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Artificial Intelligence and Large Language Models in Higher Education: Results of A Systematic Review

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Abstract: Artificial Intelligence (AI), and in particular Large Language Models (LLMs), has gained significant importance in the education sector in recent years. These technologies offer a variety of applications, such as personalizing learning, improving the efficiency of administrative processes, and introducing innovative teaching methods. Despite the numerous possibilities, there is a research gap regarding the concrete design and implementation of AI systems in higher education, considering both technical efficiency and ethical standards. The present work addresses this gap through a systematic literature review in accordance with the PRISMA guidelines, evaluating 111 relevant studies from the Web of Science, Scopus, and Google Scholar databases.

The analysis shows that AI and LLMs offer significant advantages for higher education, such as the creation of individualized learning paths and the automation of assessment processes. At the same time, the study identifies significant challenges, including privacy issues, algorithmic biases, and the lack of explainability of complex models. Ethical implications such as fairness and equity are also critically examined. To address these challenges, concrete recommendations for educational institutions are developed. These include the development of proprietary, internally hosted AI systems for better data control, the promotion of interdisciplinary collaboration, comprehensive training programs for educators, and the establishment of governance structures and ethical guidelines.

The findings emphasize the need for an integrated perspective that considers both technical and ethical aspects in order to harness the full potential of AI in education in a responsible way. This work provides practical guidelines for the effective and ethical implementation of AI technologies in higher education, thereby contributing to improving the quality of education while ensuring data protection and fairness.

Key words: artificial intelligence, AI in education, systematic literature review, AI applications in higher education, explainable AI

1. Introduction

The field of artificial intelligence (AI) has witnessed a notable surge in prominence in recent years, exerting a pervasive influence across a multitude of societal domains, particularly within the realm of education (Kasneci et al., 2023). Artificial intelligence (AI) is defined as the capacity of a machine to emulate human abilities, including

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logical reasoning, learning, planning, and creativity (European Union, 2024). While AI was originally developed primarily in technical disciplines, it has now become a key technology that enables profound changes in numerous scientific fields (Russel & Norvig, 2021). Consequently, AI presents a multitude of prospective applications in the field of education (e.g., Zawacki-Richter et al., 2019). It is particularly noteworthy that generative AI systems, such as large language models (LLMs), have the potential to open new application possibilities due to their ability to understand and generate human language (Singh et al., 2024). Despite the numerous potential applications of AI and LLMs in the field of education, as highlighted in numerous studies (e.g., Chen et al., 2020; Daun et al., 2023), the legal compliance of AI systems and LLMs remains a significant challenge (Vincent-Lancrin & Vlies, 2020; Singhal, 2024). In the context of data-sensitive education, there is a notable research gap concerning the specific design and implementation of AI systems based on LLMs that simultaneously prioritize technical efficiency and ethical standards within the university setting. This paper seeks to address this research gap by means of a systematic literature review and to derive recommendations from the synthesis.

2. Theoretical Principles and State of Research

Previous research has frequently focused either on the technical advantages of AI in education or on its ethical implications, without offering an integrative perspective (Holmes et al., 2019; Selwyn, 2019). There is a lack of detailed analyses on overcoming challenges such as the "hallucinations" of LLMs (Valentin et al., 2024) and the lack of explainability of complex models (Lipton, 2018). Although some studies emphasize the significance of data privacy (Drachsler & Greller, 2016; Slade & Prinsloo, 2013), the practical means by which educational institutions can effectively address these concerns remain unclear. Similarly, there is a lack of concrete recommendations to circumvent bias in AI systems that could impact equity in education (Omughelli et al., 2024).

Several systematic literature reviews have already been conducted on the use of AI and LLMs in university settings. For example, Crompton and Burke (2023) conducted a systematic literature review of the utilization of AI in higher education, based on 138 studies from 2016 to 2022. They analyzed geographical distribution, research context, and the type and scope of AI used, with a particular focus on the impact of AI on teaching and learning. The AI applications were categorized into four principal categories: assessment and evaluation (e.g., automated assessment and feedback), prediction of academic performance, intelligent assistants such as chatbots, and student management through learning pattern recognition and profiling. This overview offers valuable insights into the diverse applications of AI in higher education, while underscoring the lack of studies from German-speaking countries.

In their 2019 study, Zawacki-Richter et al. provide a comprehensive and systematic overview of research on the application of AI in higher education. Their analysis, based on 146 studies conducted between 2007 and 2018, focused on the definition of AI, its ethical implications, and its application in higher education. Only 1.4% of the studies addressed ethical issues, particularly those related to data protection, costs, and the time required to implement AI-based methods. Most studies focused on using AI for creating student profiles, enhancing admissions decisions, and predicting learning progression and dropout rates. Additional studies analyzed the use of intelligent tutoring systems for diagnosing deficiencies in knowledge and providing automated feedback, as well as automated assessment techniques, personalization of learning, and support for educators. This research highlights both the potential and the challenges associated with AI in higher education, particularly regarding ethical issues and integration into educational processes.

Chu et al. (2022) examined the 50 most cited articles on AI in higher education published on the Web of Science to assess the specific types and degrees of AI utilized, the context of the studies, and the primary topics, with a particular focus on the algorithms employed. Their study spanned from 1996 to 2020 and found that, while most findings pertain to technical applications, AI has been employed in various contexts, including recommender systems, predictive systems for identifying at-risk students, and intelligent tutoring systems providing personalized interventions. The study calls for a more pedagogically oriented approach to AI implementation and enhanced training for teaching personnel.

Castillo-Martínez et al. (2024) present a systematic literature review that evaluates the integration of artificial intelligence in higher education research. The study analyzes 85 articles published in 2023 to delineate both the benefits — such as enhanced research efficiency, adaptive learning environments, and streamlined administrative processes — and the challenges, including ethical dilemmas, data protection concerns, and the critical need for rigorous human oversight. The findings underscore emerging research trajectories and highlight that while AI offers transformative potential in advancing scholarly activities, its responsible and supervised implementation remains essential to safeguard academic integrity.

A systematic literature analysis by Pishtari, Wagner, & Ley (2024) on behalf of Forum Neue Medien Austria (FNMA) offers a comprehensive overview of AI utilization in higher education, focusing on its use for teaching and learning. The report reviews systematic literature reviews and current empirical studies from 2023, identifying systematic reviews that focus on the impact of AI on teaching and learning practices, including its uptake by teachers and learners. The studies examined a range of AI applications, such as predictive systems for identifying at-risk students, intelligent tutoring systems, and personalization of learning resources. The analysis underscores that while AI is predominantly employed in learning analytics, challenges — especially ethical and data protection issues — persist. The report advocates for an integrated approach to educational theories within AI implementation and calls for further empirical research into the long-term impact of AI applications on teaching.

The existing literature on AI use in higher education has primarily concentrated on technical applications such as automatic assessment systems, intelligent tutoring systems, prediction models for academic performance, and personalized learning resources. Ethical considerations like data protection and bias are often addressed separately from technical analyses. There is a pressing need for studies that holistically combine the technical and ethical dimensions of AI in education. The following research gaps have been identified through systematic literature searches:

- Overcoming Specific Challenges: There is insufficient detailed analysis on overcoming issues such as the “hallucinations” of large language models (LLMs) and the lack of explainability of complex AI models.
- Development of Practical Data Protection Solutions: There is a lack of concrete recommendations for educational institutions to effectively implement data protection measures.
- Avoidance of Bias: There is a dearth of tailored strategies and recommendations for reducing bias in AI systems.

These research gaps underscore the need for more comprehensive and integrative studies that encompass both technical and ethical considerations. Without a holistic approach, technical advances may progress uncontrollably while neglecting ethical standards, potentially leading to a loss of trust in AI applications in education.

This leads to the following research question:

How can AI systems, in particular Large Language Models (LLMs), be designed and implemented in an academic and higher education context to improve learning processes while ensuring technical efficiency and compliance with ethical standards such as data protection?

The objectives of this study are to:

1) Investigate the current potential and challenges of AI and LLMs in the field of education through a systematic analysis.
2) Identify the specific technical and ethical requirements that must be considered when designing AI systems for the education sector.
3) Formulate recommendations for the use of AI systems at academic institutions that facilitate responsible and effective implementation.

3. Research Methodology

A systematic literature search was conducted in accordance with the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses; PRISMA, 2020) to systematically document the current state of research concerning the integration of artificial intelligence (AI) and large language models (LLMs) in educational contexts. The initial search was conducted in September 2024 using the scientific databases Web of Science, Scopus, and Google Scholar, with an additional update performed in 2025 to ensure comprehensiveness and currency.

The objective of this systematic review is to address the formulated research question by implementing a transparent, systematic, and reproducible search strategy (Natukunda & Muchene, 2023). Relevant studies were systematically identified using clearly defined inclusion and exclusion criteria in line with established methodological standards (Gough et al., 2017).

In order to ensure comprehensive coverage of the relevant literature, the search was conducted in English. Specific search strings containing Boolean operators and wildcards were developed for each database. The exact search strings and the number of studies found per database are presented in Table 1 below.

Table 1 Search Strings and Number of Studies Found per Database

Database	Search string	Number of studies found
Web of Science	TS = (“Artificial Intelligence” AND Education) OR (“Artificial Intelligence” AND “Higher Education”) OR (“Large Language Models” AND Education) OR (“LLMs” AND “Ethical Implications” AND Education) OR (“AI” AND “Data Privacy” AND Education) OR (“LLMs” AND “Ethical Implications” AND Education) OR (“AI” AND “Energy Resources” AND Education)	858
Scopus	TITLE-ABS-KEY (“Artificial Intelligence” AND Education) OR (“Artificial Intelligence” AND “Higher Education”) OR (“Large Language Models” AND Education) OR (“LLMs” AND “Ethical Implications” AND Education) OR (“AI” AND “Data Privacy” AND Education)	386
Google Scholar	All of the above search strings were entered, supplemented by wildcards () to cover different word endings (e.g., “educat” for “education”, “educational” etc.).	749

A total of 1993 studies were identified (Web of Science: 858, Scopus: 386, Google Scholar: 749). After removing duplicates, 486 unique studies remained for further analysis.

3.1 Inclusion and Exclusion Criteria

To ensure the relevance and quality of the selected studies, clear and precise inclusion and exclusion criteria were defined:

- Inclusion Criteria:
  - Publications from 2015 to 2025 to ensure contemporary relevance.
  - Publications available in German or English.
  - Studies that explicitly address the use of AI and LLMs in the field of education or the implications thereof and provide empirical data or theoretical contributions.
- Exclusion Criteria:
  - Blind reviews, conference papers, and books.
  - Studies that do not pertain directly to the education sector or address AI in a different context.
  - Studies with inaccessible full texts or those with significant methodological shortcomings (e.g., inadequate sample description, insufficient methodological detail, or lack of scientific evidence).

The AI management system developed by the Private University College of Teacher Education Burgenland was utilized for the processing of the literature. The following steps were conducted with the assistance of the AI system. (1) Duplicate identification (KI@PPHBurgenland; GPT4, 2025a), and (2) abstract and title summarization to identify relevant studies (KI@PPHBurgenland, GPT 4, 2025b). Furthermore, the abstracts were examined and screened for potential applications in the field of education with the assistance of the AI system (KI@PPHBurgenland; GPT4, 2025c). This process involved prompting and output variations observed in the bibliography. All of the aforementioned work steps were conducted manually and subsequently transferred to the AI system for a second examination.

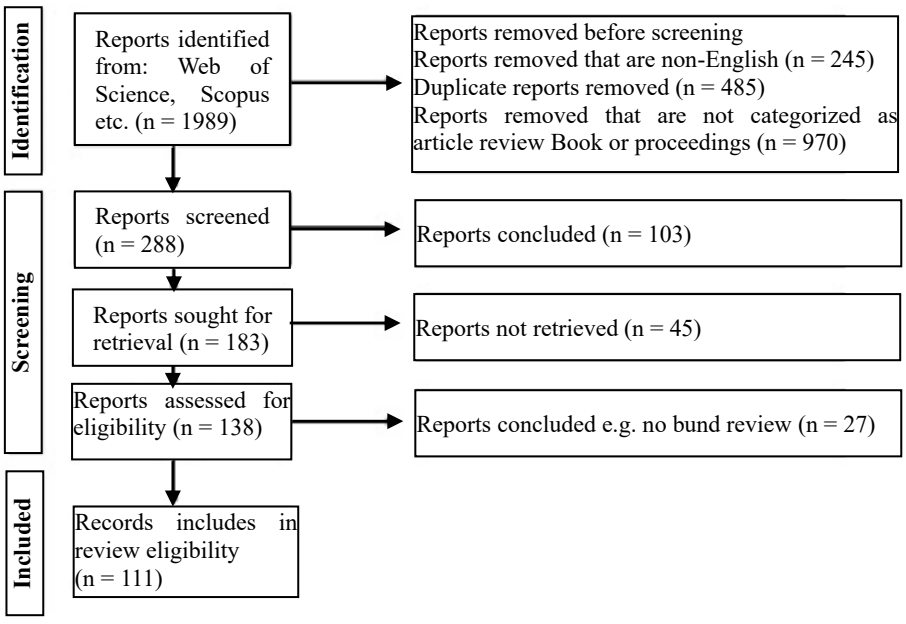

Figure 1 PRISMA Diagram (Slightly Modified)

3.2 Qualitative Content Analysis: Coding Process and Category Development

The coding scheme was developed based on the research questions and existing literature (Mayring, 2015; 2019) and proceeded in three phases:

1) Open Coding: Identification of relevant text passages from the full texts of the selected studies and

assignment of initial codes (e.g., a section describing the adaptation of learning materials to individual needs was coded as "personalization").

2) Axial Coding: Summarizing the initial codes into superordinate categories to structure and link the codes and identify broader correlations and patterns.
3) Selective Coding: Integration of the categories into an overall model that comprehensively addresses the research question. This integration linked categories such as "Potentials of AI", "Implementation Challenges", "Ethical Implications", and "Proposed Measures and Strategies".

Specific sub-categories and codes were defined for each main category to enable precise data recording. The main categories and their operationalizations are as follows:

1) Potentials of AI and LLMs in Education
- Personalization of Learning
  - Systems that adapt learning content based on learners' individual progress and needs.
  - Creation of customized learning paths based on students' abilities and goals.
- Increasing Efficiency
  - Use of AI to automate administrative processes such as course planning and student administration.
  - Use of LLMs to automate exam assessments and generate personalized feedback.
- Innovative Learning Methods
  - Integration of chatbots and LLMs to provide personalized support and immediate feedback.

2) Challenges in the Implementation of AI
- Data Quality
  - Ensuring the accuracy, completeness, and consistency of the data used, and access to high-quality data sets.
- Resources and Infrastructure
  - High investments required for the development and implementation of AI systems.
  - High energy consumption and ecological impact due to the use of large AI models.

3) Ethical Implications
- Data Protection
  - Ensuring that AI systems comply with legal data protection requirements.
  - Measures to protect student data from unauthorized access.
- Bias – Systematic Distortions in the Decisions or Outcomes of AI Systems
  - Measures to identify and reduce bias in AI models.

4) Recommended Measures and Strategies
- Guidelines
  - Creation of guidelines that regulate the responsible use of AI in education.
- Professionalisation
  - Programs to train teachers in the use of AI technologies.
  - Training programs to promote awareness of data protection, fairness, and responsibility.

3.3 Examples of Operationalization:

- Example 1: Personalization of Learning
  - Text Passage: "The adaptive learning system continuously analyses the students' progress and adjusts

the difficulty level of the tasks accordingly."

- Applied Code: "Adaptive learning systems"
- Operationalization: This passage describes the dynamic adaptation of learning content based on individual student progress, hence the code "Adaptive learning systems" is applied.

- Example 2: Data Protection and Privacy
  - Text Passage: "The implementation of encryption technologies ensures that students' personal data is protected from unauthorized access."
  - Applied Code: "Data protection and privacy"
  - Operationalization: The passage describes specific measures to secure personal data, corresponding to the code "Data protection and privacy."

3.4 Data Extraction and Synthesis

- Data Extraction: The coded data was extracted and recorded in a table containing the relevant categories and key findings for each study.
- Qualitative Content Analysis: A qualitative content analysis was conducted according to Mayring (2015) to identify patterns, correlations, and central statements.
- Integration into the State of Research: Quotations and key findings were collected and integrated into the synthesis of the current state of research to underpin the argumentation.

4. Analyzing the Identified Studies

In this chapter, the operationalization of the main categories is used to review the current state of research.

4.1 Potential of AI and LLMs in the Education Sector

4.1.1 Personalization of Learning

The advent of artificial intelligence and LLMs has brought about a revolutionary transformation in the field of education. These technologies are paving the way for the creation of adaptive learning environments, which facilitate the development of personalized learning pathways for students. As demonstrated by Ng and Fung (2024), LLMs such as GPT-4 are capable of devising meticulous and tailored learning pathways for learners through the incorporation of prompt engineering. This approach has been shown to enhance learning efficiency and outcomes. Furthermore, adaptive learning systems benefit from LLMs, as they enhance human-machine interaction and facilitate real-time personalized feedback, thereby offering a more flexible and dynamic learning experience (Wen et al., 2024). These technologies facilitate the creation of individual learning pathways by enabling the dynamic adaptation of learning strategies, thereby optimizing the learning process for each individual.

While LLMs have the potential to promote a more personalized approach to learning, there are a number of challenges that must be considered, including the avoidance of errors and the ethical implications of potential bias. Suresh and Misra (2024) highlight the importance of ensuring the accuracy of the content generated by LLMs and the avoidance of algorithmic bias as crucial factors for successful utilization in an educational context.

In their systematic literature review of 146 studies, Zawacki-Richter et al. (2019) additionally assert that such technologies facilitate the creation of individualized learning paths that are tailored to the specific needs of

learners. Modran et al. (2024) identify the limitations of traditional tutoring methods and the shortcomings of relying on LLMs such as ChatGPT as the sole source of guidance in higher education. They develop an innovative intelligent chatbot tutoring system that combines the Retrieval-Augmented Generation (RAG) approach with a customized LLM to provide accurate, contextually relevant and personalized support. The objective of the system is to enhance student comprehension and engagement, as well as provide an enriched educational experience and increased academic achievement. Such systems have the potential to augment traditional learning approaches and achieve more profound learner engagement, as they can respond to user progress and needs in real time. Akinwalere and Ivanov (2022) emphasize that AI offers significant opportunities in education, particularly through applications such as profiling, prediction, intelligent tutoring systems and personalized learning approaches.

4.1.2 Increasing Efficiency

The integration of AI into educational systems offers numerous opportunities for improving learning outcomes through the design of customized learning routes and the automation of administrative procedures. Abimbola et al. (2024) emphasizes the potential of AI to adapt learning processes to individual needs, thereby enhancing learning success. Concurrently, however, ethical challenges such as data protection and the potential for algorithmic bias must be considered, given that the handling of vast quantities of data entails the processing of sensitive student data. Furthermore, unequal access to these technologies has the potential to exacerbate existing educational inequalities.

Recent research indicates that LLMs are further revolutionizing the field of automated assessment. In a recent study, Larondo et al. (2024) demonstrated the efficacy of LLMs in automated assessment of intricate technical operations, achieving an accuracy rate of 80% in the classification of identified issues. Stamper et al. (2024) put forth the proposition that LLMs can be employed in intelligent tutoring systems to generate personalized feedback, thereby markedly enhancing teacher efficiency and improving student learning performance.

Further research, as exemplified by the work of Estévez-Ayres et al. (2024), has demonstrated that LLM-based tools are capable of identifying common errors in programming tasks, such as deadlocks, and providing consistent feedback. While the accuracy of error detection remains a point of improvement, these systems have demonstrated promising results in the automation of assessment processes. In parallel, AI enhances administrative efficiency by automating routine tasks, optimizing resource allocation, and strengthening student support services (Kayyali, 2025).

4.1.3 Innovative Teaching Methods

The deployment of chatbots and LLMs in the field of education offers a promising avenue for further investigation. In a systematic literature review conducted by Deng & Yu (2023), the authors analyzed 32 scientific studies published between 2010 and 2022, comprising a total of 2201 subjects. The studies examined the deployment of chatbot technology in an educational context. The findings indicated that the utilization of chatbots has the potential to enhance learners' interest and performance in learning. However, they also identified the ethical and technological challenges inherent to this field, particularly with regard to data protection and the avoidance of algorithmic biases.

Winkler and Söllner (2018) conducted a comprehensive analysis of the use of chatbots in education, emphasizing their potential to provide personalized support and immediate feedback. In a study conducted by

Fryer, Nakao and Thompson (2019), the utilization of chatbots as conversational partners in language learning was examined. The students participated in discourse with both human interlocutors and chatbots, after which they provided feedback on their level of interest and the extent of their learning success. The findings indicate that prior interest in human conversation partners is a robust predictor of interest in chatbot conversations. Moreover, language proficiency is more strongly correlated with interest in chatbots than with interest in human partners. Furthermore, the perception of having acquired more knowledge through chatbots fosters greater interest in the learning tasks, even when communication challenges emerge. The study offers valuable insights that can inform the effective use and further development of chatbots in the context of language learning. One practical example is the AI-supported chatbot "Jill Watson" at Georgia Tech University, which provides students with answers to frequently asked questions and alleviates the burden on teachers (Taneja et al., 2024).

In a comprehensive analysis of the role of generative AI and chatbots in education, Akpan et al. (2024) presents a detailed examination of the potential applications and implications of these technologies in the field of education. The study demonstrates that chatbots are employed in a range of disciplines, including computer science, healthcare and engineering, with the objective of enhancing the learning environment and providing automated feedback. However, the authors also highlight potential limitations, including the loss of human interaction and the necessity for critical thinking (Duran, 2024). Additionally, Ali et al. (2024) demonstrates that chatbots such as Google Bard and Microsoft Bing Chat assist in enhancing academic competencies, particularly in source evaluation and critical thinking.

This study by Maphalala and Ajani (2025) demonstrates the significant potential of Artificial Intelligence (AI) integration into higher education, particularly highlighting its alignment with constructivist and social constructivist educational theories. AI-driven tools, such as intelligent tutoring systems and chatbots, effectively personalize learning by adapting content based on individual student needs and performance. These technologies enhance student engagement, motivation, and overall academic success, particularly among digital natives.

However, the successful implementation of AI is not solely dependent on technological infrastructure but also critically relies on human factors, notably extensive professional training and continuous support for educators. Additionally, the study identifies significant ethical challenges, including data privacy concerns, algorithmic biases, and equitable access. Addressing these issues requires carefully developed institutional and policy frameworks to ensure inclusive and fair use of AI, avoiding reinforcement of existing inequalities.

The findings suggest that AI facilitates learner autonomy and self-directed learning, actively engaging students as co-creators of their knowledge. For the ethical and effective integration of AI in higher education, the study recommends comprehensive professional development programs for educators, increased student awareness regarding ethical issues associated with AI, and explicit policies to safeguard privacy and equity. In the South African context, these recommendations emphasize the need for inclusive practices ensuring that all learners equally benefit from technological advancements.

4.2 Challenges in Implementing AI

4.2.1 Data Quality

It is imperative that the utilization of big data in the field of education adheres strictly to established frameworks governing data quality and data protection. As evidenced by studies such as those conducted by Budach et al. (2022), data quality in multiple dimensions, including accuracy, completeness, and consistency, is a

critical factor influencing the efficacy of machine learning models. Incomplete or erroneous data can erode trust in AI systems due to unreliable predictions. Additionally, there are significant challenges in numerous domains pertaining to data accessibility, particularly with limited access to high-quality data sets.

4.2.3 Resources and Infrastructure

The development and implementation of AI systems requires a significant financial investment. The study by Li (2023) demonstrates that the use of AI in education can reinforce existing inequalities, as institutions with limited resources struggle to provide the necessary funding to implement AI systems. This disparity results in wealthier institutions advancing technologically while others are left behind. Li emphasizes the necessity of international cooperation and a fairer distribution of AI resources to overcome these inequalities and promote equal educational opportunities.

A study by Gowda et al. (2023) examined the increasing energy consumption of deep learning models and their environmental impact. In contrast to existing research, which primarily focuses on model accuracy, the authors analyzed the relationship between accuracy and energy consumption. This research advances our understanding of energy-efficient AI model development and emphasizes the need to consider environmental sustainability in model architecture.

In a study published in 2019, Strubell and colleagues investigated the considerable energy and resource consumption associated with training large language models (LLMs). The researchers demonstrated that models such as BERT and GPT-2 not only entail considerable financial costs but also leave a significant environmental footprint. The research findings indicate that access to sophisticated hardware is frequently constrained to major research institutions and corporations, thereby perpetuating disparities within the research community. In light of these findings, the authors emphasize the necessity for the development of more efficient algorithms and hardware solutions, as well as the importance of ensuring greater equity in access to computing resources.

In their study, Hidalgo et al. (2023) also examined the growing environmental impact of energy consumption by AI systems, demonstrating that this accounts for up to 9% of global electricity demand. The authors highlight the necessity of developing AI models with enhanced energy efficiency to mitigate CO_2 emissions. They put forth a comprehensive strategy that integrates optimizations at all stages of AI development. The objective is to ensure the continued performance of AI systems while reducing their energy consumption, thereby promoting the sustainability of AI.

4.3 Ethical Implications

4.3.1 Data Protection and Security

The implementation of AI systems in educational institutions presents a number of challenges in relation to compliance with legal requirements, including the General Data Protection Regulation (GDPR). It is of the utmost importance to ensure the protection of personal data in order to maintain the trust of students in the use of AI applications. Drachsler and Greller (2016) posit that inadequate data protection measures may erode trust in such technologies, which could have a detrimental impact on the acceptance of AI in education. Bai et al. (2024) further contend that the compliance with the GDPR and the implementation of data protection mechanisms are becoming increasingly challenging in the context of the advent of new AI technologies such as ChatGPT. Such systems process a considerable amount of personal data.

The processing of substantial quantities of sensitive data gives rise to considerable concerns with regard to

privacy. Slade and Prinsloo (2013) were among the first to discuss the ethical implications of learning analytics, emphasizing the necessity for a balanced approach that aligns the benefits of such technologies with the potential risks.

In particular, in domains such as education and healthcare, where sensitive personal data is processed, data breaches represent a significant and critical threat. The vast quantities of data on which AI systems, including machine learning and automated data collection systems, are often based increase the risk of data leaks and improper processing. In the healthcare industry, it is therefore recommended that measures such as encryption and anonymization be employed (Singhal, 2024).

The potential for algorithmic biases to be unconsciously reinforced by AI applications represents a significant risk of injustice, particularly in sensitive domains such as education. The study by Omughelli et al. (2024) addresses the role of AI in education, with a particular focus on the potential for bias in the prediction of academic success. By analyzing the Open University Learning Analytics Dataset and the utilization of AI algorithms, the study identified potential biases that could result in disparate outcomes for different demographic groups. Consequently, the authors emphasize the necessity for the development of ethical guidelines and techniques for the detection of bias, with the objective of ensuring a fair and inclusive learning environment.

4.3.2 BIAS — Systematic Biases in the Decisions or Outcomes of AI Systems

The potential for algorithmic biases in AI systems to produce discriminatory results and reinforce social inequalities represents a significant challenge. Baker and Hawn (2022) highlight the necessity of identifying and reducing bias in AI models to guarantee equitable outcomes in education. As demonstrated by Pagano et al. (2023), the utilization of metrics such as “equalized odds” and “demographic parity” can assist in the identification and mitigation of bias. These approaches are of paramount importance in the promotion of equal opportunities for all learners and in the prevention of AI systems from reproducing or reinforcing unconscious biases.

In their article, Floridi & Cowls (2019) conducted an examination of the multitude of existing ethical principles for AI and identified a significant consensus between these approaches. Based on their analysis, they developed a unified framework consisting of five core principles: transparency, fairness, accountability, privacy, and human control. The objective of this framework is to provide a foundation for the establishment of consistent legislative, technical, and best practice standards that facilitate the ethical and socially beneficial advancement of AI.

Holmes et al. (2019) posit that AI systems should be designed in a manner that promotes equal opportunities, ensuring that all learners have access to high-quality educational resources, irrespective of their background. This can be achieved by designing appropriate algorithms and avoiding discriminatory decisions, as Misino et al. (2024) emphasize. The promotion of equal opportunities through AI in education thus requires the conscious design and continuous review of the technologies used to ensure that they are inclusive and fair.

The problem of algorithmic bias is closely linked to the “black box”[1] nature of many AI algorithms, which hinders the traceability of decision-making processes and makes it more difficult to detect bias. As demonstrated by studies such as those conducted by Chinta et al. (2024), prejudices inherent in data or algorithmic weaknesses can give rise to inequalities that are particularly detrimental to disadvantaged groups. It is of the utmost importance to ensure fairness in the aspects, namely data collection, pre-processing and algorithmic design. Chaudhary (2024) also emphasizes the significance of transparency in AI systems through the utilization of explainable AI models (XAI), with the objective of fostering trust and addressing ethical concerns. A deficiency in

algorithmic transparency impedes the capacity to discern bias, which can culminate in injustices in evaluation and selection in domains such as education (Samek et al., 2017). Consequently, the imperative for algorithmic fairness is pivotal in guaranteeing that AI systems make decisions in a transparent and equitable manner.

4.4 Recommended Actions and Strategies

4.4.1 Developing Ethical Guidelines

The accelerated adoption of generative artificial intelligence (GenAI) in higher education since the release of ChatGPT in November 2022 has underscored the necessity for transparent ethical guidelines and policies. A number of studies and initiatives are addressing the challenges and opportunities presented by the use of GenAI in higher education.

In a survey of 116 US universities conducted by McDonald et al. (2024), it was found that 63% of these institutions encourage the use of GenAI, with many providing detailed instructions for its use in the classroom, particularly in the area of writing. In this context, discussions frequently center on matters pertaining to data protection, ethical considerations and diversity. Furthermore, the authors caution that the significant alterations to pedagogical approaches may impose a considerable burden on educators.

Similarly, Ioku et al. (2024) identify four profiles of universities based on their adoption of generative AI, such as ChatGPT. The findings underscore the vital importance of clear guidelines and supportive environments for the responsible use of AI in higher education. Furthermore, Sanasintani (2023) investigates the incorporation of AI into higher education curricula to address global developments. In a quantitative survey of 20 students, 70% indicated familiarity with AI, and 80% believed that AI could enhance the quality of learning, while 20% expressed neutral opinions.

In order to address these developments, the PH-Verbund Süd-Ost has published a set of guidelines for the utilization of artificial intelligence (AI) in higher education (Leitgeb et al., 2024). The guidelines provide a comprehensive framework for the utilization of AI in both teaching and examination assessment. The guidelines address a number of key areas, including legal aspects, IT security and subject-didactic recommendations. In light of these considerations, the utilization of generative AI in pedagogical contexts may be permitted, contingent upon the adherence to legal stipulations and the safeguarding of data privacy. The recommendations proffered encompass the integration of AI in a responsible and ethical manner within the domain of education, while ensuring the autonomy of the learners. It is advised that transparent guidelines be established for the utilization and assessment of AI-generated work (Leitgeb et al., 2024).

Ogalo and Mtenzi (2024) conducted a qualitative study examining how the integration of AI in higher education across the UK and Ireland is transforming pedagogical methodologies, student engagement, and academic integrity (Dogru et al., 2023). Drawing on semi-structured interviews with students, the study reveals that while AI enhances study efficiency, offers personalized learning support (Hanaba et al., 2020), and promotes academic equity, it also raises significant concerns regarding academic honesty, potential dependency on AI, and inequitable access to AI resources. Furthermore, the authors highlight a critical gap in institutional guidance on AI use, advocating for a balanced approach that harnesses AI's benefits while addressing ethical, educational, and equity challenges, and calling for further research from both student and staff perspectives (Ogalo & Mtenzi, 2024).

4.4.2 Professionalization

It is of paramount importance to provide training to educators on the utilization of AI technologies in order to ensure the effective integration of these technologies into the teaching process. The study by Umanets et al. (2024) identified the development of technical, pedagogical, ethical and legal skills in teachers as a prerequisite for the successful integration of AI technologies into the educational process. This encompasses the capacity to utilize AI tools in an efficacious manner to enhance pedagogical practices and facilitate the provision of personalized learning pathways for students. Moreover, Brandão et al. (2024) demonstrate that the incorporation of these competencies into professional development program is vital to equip teachers with the skills necessary to navigate the challenges and opportunities presented by the use of AI. It is also recommended that professional development program address ethical aspects, with the aim of increasing awareness of data protection, fairness and accountability. Zawacki-Richter et al. (2019) highlights the necessity of providing educators with training in the ethical issues associated with the utilization of AI. Furthermore, Brandão et al. (2024) emphasize the necessity of integrating ethical considerations, such as data protection and fairness, into professional development program for educators to ensure the safe and ethical use of AI. Ethical awareness is of paramount importance in order to comprehend the potential risks and challenges associated with the utilization of AI, and to ensure the responsible handling of the data generated. This not only encourages the responsible deployment of AI technologies but also reinforces the trust that learners place in the systems employed. By integrating ethical training into the curriculum, educational institutions can guarantee that teachers are not only technically proficient, but also possess an ethical awareness, thus contributing to the creation of a fair and transparent educational environment.

5. Synthesis of Current Research on Potentials, Challenges and Strategies for AI systems in Higher Education

The literature was subjected to axial coding to facilitate a systematic analysis of the identified potentials, challenges, ethical implications, and recommended measures in the context of implementing AI and LLMs in higher education. The extant literature highlights the considerable potential of AI — particularly LLMs — in transforming educational experiences. The application of artificial intelligence enables the personalization of learning through the creation of adaptive environments and individualized learning paths, thereby facilitating tailored educational experiences for students (Ng & Fung, 2024; Wen et al., 2024; Zawacki-Richter et al., 2019). The provision of real-time feedback and automated adjustments enhances learning efficiency by dynamically adapting strategies to the specific needs of learners (Wen et al., 2024). Moreover, AI enhances efficiency by automating routine tasks; for example, automated assessment and feedback processes not only reduce teachers' workload but also improve student performance (Larrondo et al., 2024; Stamper et al., 2024), allowing educators to dedicate more time to core pedagogical tasks (Abimbola et al., 2024). Innovative teaching methods — such as the integration of chatbots and LLMs — have been shown to foster learner interest and provide personalized support, thereby promoting critical thinking and source evaluation skills (Deng & Yu, 2023; Fryer et al., 2019; Winkler & Söllner, 2018; Ali et al., 2024; Duran, 2024). One illustrative example is the AI-supported chatbot "Jill Watson" at Georgia Tech University, which efficiently addresses frequently asked questions and alleviates the burden on teachers (Taneja et al., 2024). In addition, recent work by Wang et al. (2024) demonstrates that hybrid data clustering algorithms can be applied to develop improved interactive e-learning course simulations in legal education, thereby reinforcing the potential of AI to transform teaching and learning experiences.

Nevertheless, the promise of these technologies is accompanied by several significant challenges. The

efficacy of AI systems is contingent upon the quality and accessibility of high-quality data sets — incorrect or incomplete data can impair system performance and erode public trust (Budach et al., 2022). Disparities in institutional resources and infrastructure further contribute to unequal access to advanced hardware, exacerbating existing educational inequities (Li, 2023). Moreover, the considerable energy consumption of contemporary AI models raises concerns about environmental sustainability (Gowda et al., 2023; Strubell et al., 2019), and the deployment of AI may result in a decline in human interaction, potentially affecting the overall quality of education (Duran, 2024).

Ethical implications, particularly those pertaining to data protection, are of paramount importance. Ensuring compliance with legal requirements for processing sensitive personal data is crucial (Drachsler & Greller, 2016; Bai et al., 2024), as data breaches can significantly erode public trust (Slade & Prinsloo, 2013). Furthermore, the potential for algorithmic bias to result in discriminatory practices and undermine equal opportunities has been highlighted by Baker and Hawn (2022) and Omughelli et al. (2024). Consequently, it is imperative that AI decision-making processes are transparent and explainable to counteract the "black box" issue and ensure equitable treatment for all students (Chaudhary, 2024; Chinta et al., 2024).

In order to respond to the research question of how AI systems, in particular LLMs, should be designed and implemented in academic and higher education contexts to enhance learning processes and guarantee technical efficacy while adhering to ethical standards such as data protection and fairness, three aspects for the optimal utilization of AI in higher education could be identified on the basis of current research. These are the three key areas for consideration: (1) the implementation of AI systems that are specific to the higher education institution (Modran et al., 2024), (2) the introduction of up-to-date guidelines that are subject to continuous revision (Leitgeb et al., 2024) and (3) the provision of high-quality professional development measures (Umanets et al., 2024; Brandão et al., 2024).

5.1 Regarding 1) Implementing AI Systems Developed In-house Offers Several Key Advantages

5.1.1 Control Over Data and Data Protection Compliance

It is of the utmost importance for organizations to have the ability to control their data and ensure compliance with relevant data protection regulations. The deployment of AI systems allows universities to maintain comprehensive control over their data, thereby facilitating compliance with pertinent data protection regulations, such as the GDPR (Drachsler & Greller, 2016). This fosters user confidence and permits the utilization of data for scientific purposes within the institution. Bai et al. (2024) highlight the crucial importance of adhering to legal requirements and implementing robust data protection measures in the context of emerging AI technologies.

5.1.2 Adaptation to Specific Needs

These AI systems can be adapted to align with the particular requirements of the institution, thereby enhancing the efficacy and acceptance of the technology. The customization facilitates more seamless integration into existing pedagogical and learning processes, while also accounting for the unique pedagogical and organizational objectives of the university (Umanets et al., 2024).

5.1.3 Bias — Systematic Distortions in the Decisions or Results of AI Systems

The utilization of AI systems developed in-house by universities ensures that interactions with the AI system are transparent and free from discriminatory bias (Holmes et al., 2019). The implementation of explainable AI (XAI) models facilitates the traceability of decisions and promotes fairness in the educational process (Chaudhary,

2024). Similarly, Omughelli et al. (2024) emphasize the necessity of identifying and minimizing bias in AI models to ensure the attainment of high-quality results.

5.1.4 Independence and Sustainability

The ownership of AI systems by universities serves to reduce the reliance on external providers, thereby facilitating the sustainable and autonomous development of AI infrastructure. This supports the institution's long-term self-determination and promotes adaptability to future technological developments (Li, 2023).

By implementing these measures, universities can fully exploit the technical potential of AI systems while complying with the necessary ethical standards. The implementation of university-owned AI systems is thus an effective strategy for combining technical efficiency with ethical responsibility and sustainably improving the educational process.

5.2 Regarding 2: The Development of Guidelines Should Ensure Transparency and Consistency and Maintain Academic Integrity

In addition to the development of institutional AI systems, the establishment of clear guidelines is of paramount importance for the successful and responsible use of AI in higher education (Castillo-Martínez et al., 2024). Guidelines provide a structured framework to ensure that the use of AI technologies is in accordance with ethical principles and legal requirements. They define guidelines for the handling of data, the utilization of AI tools in the classroom, and the evaluation of AI-generated work, thereby ensuring transparency and consistency in application (Leitgeb et al., 2024). These guidelines should be adapted cyclically in line with rapid developments in this field.

5.3 Regarding 3: Professional Development Measures Are Essential

It is imperative that educators receive professional development in the form of targeted training and continuing education program in order to equip them with the requisite knowledge and skills to utilize AI technologies in an effective manner. Such programs should not only encompass technical competencies but also address ethical concerns, data protection regulations, and pedagogical approaches for integrating AI into the classroom (Umanets et al., 2024; Brandão et al., 2024). Continuous professional development can equip educators with the knowledge and skills to utilize AI tools in a responsible and effective manner, thereby enhancing the quality of education while upholding ethical standards.

6. Summarizing

The present study examined the ways in which AI, and in particular LLMs, can be responsibly implemented in the field of education in order to exploit technical potential while adhering to ethical standards. Through a systematic literature review, current research results on the potential, challenges and requirements of AI systems in higher education were analyzed.

The extant literature indicates that the successful design and implementation of AI systems, particularly LLMs, in an academic context is contingent upon three main pillars: the development of AI systems that are tailored to the university context, the establishment of clear guidelines, and the implementation of high-quality professionalization measures. Firstly, the development of bespoke AI systems allows universities to retain complete control over their data and adapt the technologies to align with their specific institutional requirements,

thereby enhancing technical efficiency and ensuring compliance with ethical standards (Modran et al., 2024; Drachsler & Greller, 2016). Secondly, the regular updating of guidelines ensures transparency and consistency in the utilization of AI. Such measures ensure the maintenance of academic integrity and compliance with legal requirements (Leitgeb et al., 2024). Thirdly, comprehensive professional development is vital to equip educators with the requisite technical and ethical expertise to integrate AI tools into teaching in a responsible manner (Umanets et al., 2024; Brandão et al., 2024). By combining these three aspects in a targeted manner, universities can effectively leverage the potential of AI technologies to optimize learning processes while maintaining high ethical standards.

Although this study provides valuable insights into the responsible deployment of AI and LLMs in education, several limitations warrant consideration.

1) The study is based on a limited data set. The systematic literature review is based on a selection of available studies and publications published between 2015 and 2025. The restriction of the review period may result in the exclusion of pertinent, more recent developments.
2) The theoretical focus of the study is as follows: The study's theoretical and conceptual approach to the implementation of AI in education is of primary importance. However, there is comparatively less empirical evidence evaluating the real-world implementation of AI systems in educational settings. As a result, the recommendations may not be readily transferable to practical contexts.
3) The sources are heterogeneous. The studies included in the systematic literature review exhibit considerable heterogeneity in terms of their methodology and areas of application, which represents a significant limitation in terms of the comparability and generalizability of the conclusions drawn.
4) A notable deficiency is the dearth of long-term studies. The majority of the studies analyzed pertain to short-term outcomes or pilot projects for the introduction of AI in educational institutions. There is a paucity of long-term studies that examine the long-term effects of the implementation of AI on the education system and learners.
5) The lack of a cost-benefit analysis is a significant shortcoming. Although the study provides recommendations regarding the investment of resources in technical infrastructure and training, the financial implications, particularly for smaller or less financially robust educational institutions, are not sufficiently addressed. The economic feasibility and cost-benefit ratios are only touched upon in a cursory manner.
6) The ethical implications of the study are as follows: Although ethical issues such as algorithmic bias and data protection are addressed, the analysis of these topics remains at a general level. The study does not examine in great detail the concrete, practice-oriented solutions that are required, particularly with regard to compliance with complex legal requirements such as the GDPR. The limitations mentioned make it clear that further research, especially empirical studies and long-term investigations, are needed to gain a more comprehensive understanding of the impact of AI and LLMs in education and to develop more practical recommendations for action.

The study offers practical guidance for the responsible integration of AI technologies in education, with a particular emphasis on LLMs. The study demonstrates that universities can adopt targeted measures to both leverage the technical potential and adhere to ethical and privacy standards. Key recommendations include investing in technical infrastructure, fostering interdisciplinary collaboration, training faculty in technical and ethical skills, and establishing policies. These steps will facilitate the successful integration of AI systems into

education, enhancing the quality of education while maintaining high ethical and legal standards.

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KI@PPHB (2025a). Interaktion mit KI@PPHB zwischen 28.06-30.06.2024 (GPT4o). Input: [Kontrolliere nachfolgende Liste von Publikationen und identifiziere doppelte Studien (schrittweises Vorgehen – jeweils 100 Titeln)]. Output: [Identifikation doppelter Titel], available online at: https://ai.ph-burgenland.at.

KI@PPHB (2025b). Interaktion mit KI@PPHB zwischen 01.07-04.08.2024 (GPT4o). Input: [Fasse mir die Abstracts zusammen und füge mir den Titel hinzu. Maximal 2 Sätze. Wichtig sind die Stichprobe die Methodik und das Ziel der Studie]. Output: [Zusammenfassung der Abstracts mit Titeln], available online at: https://ai.ph-burgenland.at.

KI@PPHB. (2025c). Interaktion mit KI@PPHB zwischen 01.07-04.08.2024 (GPT4o). Input: [Untersuche nachfolgende Abstracts, Identifiziere Studien, Artikeln, Konferenzbeiträge, die sich KI-Anwendungen in der Bildung beschäftigen (Zahlreiche

Iterationen waren nötig)], Output: [Identifikation der Titeln], available online at: https://ai.ph-burgenland.at.

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