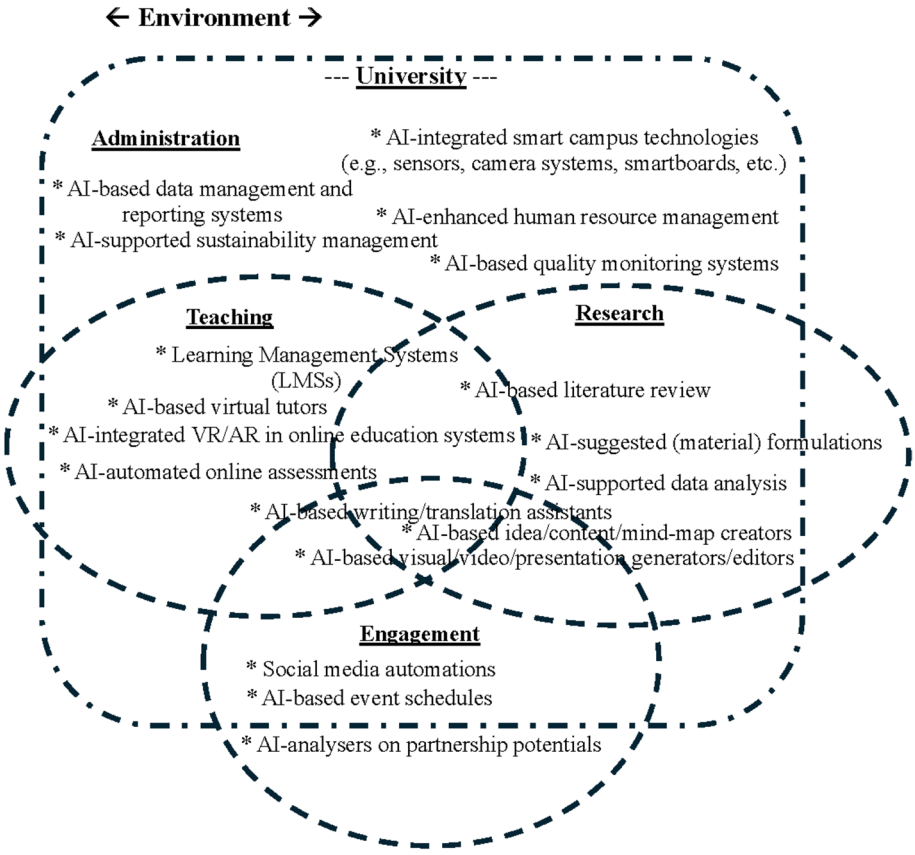


Fig. 1 AI technologies in university practices

2.8 (Limited) data availability

AI models normally need to access a substantial amount of data in order to operate with optimal effectiveness. However, such data may not be readily accessible across universities; this limitation can arise from multiple factors, including underdeveloped data collection infrastructures, personal data protection regulations or relatively low student enrolment figures. In turn, inadequate data availability may constrain the predictive accuracy of AI algorithms and restrict their capacity to deliver accurate recommendations [3].

2.9 Ethical concerns

The integration of AI into universities introduces a range of ethical concerns, with particular challenges in terms of data privacy and systemic biases [8]. For example, the deployment of AI systems requires the implementation of robust data protection frameworks to ensure that collected information is processed solely for lawful and legitimate purposes. A further ethical consideration arises from the potential for bias embedded within AI algorithms, since such systems may inadvertently amplify disparities related to gender, race, or socioeconomic status, thereby exacerbating existing structural inequalities within the higher education landscape.

2.10 Human resistance

Resistance to the integration of AI at universities may originate from multiple stakeholder groups, including students, academics, and administrative staff. The employment

of AI technologies to automate tasks traditionally carried out by humans can lead to serious concerns among academic and administrative staff related to their job security [10]. Additionally, these individuals may express concerns that the increasing reliance on AI would lower the appreciation of their professional expertise or decrease the overall quality of instruction delivered to students.

Beyond these prominent challenges, in the reviewed literature, some further difficulties are also discussed about the integration of AI into university settings. Among these challenges, 'Insufficient Technical Infrastructure', 'Data Privacy and Security Measures', 'Lack of Transparency', 'Shortage in (ICT) Skills and Expertise', and 'Legal and Regulatory Framework Needs' are often underlined ([29], p. 232). Nevertheless, as summarised in Fig. 1, many universities have already begun to adapt various AI-based technologies into teaching, research, engagement, and administrative activities. In this regard, the evidence of the technical, managerial, and ethical developments that are necessary to enhance effective and ethical usage of such AI technologies gain importance at universities, as discussed in the following sections.

3 Methodology

This study aims to explore the areas in which AI technologies are used in universities, as well as the cases of their technical, institutional, and ethical integration. To analyse the relevant literature, the researchers followed a systematic review strategy; then, considering the qualitative analysis of the selected cases [28], they employed the meta-synthesis of systematic reviews. Schreiber and colleagues [25] define a meta-synthesis as the "bringing together and breaking down of findings [from case studies], examining them, discovering essential features and, in some way, combining phenomena into a transformed whole" (p. 314). In line with this definition, Paterson and colleagues [20] stated that if "primary studies are themselves constructions; then, meta-synthesis deals with constructions of constructions" (p. 7). While explaining and analysing a phenomena based on the selected studies, the significant advantage of the meta-synthesis approach for researchers is "its ability to identify common themes and build conceptual frameworks from [the related] literature" ([5], p. 133). Keeping this advantage in mind, and to be able to identify the relevant studies from the global literature, the researchers followed five steps of systematic reviews suggested by Petticrew and Roberts [21]: i) Formulating the research question(s), ii) Defining inclusion/exclusion criteria, iii) Recording eligible studies systematically, iv) Assessing the quality of the selected studies, v) Integrating prominent findings. While the research questions were already presented, the remaining four steps are explained below.

3.1 Inclusion–exclusion criteria

To select the studies related to the integration of AI technologies in universities, the researchers defined the inclusion–exclusion criteria before employing the systematic search protocol. These criteria are listed in Table 1.

3.2 Systematic search protocol

In the first phase, the researchers used 'artificial AND intelligence (or AI) AND higher AND education' keyword combination for the systematic search through All Fields section of WoS. Using https://www.webofscience.com/wos/woscc/basic-search plat

Table 1 Inclusion–exclusion criteria

Inclusion	Exclusion
+ Listed in the Web of Science (WoS) database*	– Country-specific indexes of WoS (e.g., Korean Journal Database, Russian Science Citation Index, etc.)
+ Relevance to AI in higher education	– No relevance to AI in higher education
+ Written in English	– Not written in English
+ Peer-reviewed studies (e.g., articles, conference papers)	– Not peer-reviewed articles (e.g., editorials, book reviews)
+ Empirical research	– Not empirical research
+ Introducing a case of AI integration in a university	– Not introducing (sufficiently) a case of AI integration in a university

*Web of Science was selected because of including the lowest number of potentially fake journals in the Beall list [6],studies from SCI, SSCI, AHCI, ESCI, and CPCI indexes were included in the search process

form, this general search hit more than 36,000 studies on 02.06.2025. To narrow this search, the researchers then entered same keyword sequence by selecting Topic section of WoS. This search yielded 5,368 studies, and choosing English language, this number reduced 5,149 studies. In the next step, the researchers selected peer-reviewed publication options (as of, articles and full-papers), which narrowed down to limited 4,581 studies. Then, they added additional keyword one by one to further narrow their search, as follows: 'artificial AND intelligence (or AI) AND higher AND education AND management/administration/governance/teaching/learning/research/(external)engagement'. This search limited studies to 2,210. After eliminating the overlapping publications, there were 1,998 studies. The researchers then employed the remaining inclusion–exclusion criteria (empirical studies and introducing an actual case of AI integration in a university) and defined 49 studies for the meta-synthesis (see Fig. 2).

3.3 Quality appraisal

All studies included in the meta-synthesis review are based on empirical research, as well as WoS-indexed publications that have undergone editorial and peer review processes. The authors evaluated each study paying specific attention to the methodological approach underlying its empirical evidence. For quantitative studies, our appraisal checks focused on the definition of the population and sample, the selected analytical techniques, and the presentation of findings. Considering qualitative studies, the researchers examined the study group, the credibility of the analysis process, and the inclusion of direct evidence from primary data sources. Further, studies employing mixed methods were also assessed using the same appraisal approaches applied to both quantitative and qualitative components. At the end, the researchers included 49 studies that provide sufficient analytical/procedural details (see Reference List of the Selected Cases). According to first authors' affiliations, these 49 studies are distributed to: 1 Australia, 1 Austria, 1 Canada, 13 China, 2 Ecuador, 1 Finland, 1 France, 4 Germany, 1 Hong Kong, 1 India, 2 Israel, 1 Latvia, 1 Malaysia, 1 Morocco, 1 Netherlands, 1 Philippines, 1 Portugal, 2 Romania, 2 Russia, 1 Slovakia, 1 South Africa, 1 South Korea, 1 Ukraine, 6 United States, and 1 Vietnam, in total from 25 countries (see Appendix 1). Here, it is important to underline again these studies focusing on actual cases of new AI tool development or adoption of existing AI tools into system-level university practices rather than AI-chatbot usage only in a particular training or course. Although there is only one main expectation for the inclusion of case studies in meta-synthesis and no strict rule for peer-reviewed publication inclusion [25], these actual cases were generally published in educational technology or ICT engineering publication platforms (as of, 35

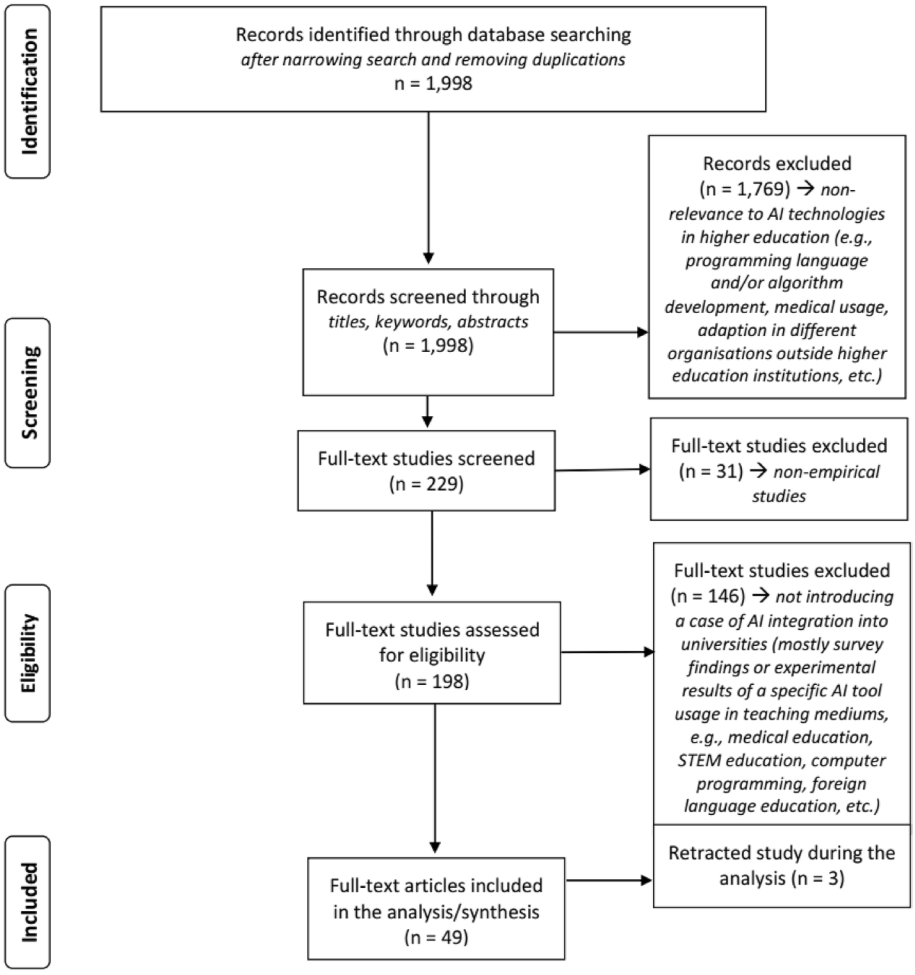


Fig. 2 PRISMA Flowchart of systematic search on the integration of AI in universities

articles in prestigious WoS-indexed journals and 14 full-papers from well-known refereed engineering conferences listed in IEEE Xplore platform or published with Springer proceeding books, as well as indexed in WoS database). All in all, with their rich empirical evidence regarding practical test results of AI development or existing AI adoption in various university practices, as well as including one exceptional case of institutional AI regulation experience from a Ukrainian university, these selected studies provide altogether a strong basis to explore the integration stages of AI technologies in universities.

3.4 Integration of analysis results

The researchers used thematic analysis approach to qualitatively evaluate the selected studies. During the analysis, they focused on the empirical parts of these studies rather than their theoretical and literature review sections. Hence, 'methodology/procedure', 'findings/results', and 'discussion/conclusion' sections were included. During the analysis, they followed three steps of qualitative analysis suggested by Miles and colleagues [13]: i) Data reduction, ii) Data display, and iii) Conclusion drawing/verification.

Accordingly, the researchers first coded each selected study separately to reduce the data regarding the integration of AI in universities into a complete code-list. Second, they categorised related codes following their research questions; for RQ1, categorising

relevant codes parallel to the Fig. 1; for RQ2, collecting similar/close codes together and defining potential themes overseeing the procedural sequence in the integration of AI in universities; for RQ3, connecting similar/close codes under various ethical aspects to identify themes regarding AI regulations in universities. In this stage, the researchers also benefitted from AI to compare their codes/themes with AI-suggested codes/themes. They uploaded the selected studies to the NotebookLM platform (on 10.07.2025) and asked to define potential codes/themes related to the adoption of AI technologies into universities. They generated the AI suggested codes by uploading all selected studies to the NotebookLM platform and entering the prompt: define relevant codes for these studies focusing on AI integration in universities; and then, place each code under relevant themes named "Purposes of AI usage for; teaching, research, externalengagement, or administration", "Technical and institutional integration stages of: AI system design, AI algorithm models, Data preprocessing management, AI system implementation, Strategic management and policies, Operational roles and management, Curriculum design and integration, Monitoring and performance evaluation", or "Ethical AI usage regulations for: Data ethics, Algorithmic ethics, Human-AI interaction and impact, Academic integrity and responsible AI use, Institutional and managerial ethics". While there was no visible difference between the codes defined by the researchers and the AI platform, the researchers integrated several codes from AI-suggested ones related to technical design and construction of AI in universities, such as system architectures, layered ICT infrastructure, programming languages, parameter optimisation, 5G edge computing, cloud servers, etc. At the third and last stage, the researchers discussed their results around direct evidence from the selected studies in the next section.

4 Findings

After listing their references and contexts in the Appendices, the researchers analysed the selected studies of actual cases to identify the purposes, technical, institutional, and ethical adoption of AI in universities. Following the general framework of major areas in university services, they categorised various usage of AI under teaching, research, external engagement, and administration (see Table 2). Then, they outlined common stages for the integration of AI technologies in universities (see Table 3). Lastly, they defined ethical management initiatives for AI use in university settings (see Table 4).

Table 2 Purposes of AI usage in universities

Teaching	Research	External Engagement	Administration
- Active & immersive learning environments - Intelligent tutoring & interactive learning systems - Personalised & adaptive learning/support - Automated assessment & feedback (for students) - Academic writing & communication assistance - Creative thinking & design stimulation (by students) - Talent cultivation & skill development (for students) - Student learning & behaviour analysis - Student success & dropout prevention - Teacher support & efficiency (for pedagogical tasks) - Curriculum development & optimization - AI Literacy & ethical AI understanding	- Writing assistance & literature analysis - Research process enhancement & automation - Peer reviewer selection - Academic Collaboration Network analysis	- Marketing & communication - Applicant/constituent engagement & support - Industry & workforce alignment - Community outreach & sustainable development	- Strategic planning & decision support - Resource & operational management - Employee management - Campus infrastructure & security management - Identity & access management - Policy & governance framework development (for AI)

Table 3 Technical and institutional integration stages of AI technologies in universities

1. AI System Architecture & Technical Design	5. Strategic Management & Institutional Policy
- Ontology as core knowledge model	- Leadership and readiness for AI implementation
- System architecture design (with layers/components)	- Revising and developing institutional AI policies
- Database design and architecture	- Strategic Management with AI technologies
- ICT (hardware/software) infrastructure	- Aligning curriculum with AI technologies
2. AI Models & Algorithm Development	6. Operational Management & Roles
- AI-code platform services	- Defining responsibilities in human-AI collaboration
- AI-tools' orientation	- System implementation and strategic planning
- Specific AI-models	- Support for strategic decision-making
- Machine Learning approaches	- Resource and knowledge management
3. Data Management & Preprocessing	7. Curriculum & Pedagogical Design
- Database design and multidimensional models	- Curriculum development and adaptation
- Data collection from the variety of sources	- Teaching methods and learning environments
- Data storage and management	- Personalised/adaptive learning
- Data preprocessing implications	- AI Literacy and skills development
4. AI System Implementation & Integration	8. Evaluation & Performance Monitoring
- Multi-role design recognizing roles of actors and AI	- Feedback mechanisms for students
- Introduction and implementation of AI systems	- Assessment and grading in training
- Integration of AI to relevant platforms and devices	- Teaching quality feedback for teachers
- Evaluation of AI outcomes and necessary measures	- Performance monitoring and reporting to managers

Table 4 Regulatory components for the ethical use of AI in universities

Data ethics	- Data privacy and confidentiality - Data quality, authenticity, and integrity - Bias in training data
Algorithmic Ethics	- Algorithmic bias and fairness - Transparency and explainability of AI decision-making
Human-AI Interaction and Social Impact	- Over-reliance, diminished critical thinking, and autonomy - Role of human educators and social interaction - Impact on empathy - Digital divide and inequality
Academic Integrity and Responsible Use	- Accuracy, reliability, and misinformation ("Hallucinations") - Plagiarism and academic misconduct - Attribution, acknowledgment, and content ownership
Institutional and Managerial Ethics	- Institutional policies and ethical frameworks - Accountability and human oversight - Ethical review and compliance - Training and AI Literacy for ethical use

In line with the advantages that AI technologies bring to universities outlined above (in the literature-based explanations), they are used for highly different purposes from teaching to external engagement, and from research to administration (Table 2). For example, such a technology could be employed "to develop an embodied GenAI system designed to facilitate active learning, self-regulated learning and enhance human-AI shared regulation in educational settings" [57], p. 5). Likewise, AI applications for teaching and learning include "profiling and prediction, intelligent tutoring systems (ITS), [mostly automated] assessment and evaluation, and adaptive systems and personalization [for students]" ([35], p. 17146). While supporting students in various stages of academic writing, from content generation, idea refinement, literature search and source integration, to proofreading and translation, AI tools can also enhance writing proficiency and save time for students [67, 78]. Against all such positive aspects, serious criticisms about the impact of AI on students' creativity and critical thinking skills are expressed. However, "student feedback suggests that AI stimulates creative thinking by offering greater creative freedom and possibilities" ([79], p. 90814) and assists

in transforming their professional development through "simulation/scenario-based preparation to business world" [66]. Moreover, "by leveraging AI optimization algorithms, universities can effectively mine and analyze student learning data to accurately characterize their learning situation" [76], as well as identifying weaknesses, predicting struggles, and providing insights for differentiated interventions. Further, academics can prepare classes with the support of AI, including after-class tutoring and assessment, hence, the application of AI can contribute to achieve higher teaching efficiency, as well as reducing the burden on teachers' course preparation [62]. Yet it seems important to include new topics like AI literacy into curriculum to be able "to cultivate an understanding among students and researchers about the benefits and risks associated with the new reality [of] artificial intelligence [and] promot[e] AI literacy, ethical understanding, and responsible usage among all parties involved" ([68], p. 189).

Expanding the list of previously discussed benefits, researchers can use AI tools to polish their scientific texts, as well as "assisting with literature reviews, finding recent research topics, [and] summarising [existing] research" ([73], p. 159). AI technologies can also support various stages of scientific inquiry (e.g., experimental design, hypothesis testing, data analysis, report generation), as follows: "AI can reduce the time required to complete academic papers from several months to a few weeks [and] increase the productivity of scientific research, enabling scholars to dedicate more time to advanced cognitive tasks" ([37], pp. 1–2). Further, employing AI algorithms might assist to "unravel and examin[e] the Academic Collaboration Network (ACN) within the design field", which involves analyzing scientific production data within university research priorities ([60], p. 3). Yet it is interesting to see how AI can contribute to research evaluation by helping "to identify suitable reviewers [that] editors might not have initially considered, including lesser-known experts" ([42], pp. 2–6). Likewise, AI can be used as amarketing tool "for creating speakers' bios, developing social media advertisements, creating event descriptions, writing invitations to various stakeholders, developing press releases, and creating marketing content" ([68], p. 189), or it may also be beneficial to assist with applicant inquiries, student services , interactions with students, and overall engagement in admissions, student support, and alumni relations. Further, "adapting Higher Education in the field of AI and restructuring of didactic methods to meet the Industry 4.0 needs" ([38], p. 23) seems necessary to enhance graduate employability, as well as achieving Sustainable Development Goals (SDGs) by means of AI automated data analysis that support the decision-making and management process to promote the SDGs.

As seen in Table 2, AI can be also beneficial by providing statistical reports and predictive capabilities to support strategic planning, as well as "us[ing] artificial intelligence (AI) algorithms extensively in the background to provide data-driven insights for [decision-making in] management" ([59], p. 17). In the similar vein, "AI optimization algorithms… can be employed to optimize the allocation of various resources [e.g., human, material, and financial] in higher education institutions" [76], streamline administrative processes, and improve overall operational efficiency across universities. Further, "the AI engine also could bring out recommendations to the employees when they needed to undertake training programs for skill enhancements, based on their workload and training need analysis" ([59], p. 18). Additionally, AI tools seem highly convenient to enhance physical fitness/health management systems, automate waste management, and strengthen information system security by detecting threats and improving physical

campus safety. Even "a web-based application that uses real-time face tracking via a webcam [and then] use facial features to automatically detect" identity without contact, as well as employing AI algorithm to decide whether the identified person is safe and reliable ([53], p. 2039). To achieve such innovations, on the other side, universities need to develop institutional policies for safe AI use, academic integrity, and broader digital transformation initiatives, especially involving all relevant stakeholders in the innovation process: "Higher education institutions must have clarity in policy and provide continual information and support for faculty and students as AI advancements shape a new academic landscape" [56].

Reviewed literature suggests, the universities mostly follow eight steps to successfully integrate AI technologies in their institutional systems (Table 3). First, relevant experts focus on AI System Architecture & Technical Design, and the core knowledge model in their system approach might be an ontology to define "classes that encompass the different components that make up the academic… ecosystem" ([63], p. 120). After defining important concepts of their university ecosystem, they start to design AI system architecture using different models such as four [35] or five [63] layers multi-platform architecture, which commonly consists of a data chain system with data collection, analysis, and application parts. Requiring special attention, then, they may consider a specific database design, for example, the design of specific database tables for spatial table, user table, curriculum, and class table [64] or as "a modular big-data-based Information System [which] primarily residing in the NetFlow data analysis (NFAI) module" ([55], p. 340). Here, it is also important to consider necessary hardware and software developments for AI adaptation in university practices, and they might be defined through "Layered ICT Infrastructure (with Sensing, Transmission, Data Management, Application layers)" approach for smart campus environment ([58], p. 141). Yet these technologies include highly diversified equipment and software such as high-performance computers, servers (shared/cloud), cameras, sensors, motors, smart card readers, and/or intranet-based social platform (see [39, 48]). Second, after deciding system architecture and technical design for AI integration, universities general have two choices for AI-code services, open source (see [55, 73]) or paid one (see [36, 42]). Then, related experts in universities can focus on what kind of orientation they may need, prompt-based (e.g., ChatGPT, ClaudeAI, Google Gemini) or task-oriented AI-tools (e.g., Covidence, Typeset, Citationchaser) [40]. Yet they can consider adapt/developing a specific AI model for different purposes such as Intelligent Word Vector Generation Methods or AI-based Emotional Dialogue Generation Algorithms for mental health services to students [44], Graph Neural Networks for modelling relationships and optimizing educational pathways among learners [48], or Semantic topic modelling which combines BERT (Bidirectional Encoder Representations for Transformers Model) and LDA (Latent Dirichlet Analysis) for academic research evaluation [60]. In all cases, the roots of Machine Learning Algorithms are highly critical for successful results from AI technologies, whether they employ SVM (Support Vector Machine) or NN (Neural Network) approach [38],even nowadays Unsupervised ML (Machine Learning is common for pattern discovery and intention identification through NLP (Natural Language Processing for language acquisition, identification, and processing, (NLU Natural Language Understanding for identifying user intention, and NLG (Natural Language Generation for generating natural language responses [74].

In the third step, 'Do Data First' Approach is critical because "Data's a mess [and their] quality is [generally a prominent] challenge for AI implications in universities" ([54], p. 14). On this point, following database design principles becomes important through "standardization, normalization, unique keys, data integrity methods" [81], pp. S1105-S1106). This provides the basis for the design of different and mostly multidimensional database models (e.g., Transformer-Based Models [48], SLDM university data architecture [77], Relational and a Snowflake-type data model [34]. Then, the process involves the collection of data from different (but relevant for your purposes) sources, for example, from live sessions of team-work learning [53], student learning activity log data [65], data combining online/blended learning activities and real-time sensor data [38], health data collected from remote sports bracelets and mobile devices [81], data generated from corpus of relevant studies [45], or corpus data of (institutional) audit findings [71]. Yet managing data storage might need different approaches, for example: data transmission and storage via Bluetooth [34], real-time data upload to health cloud application [81], simultaneously copied data input to ChatGPT [43], or sometimes data selection from university's existing computerized systems (e.g., Extension Information System—SIEX). Now collected data should be pre-processed to finalise and generate good (rather than messy) dataset by cleaning, validating, and formatting data steps (e.g., removing duplicates in data [60], removing stop words, punctuation, other characters [44], handling missing data [48], structuring and normalising data [49], evaluating the interoperability of data [54], and designing specific database tables if necessary [61]. For the fourth stage, technomanagers in university can "implement a multi-role design [to] recognize the role of different actors and AI-based tools, [which helps to] understand how these different systems interact and influence one another in order to effectively design and implement ethical educational technology solutions" [35]. To define roles both for university actors and AI-tools, they might prefer a scenario-based approach, such as "university teaching management, intelligent identification and warning of campus risk events, and analysis of students' behavior trajectory" [77]. Then, they can introduce various AI tools as part(s) of their university information management system(s) with different priorities, for instance, advancing their Learning Management System (LMS) [39], system adaptation to student affairs management and simplified services [61], application of AI on mental health counselling services for students [44], replacing existing manual system for staff's attendance, leave, and payroll [59], deployment in a security management system [55], website renewing/construction for chatbot integration [46], as well as integration into various communication channels in a university for easy accessibility of AI-tools [64]. As a next step, AI technologies become possibly ready to be integrated into different platforms and work with various devices (e.g., integrating Learning Analytics Cockpit (LAC) as a Moodle plug-in [38], connecting to main scientific databases as to SCOPUS, Science Direct, or another [63], adapting AI to Smart card attendance system [59], or integration with external APIs, business information systems, and social networks—Facebook, WhatsApp, Office 365 calendars [74]). At the end, it is also important to continuously evaluate AI-based results usingdifferent approaches such as vendor identification via CSS coding of webpage [46], real-time digitization, comparison, and recognition of captured face images [53], or use iterative design feedback of movie character designer [57], and finally, if necessary, deploy security measures mostly

based on "a system abnormal monitoring model… to identify the system error data flow [and] monitor abnormal data" [61].

As an institutional integration, in the fifth stage, "leadership and vision [are] highlighted as critical for successful AI implementation" ([54], p. 5) while readiness evaluation seems to be equally important to be able to address a university's need for digital transformation [52]. When establishing clear institutional policies on AI technologies, university leadership should prioritise credibility, security, and privacy [46] while simultaneously revise the existing regulations [35] and develop new, necessary AI policies through professional discussions and experience sharing across education, research, and managerial domains [68]. For university managers, "the need for artificial intelligence is very high in Big Data analytics [for] strategic planning and decision making" ([49], p. 1741), especially through monitoring the impact of Research, Development, and Innovation activities [63] and the outcomes of intelligent teaching management systems [61]. Likewise, in the case of curriculum alignment with AI integration, generally there are two important aspects: i) benefitting from AI to discover recent industry trends and reflecting them in the curriculum [41], and ii) enhancing curriculum with AI literacy skills that industry needs [47]. Looking at operational side as the sixth step, "simultaneous use of staff and artificial intelligence" ([49], p. 1738) indicates potential responsibility areas between human (e.g., professors, managers, counsellors) and AI systems to respond how AI augments human capabilities and automates routine tasks for human personnel to effectively interact with and oversee AI while maintaining a human-centric approach [69]. Then, following all steps of designing, developing, deploying, and integrating AI systems, university managers should also include AI adoption in their university's strategic planning as a further policy development [50, 71]. Likewise, university manager may "use artificial intelligence (AI) algorithms extensively in the background to provide data-driven insights" ([59], p. 17), and "AI optimization algorithms can [offer] effective sol[ution strategies] to complex educational management problems" ([76], p. 1). In this regard, AI technologies can become highly beneficial to manage and accelerate knowledge generation, optimise the allocation of human and material resources, and enhance the overall efficiency of university operations, including managing research lines, creating resource platforms, and ensuring efficient data flows [49, 61, 77].

Deepening the curriculum alignment to the needs of the job market, in the seventh step, AI can provide data-driven analysis to inform and facilitate the ongoing evolution of curricula and study programs, helping to "adapt their curricula or study programmes to the ever more rapidly changing requirements [in job markets]" ([45], p. 8146). AI may also influence pedagogy by enabling new teaching methods, enhancing existing ones, and transforming learning environments. This includes supporting interactive learning [41], developing smart platforms [58], facilitating practical training (e.g., virtual reality, video showcase, mock interviews) [51, 66, 77], and promoting self-regulated learning [48]. All these AI-based practices can naturally "enable [more] personalized learning experiences by dynamically generating and recommending learning paths, resources, and activities based on individual students' characteristics, preferences, and performance" ([76], p. 16). Such an intensive and active engagement with AI technologies in universities will expectedly assist students (as well as academics) to "become aware of the potential applications of GAI in future job or business settings, to learn how to interact with GAI through prompting, to gain experience in using GAI collaboratively, and

to engage in critical reflection on their GAI skills" ([47], p. 1046). As an extension of the curriculum and pedagogical design with AI, in the eighth and last stage, AI systems can "automatically evaluate [students'] responses [and] provide immediate feedback by indicating whether each answer is correct or incorrect. In cases where the answer is incorrect, an explanation is provided to help the student understand the correct response and the underlying reasoning" [64], p. 11). Further, AI platforms will be useful for evaluating student work, providing grades, and offering diagnostic check on performance, including automatic essay assessment, skill assessment in practical fields, and identifying areas for improvement [38, 62, 79]. "The use of AI technology [can also assist] to evaluate the quality of… teaching" ([41], p. 1) by providing different types of feedback for university teachers such as learning analytics which involves instructional interventions based on LMS log data collection and analysis to define common problems among students with low academic progress. Likewise, AI tools help to dynamically analyse performance, monitor progress, track behaviours, and generate various types of reports (e.g., statistical [63], vulnerability [55], audit [71], health [81]) that assist managers to shape their future-looking strategies in universities.

Given this far reaching potentional of AI to transform university strategies and operations, it is crucial to ensure necessary regulations in order to ensure ethical design and use AI technologies in universities. As can be seen in Table 4, related experts should focus first on data ethics in terms of data privacy and confidentiality [65, 72, 82], as well as data quality, authenticity, and integrity [69, 75, 80]. Nonetheless, AI-generated information and "results may be biased if ML (machine learning) algorithms were trained on small and incomplete data sets" ([68], p. 187), hence, related experts should give special attention to "questions around bias or discrimination in the data sets used to train the AI [systems in universities]" ([35], p. 17153). Simultaneously, they need to consider concerns related to algorithmic ethics, as a combination of bias, fairness, transparency, and explainability, for example, "a risk that AI-based approaches could reinforce biases and perpetuate inequalities if not designed and implemented carefully" ([41], p. 18). As another example, AI platforms may emphasise "refining best practices based on feedback from learners, teachers, and administrative staff, ensuring transparency and accountability [which are] highlighted in ethical AI documents" ([35], p. 17163).

Additionally, AI users in universities should consider potentially negative outcomes, as follows: "Relying too much on AI can bypass critical thinking processes and even introduce misinformation or bias, [highlighting some] risks of technical dependence and misuse" ([70], pp. 2–3). In this regard, the integration of AI "must be seen as complementary to human interaction, ensuring that students are still encouraged to seek personal guidance for complex issues, thereby maintaining the human element in education, [as well as] preserving the social element ([65], p. 7), where "the level of empathy" ([79], p. 90817) in student–teacher relationships remains a key consideration. As another issue, possibly "worsening inequalities in education due to the widening digital divide between students" ([68], p.187) requires thoughtful considerations by university managers too. While AI technologies also "suffer from hallucinations and other challenges to their… value" ([54], p. 15), this becomes a bigger problem combining with the ethical concerns related to intellectual honesty, correct attribution, and the prevention of academic misconduct when using AI in educational and research outputs. Thus, "transparency in AI's involvement is critical to appropriately give credit where it is due,

[otherwise,] undisclosed use of AI to complete assignments [or research] is comparable to plagiarism… [And,] Failure to acknowledge… AI's contribution [hinders] reproducibility of academic research" ([56], pp. 2–4). To be able to prevent all such challenges, it is obviously critical to overview institutional management aspects of AI ethics, including the development of policies and the creation of an ethical culture around AI ethics framework [37, 47, 76]. Nonetheless, there is a need for "accountability and the development of rules to ensure that accountability is maintained" ([43], p. 126) regarding AI use in universities, by human oversight through technical design (e.g., Trustworthy Ethical Firewall [69]) and/or experts' check on AI ethics (e.g., continuous committee review for research ethics [76]). At the end, managers should integrate all such institutional policies and practices into training programmes for university stakeholders to introduce the basics of AI usage and enhance AI literacy, as the combination of competencies assisting users to critically evaluate AI technologies and enhance their awareness on AI ethics [35, 56, 68].

5 Conclusion, discussion, and recommendations

This research examined the technical, institutional, and ethical integration of AI technologies into university management through practical cases of different universities from different parts of the world. The researchers employed meta-synthesis review to outline common stages for effective and ethical AI integration in university systems. In this regard, following systematic search protocol, they selected 49 empirical case studies from 25 countries and identified the primary purposes, structural processes, and regulatory mechanisms through which AI technologies are embedded within universities. While they drew on common themes to categorise the purposes for AI in universities, they identified eight sequential steps regarding technical and institutional integration of AI. They also defined five essential themes including regulations and practices to ensure ethical AI use in universities.

The literature review shows that AI technologies are not only useful within the core academic domains (teaching, research, and engagement) but also beneficial in administrative functions to optimise service operations, inform strategic decision-making, and support resource and knowledge management in universities. While AI technologies can be used to provide active learning environments, personalised learning support, automated feedback, learning analytics for teaching quality enhancement, writing enhancement, literature reviews, data analysis, scientific reporting, communication with external stakeholders, sustainability partnerships, data-driven decision-making, operational management, human and infrastructural resource management, or for many other aims (Table 2), it is obviously in the first stage for university leadership to decide for which purpose(s) to use AI technologies in their institutions. The literature suggests eight steps defined in this meta-synthesis to ensure technical and institutional adoption of AI technologies in universities. Rather than repeating here the eight themes and relevant codes in Table 3, we can briefly say that the successful integration of AI in universities requires a proper design for AI system architecture, deciding on relevant models and algorithms, high-performing technical systems, robust data infrastructure, reconfiguring the roles of human and non-human agents, coherent institutional strategies, monitoring operational efficiencies, and curriculum integration with AI skills altogether. On this point, it is highly important to note that available infrastructure and technological

capacity (for AI System Integration) in any university may limit the contents of institutional policy (as well as Strategic Management Policies of AI usage). While Socio-Technical Systems (STS) theory provided a clear perspective to highlight the advantages of having high level resources to quickly adopt new technologies in research organisations [12], apart from a couple of high-ranked universities (e.g., Pennsylvania State University, Purdue University) among the selected studies, different examples from these studies showthe possibility of successful AI integration in resource-constrained universities (e.g., ADVi, an AI chatbot that answers college admission-related inquiries; Learning analytics tool for active writing support to students; OwlMentor, an AI-powered learning environment to assist to students in comprehending scientific texts and reviews; Moodle to Moodle LXP, for personalised feedback to a student's progress; Artificial Intelligence Smart Sketchpad (AISS), to support students' learning in (film) character design in a multimedia environment; CREAMINKA, a smart tool for scientific productivity analysis through Scopus-indexed publications—see Appendix 1). In addition, STS approach underlines the role of a human factor in effective usage of AI technology in universities in terms of resistance to change, or vice verso acceptance of new technologies, experience with machine interaction, and socially oriented behaviours shaping back-propagate into algorithmic design [24].

Further, this research clearly underlined how institutional regulations and practices are important to ensure ethical use of AI in universities (Table 4). Therewith, as the last stage for AI integration in universities, ethical regulations, particularly regarding academic integrity, human-AI collaboration, and social equity, should be systematically addressed through formalised regulatory frameworks and AI-Literacy initiatives, not only for students but also for academic and non-academic personnel. In this regard, the university leaders should also take relevant and binding regulations into account for their institutional policy development on AI technologies. In fact, nowadays any university in any country is somehow forced to align its AI-based systems with concrete national and/or international legislations. For example, Digital Operational Resilience Act (DORA), General Data Protection Regulation (GDPR), European Union Artificial Intelligence Act (EU AI Act), UNESCO's Recommendation on the Ethics of Artificial Intelligence, OECD. AI Observatory for policies, data and analysis for trustworthy artificial intelligence are some of well-known international regulations which may guide university leaders, as well as different national regulatory frameworks in their countries such as Australia's AI Ethics Framework, Artificial Intelligence and Data Act in Canada, China's Generative AI Regulation, Finland's Age of Artificial Intelligence, Executive Order on the Safe, Secure, and Trustworthy Development and Use of Artificial Intelligence by the USA, or Ethics Guide of Generative AI Use from the Council of Higher Education, Türkiye [30].

As a result, the integration of AI into university practices seems not merely as a technological advancement but as a strategic initiative for universities nowadays. Parallelly, this meta-synthesis review defined a structured roadmap about the stages of AI adoption into university management. When university leaders and relevant experts decide regarding the purpose(s) of institutional AI usage, they can follow the eight-steps framework to navigate the technical and institutional complexities of AI adoption in their universities. Yet they should ensure ethical oversight extending beyond compliance mechanisms, that canevolve into a sustained institutional culture of responsible AI use, which simultaneously integrates transparency, accountability, and human oversight. On

the other hand, this literaturereview is limited to the selected case studies. Hence, to generate a more comprehensive picture, researchers can investigate holistically a case of AI integration into various universities by employing the AI adoption framework outlined in this research. They can also develop different data collection tools (e.g., semi-structured interview protocols, open-ended questionnaires, structured Likert-type surveys, etc.) based on the theoretical outcomes here to collect quantitative and/or qualitative data from various stakeholders (students, academics, administrative staff, external partners, etc.) in further research on AI adoption in universities.

Table 5 Country case distribution of the selected studies

Country*	Institution	Study	Topical focus	Main result
Australia	Edith Cowan University	[43]	Use of AI for qualitative data analysis	Revealed the potential of AI-assistance in qualitative analysis and need to be a clear about the role of AI tools in research processes, and require expert human overview
Austria	Austrian Institute of Technology	[60]	Benefitting from AI and network science in academic research evolution	Explore the application of AI and network science methodologies in characterizing interdisciplinary fields, and (with an example of Italian design field), and text analysis and semantic topic modelling successfully identified the evolution of research interest over time
Canada	Université du Québec à Trois-Rivières	[40]	Human-centered AI in higher education	Proposed the Human-Centered AI for Systematic Literature Reviews (HCAI-SLR) framework to guide educators and researchers in integrating AI tools effectively
China	University of Sanya	[34]	College students' physical fitness and health management based on physical measurement big bata	Health data collection and recording, health assessment, health planning, and tracking and execution (for intelligent health warning and disease risk assessment to students)
	Beijing Institute of Technology	[75]	College students' psychological health service system design based on AI technology	Developed a framework to design health service system for students' psychological needs, and aiding relevant departments and units to effectively manage all documented processes from psychological consultation sessions to survey records
	Tianjin University of Commerce	[80]	AI technology for information service in university physical education	Explored the relationship between big data and the development and application of information technology such as the Internet, Internet of Things, cloud computing, and clarified the difference and connection between big data, informatization and AI in college physical education management
	North China University of Science and Technology	[61]	AI of internet of things based on machine learning and college student management	Constructed an intelligent college student management system of Internet of things based on machine learning, and the system data (filled and classified by the k-nearest neighbour model) are trained to successfully monitor abnormal data flow in student management operations
	Zhejiang College of Security Technology	[81]	Construction of college students' sports health management service platform based on AI	Built a data chain system with college students' physical health test scores and designed a college students' sports health management service platform to evaluate and diagnosis for individual performance and forms comprehensive exercise prescription intervention mechanism
	Weifang University of Science and Technology	[41]	AI-driven interactive learning methods for enhancing art and design education in higher education institutions	Proposed interactive learning method is beneficial for art and design majors as it allows students to improve their practical skills and learn more engagingly and effectively
	Xi'an International Studies University	[51]	Development countermeasures of college sports training and management based on the background of AI	Proposed an AI-based DTW pose matching algorithm for sports training movement completion and evinced the potential of AI-based sports training management model to improve the practical accuracy of sports movement training

Table 5 (continued)

Country*	Institution	Study	Topical focus	Main result
	Wuhan Business University	[77]	Higher education information management system based on digital twin technology and AI algorithms	Combining with AI algorithm, applied the digital twin technology in the informatization of college education management, and exemplified the new mode of information ecosystem of close-loop operation and intelligent decision-making with entities in higher education institutions
	Tangshan Vocational and Technical College	[44]	Application of AI technology on mental health counselling services for college students	Improved Seq2Seq model to enhance the emotional understanding and interaction capabilities of emotional dialogue generation algorithms in mental health counselling
	Ganzhou Vocational and Technical College	[48]	Personalized learning in STEM education using high-performance computing and AI	Developed an adaptive learning framework that leverages Transformer-Based Models, Graph Neural Networks (GNNs), and Reinforcement Learning (RL) under high-performance computing (HPC) infrastructure to optimize STEM education personalization and supercomputing provides potential to deliver real-time adaptive learning, significantly enhancing student engagement, efficiency, and retention in STEM education
	Dalian Polytechnic University	[52]	Optimization strategies of university ideological and political parenting models under the empowerment of digital intelligence	Proposed digital and intellectual technology-enabled university civic and political education model (based on differential game approach) and concluded as resource input cost and technological innovation cost are the key driving variables of university ideological and political parenting
	Southwest Minzu University	[79]	College students' achievement, motivation, and engagement in film character design through AI-driven smart sketchpad	Proposed a teaching method based on an AI tool, the Artificial Intelligence Smart Sketchpad (AISS), and enriched students' abilities character design by assisting in active teaching experience of "character art design" in a multimedia environment
	Ocean University of China, Qingdao	[82]	Anti-plagiarism literacy practices among undergraduates with AI	Introduced an Anti-Plagiarism Literacy Practices (APLP) programme, which includes a customised AI tool called the Academic Writing System (AWS), to support students' anti-plagiarism literacy practices in academic writing scenarios, and evinced the programme's effectiveness in enhancing anti-plagiarism literacy practices among university students
Ecuador	Universidad Polit´ecnica Salesiana	[63]	Intelligent ecosystem based on ontologies and smart tools for the dynamic analysis of scientific production in a university	Applied standards like the International Standard Classification of Education from UNESCO to all Science Journal from SCOPUS, and assessed the productivity of a university with 1.912 individuals of papers, authors, journals and organizations by smart tool, CREAMINKA
	Universidad de Las Américas, Quito	[74]	Implementation of a virtual assistant for the academic management of a university with the use of AI	Porotyped the architecture of a chatbot, which using AI in tasks such as providing information on academic courses are addressed by students, and reduced the administrative burden and improving the user experience

Table 5 (continued)

Country*	Institution	Study	Topical focus	Main result
Finland	University of Oulu	[57]	Integrating generative AI in mixed reality for active learning in higher education	Embodied generative AI system designed to facilitate active learning, self-regulated learning and enhance human-AI shared regulation in educational settings, and evinced that AI-based educational tools generates the potential to afford more active and agentic learning experiences
France	ICN Business School	[47]	Mediation of learning by generative AI in higher education and development of students' generative AI literacy	Demonstrated that generative AI tools can mediate learning by bridging subject knowledge gaps, enabling adaptive and scalable support, and fostering GAI literacy through hands-on engagement by students
Germany	Offenburg University of Applied Sciences	[39]	Use of AI-based learning recommendations in higher education	Proposed extensions for the well-established LMS Moodle, including AI supported learning recommendations and user-based feedback mechanisms to transform Moodle to Moodle LXP
	Saarland University	[70]	Generative AI in higher education, and a RAG system for student engagement with scientific literature	Developed OwlMentor, an AI-powered learning environment, and significantly assisted to university students in comprehending scientific texts, as well as enhancing their self-efficacy in scientific reviews
	Osnabrück University	[37]	Designing principles for chatbots in academic teaching and research	Define key requirements and design principles of AI tools that support virtues such as uniqueness, generalizability, reproducibility, and also introduce a prototype, "AcademiaBot" (see the access link in the study)
	TU Dresden	[62]	AI-based learning objective-oriented formative feedback for students in higher education	Designed a self-trained Large Language Model, integrated an AI-based formative feedback system within an LMS, and effectively enhanced learner competencies and aligning with curriculum and learning objective
Hong Kong	The Chinese University of Hong Kong	[78]	University students' engagement with generative AI-supported automated writing evaluation (AWE) feedback	Designed generative AI-powered AWE platform (named Learnalytics), and tested by students for completing their research reports with active writing support from this AWE platform in each stage, as well as students' increasing engagement with Learnalytics tool
India	Thiagarajar College of Engineering	[59]	Implementing cognitive automation for employee management in a university	Developed an "Cognitive Employee Management System" information system to manage the attendance, leave particulars and payroll of the employee in a university, and defined several benefits (e.g., quicken and accuracy increase in official and financial operations) against some user critics
Israel	Emek Jezreel Academic College	[42]	AI-assisted reviewer selection across academic disciplines	Achieved a visible overlap by the AI system (around 42%) with editors' reviewer selections and reducing selection time by 73%
	Holon Institute of Technology	[72]	Student–chatbot interactions for academic writing assistance	Analysed the interaction of 43 graduate students and AI-chatbot during individual online sessions they conducted, and revealed the most frequent assistance requests from AI from content generation and expansion to source integration and verification, as well as concept clarification and definitions

Table 5 (continued)

Country*	Institution	Study	Topical focus	Main result
Latvia	Riga Technical University	[55]	AI and big data driven Information System (IS) security management in higher education institutions	Presented the architecture of a modular big-data-based IS security management system (ISMS) and elaborated with AI-driven NetFlow data analysis (NFAI) module, as well as NFAI module identified infected computer and internet-connected devices which were not detected by antivirus software nor by firewall or Intrusion Detection System
Malaysia	University of Malaya	[66]	Application of AI mock interviews in enhancing graduate perceived employability	Designed an AI mock tool for trail interviews by graduates, and effectively assisted graduates' employability performance in real-conditions imitated interview scenarios
Morocco	University Sidi Mohamed Ben Abdellah	[35]	Interactions between AI teachers, human teachers, and students in higher education and their influence one another	Proposed the Ethical AI in Education (EAIED) multi-platform architecture, which emphasizes data privacy, ethics, and interoperability between learning systems
Netherlands	University of Twente	[65]	Integrating AI chatbot technology with learning management systems	Designed considerations for implementing AI-driven chatbots and revealed the contributions of the co-creation of an AI-based StudyBuddy tool to supporting students for enhanced teaching process and learning outcome quality
Philippines	National University, Manila	[71]	AI applications in quality management systems in higher education institutions	Presented an AI-enabled Quality Management System (QSM), and demonstrated visible match between AI-enabled QMS and audit findings in accreditation compliance reports and internal quality audit reports
Portugal	University of Trás-os-Montes and Alto Douro	[36]	Comparison of the quality of human-made vs. AI-generated news by journalism students	Perceptions generally rated news generated by AI (ChatGPT-3) tool as being of higher quality than news written by journalists
Romania	University Politehnica of Bucharest	[38]	Early recognition system with machine learning to support students' success	Propose an Early Recognition System equipped with real data captured in a blended learning course with a personalized test at the beginning of the semester and to predict the final score of students before participating in final examination
	The Bucharest University of Economic Studies	[45]	Machine learning for curriculum development in universities	Described the preparation of the corpus and the derivation of themes for curriculum development based on machine learning
Russia	Moscow State Pedagogical University	[49]	Higher education management with smart technologies by digital management staff and AI	Revealed that, to achieve the automation of management in higher education on the basis of "smart technologies", need for unique AI systems, as well as need to train digital managerial personnel with strong social and technological competencies
	Lomonosov Moscow State University	[67]	Analysis of COVID-19 medical papers using AI	Developed text corpus with a model called PubMedBERT (with over 700,000 scientific papers), and applied NLP and text-based emotion detection (TBED) methods to COVID-19 text corpus to gain insights on important issues of diagnosis and treatment

Table 5 (continued)

Country*	Institution	Study	Topical focus	Main result
Slovakia	Comenius University in Bratislava	[69]	AI ethics in medical and educational AI agents and trustworthy ethical firewall formation	Introduced the Ethical Firewall Architecture and combined rigorous mathematical safeguards with structured human intervention to deliver AI systems that perform efficiently while upholding transparency, accountability, and trust in critical applications
South Africa	University of the Western Cape, Cape Town	[73]	Use of conversational AI (CAI) in academic practice within higher education	Explored the usage of CAI by younger academics more for research than teaching, with academics from the science faculty using it more for teaching, as well as identifying concerns arose about ethics and educational alignment
South Korea	Sungkyunkwan University	[76]	AI optimization algorithms and enhancement of higher education management and personalized teaching	Revealed, with an empirical study conducted over one academic semester, that AI optimization for personalized learning provides significant improvements in students' learning outcomes, engagement, satisfaction, and efficiency comparing to traditional approaches
Ukraine	Kherson State University	[68]	Institutional policies on AI in university learning, teaching and research	Exemplified the entire processes of the development of institutional AI policies, and revealed the potential connections with inclusive environment of modern digital tools for involving of lecturers of non-professional specialties and define the framework for the use of AI in education, teaching, and research
United States	Purdue University	[53]	AI-based automatic detection of online teamwork engagement in higher education	Used computer-based methods to explore productive and unproductive team engagement times, and effectively detected engagement as a viable tool for characterizing productive and unproductive engagement patterns in teamwork sessions of students
	University of Iowa	[64]	AI-enabled intelligent assistant for personalized and adaptive learning in higher education	Presented a novel framework, AI-enabled intelligent assistant (AIIA), and evinced the potential to significantly impact the design, implementation, and evaluation of AI-enabled virtual teaching assistants (VTAs) in higher education to enhance student learning outcomes, engagement, and satisfaction
	Northern Arizona University	[46]	Prevalence and usability of AI chatbots within Hispanic-Serving community colleges	Rear usage of AI chatbots in Hispanic-Serving community colleges and need for the integration of Spanish-language AI agents
	University of Texas at San Antonio	[50]	Integrating chatbots to support the college transition of autistic students	Developed ADVi, an AI chatbot that answers college admission-related inquiries and highlighted the increased utilization of ADVi by autistic students and a potential of AI tools to facilitate smoother educational transitions for students requiring specialized assistance
	Pennsylvania State University	[54]	Usage of Generative AI in higher education constituent (customer) relationship management	Highlighted 6 primary types of GenAI: textual analysis and synthesis, data summarization, next-best action recommendations, speech synthesis and translation, code development, and image and video creation; each with applications across student recruitment, advising, alumni engagement, and administrative processes

Table 5 (continued)

Country*	Institution	Study	Topical focus	Main result
	Liberty University	[56]	Comparison of the prevalence of AI and plagiarism in doctoral dissertations using Turnitin	Compared the accuracy of technology in detecting AI-generated text by dissertations before widespread AI availability and after, and not revealed any significant difference in plagiarism detection for 2013 (with 100) and 2023 (with 100) dated, 200 doctoral dissertations in total
Vietnam	Eastern International University	[58]	Autonomous waste management with AI and IoT-powered smart university campus design	Developed autonomous waste management which helps efficient and optimal collecting and recycling of garbage, and led with this system, to less fuel consumption, cuts off the carbon footprint, making the waste management process eco-friendlier

* Based on the first author's affiliation

Appendix 1

See Table 5.

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Author contributions
Baris Uslu contributed to: Conceptualization, methodology, formal analysis, investigation, data curation, visualization, writing—original draft preparation, writing—review and editing; and Liudvika Leištė contributed to: conceptualization, methodology, investigation, writing—original draft preparation, writing—review and editing.

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Declarations

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