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AI Literacy and Adaptive Learning in Moroccan Education: Advancing Critical Thinking and Personalized Learning

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Abstract

This research examines how artificial intelligence (AI) can be effectively integrated into education. It focuses on the skills and strategies that students and educators need to be successful. The study takes a qualitative approach. It includes discussions with students and faculty at a Moroccan University of Interdisciplinary Studies and a review of the relevant literature. The findings show that AI has great potential to enhance learning and critical thinking. However, there is a clear need for structured training and strong institutional support to build AI literacy. The study suggests that educational institutions should take a comprehensive approach to integrating AI. This includes creating training programs, integrating AI into the curriculum, and encouraging collaboration on AI-related projects. These steps can help prepare students for a future in which AI plays an important role in their careers. This research adds to the ongoing conversation about AI in education. It also offers practical ideas for improving teaching and learning with technology.

Keywords: *Artificial Intelligence (AI); Adaptive Learning Systems; Critical Thinking; Machine Learning; Educational Technology; Personalized Learning*

Introduction

The integration of artificial intelligence in education is a serious turn towards establishing a new trend in teaching and learning. This study discusses the various implications of AI in the Moroccan educational context, emphasizing the importance of adaptive learning technologies, AI literacy, and the development of critical thinking skills. The integration of AI in Moroccan classrooms is not simply the introduction of technology into education, but a drastic change in the way traditional classrooms operate. In this regard, it addresses the diverse needs of all Moroccan students - especially special education needs - through personalized learning experiences. Therefore, the use of AI makes the learning process more effective in developing key skills that are closely related to machine learning and educational robotics, such as computational and critical thinking. In addition, AI has the potential to provide timely and effective support for students with special needs. This support can significantly improve their educational outcomes. As a result, it can improve their overall quality of life. (Pedro et al., 2019).

Globally, various institutions have already managed to integrate AI into their learning frameworks and thus have something to share with Moroccan educators. For example, the Georgia Institute of Technology has introduced an AI teaching assistant called Jill Watson, who responds to student queries in virtual classes, allowing human instructors to attend to more complex student needs (Goel & Polepeddi, 2016). This example illustrates how AI could improve educational efficiency, but not necessarily at the expense of student support, but rather in addition to it. Another good example is from the University of Melbourne, where AI algorithms analyze student data to predict academic performance. This approach allows educators to identify at-risk students well in advance, thus providing timely interventions aimed at improving student retention and overall success (Baker et al., 2019). Such applications allow one to imagine how AI will change the face of education through a more personalized and interactive learning environment. Not all of these fancy applications come without challenges in integrating AI into the Moroccan school system; their implementation should be relevant to the social and cultural specificities of Morocco. It is also important to focus the use of AI in education on

creativity and the development of adaptive learning technologies to achieve a shift from simple algorithmic thinking to true innovation and critical analysis. This transformation requires rethinking educational practices in an AI-driven world, moving from traditional teaching and learning models to more dynamic, interactive, and student-centered environments. (Dimitriadou & Lanitis, 2023).

This article presents a thorough examination of the transformative role of AI in contemporary education in general, and in the Moroccan context in particular. It identifies pressing needs for adaptive learning technologies, AI literacy, and critical thinking in order to assess their potential to shape Morocco's educational future. Although previous research has recognized the importance of AI in education and even presented preliminary frameworks (Zawacki-Richter et al., 2019), this discussion has identified specific gaps in the literature, particularly with respect to the pragmatic challenges that educators face when attempting to use AI tools.

The present study takes a qualitative approach to the ways in which AI is taking root in Moroccan university classrooms. It focuses on the human side of the technological change, as it is experienced, debated, and lived. The methodology unfolds along two dimensions: gathering raw insights and analyzing real-life examples.

1. Data Collection and Sampling Process:

It is based on in-depth, informal discussions with students and a faculty member at a Moroccan University of Interdisciplinary Studies. This study purports to represent diverse perspectives on the use of AI in education, given the wide range of opportunities and challenges associated with its integration.

Participants were purposively selected based on their interactions with AI technologies in educational settings. The sample was divided into one faculty member who implements the use of AI tool integration in the classroom and 15 undergraduate students enrolled in classes that are allowed to use such technologies. In total, 16 participants were involved in the study. This would provide an in-depth understanding of the perspectives of educators and students regarding the integration of AI in the classroom. Similar purposive sampling methods were used by Patton (2015) in qualitative research to ensure that participants could provide rich, relevant data.

*Recruitment Process***.** Participants were recruited through announcements at academic meetings and email invitations sent to students and faculty. The invitations emphasized the voluntary nature of participation and assured confidentiality to encourage open and honest dialogue.

*Data collection methods***:** Data was collected through a series of informal group discussions and focus groups, as well as individual interviews. In these informal group discussions, views were articulated within a comfort zone that relaxed communication and encouraged a more genuine idea-sharing process. Group discussions with focus groups were prepared so that subjects could elaborate on each other's insights and experiences. Individual interviews were helpful in delving deeper into the opinions of each subject. This multi-method approach is supported by Creswell (2014), who advocates the use of various qualitative methods to enrich data collection and analysis.

*Setting and Context***:** discussions took place in classroom settings, informal gatherings during breaks, and casual meetings with some faculty members. This range of settings enriched and nuanced the understanding of current attitudes, concerns, and uses of AI in educational settings.

2. Case Study Analysis:

Following data collection, a case study analysis was conducted to synthesize the findings from the interviews. This analysis aimed to identify key themes and patterns related to the integration of AI in education.

Data Analysis Process: Data collected from discussions and interviews were transcribed and analyzed using thematic analysis. This involved coding the data to identify recurring themes, concepts, and patterns related to AI integration. The analysis focused on several key areas, including

*Validation of findings:*Member checking was used to determine the credibility of the findings. Participants were invited to review and comment on preliminary findings, allowing for adjustments and refinements based on their input. It confirmed the validity of the interpretations to ensure that the conclusions accurately reflected the participants'

perspectives. Member checking is a common practice in qualitative research, as highlighted by Lincoln and Guba (1985), to increase the trustworthiness of the findings.

*Limitations***:** Due to the nature of the data, it only relates to the context of the Moroccan Interdisciplinary University. Therefore, it cannot be generalized to other university contexts. In addition, there may be bias as the discussions were informal and participants may have been influenced by social desirability or the presence of the researcher. Future studies will therefore need to take this a step further by increasing the sample size and using more structured approaches to increase the reliability of the findings.

3. The Advent of AI in Contemporary World Education

It is predicted that AI will mark a significant change in education worldwide. The world of education has slowly begun to take a different turn globally with the emergence of improved AI products, including ChatGPT, following their release by OpenAI in November 2022. Advanced artificial intelligence systems are now changing the way education is delivered and consumed today, in addition to opening up new avenues for personalization and adaptability in learning. With the ability to process and analyze large amounts of data, AI can deliver highly personalized learning experiences. This dramatic shift in pedagogical design from a more traditional approach to education enriches learning by addressing the individual needs, styles, and paces of each student. Students today are beginning to be provided with a much more interactive and effective educational environment, moving from passive receipt of information to active, customized learning.

AI's ability to process and analyze massive amounts of data enables it to deliver highly personalized educational experiences. This shift from traditional teaching methods to more personalized approaches enhances learning by addressing individual student needs, learning styles and paces. As a result, students are now experiencing a more engaging and effective educational environment, moving beyond passive reception of information to active, personalized learning. (El-Sabagh, 2021). Moreover, the description of these AI tools towards the different learning needs of students is very promising, as they have the ability to provide individualized resources that address a range of different learning difficulties, thus making education complete and inclusive. This capability becomes very important in breaking down barriers to traditional ways of learning and enabling a more equitable atmosphere in classrooms (Ayeni et al., 2024).

Despite all the benefits, the integration of AI in education has not been smooth. Some of the problems include a lack of necessary training for teachers, a lack of awareness about the limitations of AI, and an overreliance on technology. Technical glitches in AI-driven systems further complicate the learning process. Therefore, the successful integration of AI in education requires a balanced approach that takes advantage of its benefits while paying close attention to its limitations (Roshanaei et al., 2023).

4. Case Study: AI Integration at the Mohammed VI University

The Moroccan International Center for Artificial Intelligence embodies the future vision of the Mohammed VI University. Its goal is to position Morocco as a leader in AI and data sciences. The Center builds local expertise and fosters advances in education, industry, and policy. It addresses pressing social, environmental, and economic challenges while preparing for the future. The center's executive president highlights its focus on ethical and accessible AI. The Center is applying this technology to areas such as education, health, and agriculture. AI becomes more than a tool here - it lays the foundation for innovation and growth. AI tools such as ChatGPT and Gemini have been used to improve personalization within this institution and increase support for its increasingly diverse learners. This is part of a much larger initiative to modernize pedagogical practice to meet the challenging demands of higher education in Morocco. With AI, the university envisions creating a much more dynamic, student-centered learning environment that accommodates all of these different styles and individual learning needs. Despite the promise of integration, some issues have challenged it. At the faculty level, there has been a need for extensive training in new AI tools and an understanding of their limitations. On the student side, there is concern that over-reliance on AI will interfere with the development of critical thinking and problem-solving skills. Students at Mohammed VI University have devised a holistic approach to address these challenges. It includes extensive professional development for educators, clear guidelines for responsible use, and increased efforts to raise awareness about the limitations of AI technologies. In this line of reasoning, the study aims to highlight areas that will help the institution to effectively integrate AI into educational practices, thus providing valuable insights with practical recommendations for similar institutions in the Moroccan context. Table 1 presents a

comprehensive overview of the strategies for navigating the integration of artificial intelligence in the institute, highlighting both the limitations and facilitators of the use of AI in academic settings.

Table 1. Navigating AI Integration in Moroccan Educational Institutions

Approach	Limiting AI Use in Academic Work	Facilitating AI Integration in Education
Primary Consideration	In response to AI tools like ChatGPT, some Moroccan institutions have imposed strict limits on their use in academic assignments.	With the rise of AI tools, Moroccan institutions are exploring ways to incorporate them into academic work with minimal restrictions.
Rationale for Limitation	- Insufficient training on effective AI use among students. - Risk of students relying excessively on AI, undermining their independent thinking. - Difficulty in distinguishing between student-generated and AI-generated work. - Technical issues such as AI generating inaccurate or misleading information.	- Educators' role includes guiding students on effective use of emerging technologies. - Allowing unrestricted use enhances students' adaptability to AI's benefits and challenges. - AI will permeate academic and professional environments, making its understanding crucial. - Exposure to AI fosters responsible use and prepares students for its ubiquitous presence.
Challenges of Restricting AI	- Enforcing restrictions is challenging due to high demand and potential for covert use. - Lack of practical experience with AI limits students' understanding of its responsible application.	- Students may offload cognitive tasks to AI, diminishing their learning. - Assessing genuine student effort versus AI contributions poses challenges. - Ensuring students' work is free from AI-generated inaccuracies requires additional measures.
Unique Considerations for Morocco	- Morocco 's diverse educational landscape presents varied challenges in enforcing AI restrictions. - Local cultural and educational norms influence students' and educators' interactions with AI.	- Integrating AI aligns with Morocco 's educational reforms and technological advancements. - Tailored training programs and guidelines address specific needs and ensure effective AI use.

4.1 The Pursuit of a Balanced Approach in Moroccan Education

At the University of Morocco, the emergence of AI tools such as ChatGPT and Gemini has been very interesting for students. Most students have tried to use these technologies within the last year to make their academic tasks more manageable. Most students value the support that AI offers them in managing their workload and developing better studies. Students also appreciate a fine balance in the framework so that they can use AI effectively and safely under the following four conditions:

1. Fair Use of AI: Ensuring equal opportunity to all learners to use AI tools and that no student attains an unfair academic advantage.

2. Clear Guidelines: Setting out clearly how AI tools could be used to avoid misunderstandings about what practices are permissible.

3. Understanding AI Capabilities and Limitations: This may earlier set the knowledge deficit with respect to the potential of AI and the associated limitations to deter its misuse.

4. AI Hallucinations Awareness: The student is to be made aware that AIs are prone to make convincingly incorrect information.5. Readiness for AI Challenges: Students to be able to critically judge and handle effectively the outputs from AI.

On this consideration, the Moroccan University has gone ahead to consider a nuanced approach with the "AI Integration Guidelines"—in A Arabic: "إرشادات تكامل الذكاء الاصطناعي." This forms the framework that will be used to guide students in using AI in a responsible way while still upholding the integrity of their academics. Key aspects of the guidelines include

- Use of AI for Inspiration: Students are encouraged to use AI to generate ideas or explore different viewpoints but should not rely on it for completing entire sections of their work. For example, students might use the AI

tool "MosaicAI" to generate initial concepts for a study on Moroccan architecture, but they must develop their own analysis and insights.

- Documentation of AI Use: Students must document their AI usage comprehensively, including:
- Identifying the AI Tool Used: Example: "Utilized 'MosaicAI' for generating conceptual frameworks for a study on Moroccan traditional crafts."
- Explaining the AI's Role: Example: "Used 'MosaicAI' to brainstorm potential research questions related to Moroccan cultural heritage."
- Evaluating AI Responses: Example: "Cross-verified AI-generated suggestions on Moroccan art with scholarly articles from the Moroccan Journal of Arts."
- Citing AI Contributions: Example: "Incorporated AI-generated ideas in Section 2 'Artistic Influences in Moroccan Culture' (pp. 30–45)."

The guidelines emphasize transparency and critical engagement with AI results. By clearly documenting AI use, students are reminded to critically evaluate AI suggestions and ensure that their work remains original and reflects their own understanding. Table 2 outlines the protocols for AI use in academic assignments, detailing the key components and guidelines for ensuring responsible and effective use of AI tools in student work.

Table 2: Protocols for AI Utilization in Academic Assignments at the Moroccan Higher Education Institute

Component	Details
1. Objective and Vision	Defines the vision for integrating AI into academic work, aiming to balance technological advancement with educational values and student autonomy.
2. AI Usage Framework	
2.1 Responsible AI Practice	AI should be employed with a focus on ethical use and clear documentation. All AI contributions must be explicitly disclosed and aligned with academic integrity.
2.2 Permissible AI Instruments	All AI technologies for content creation are allowed, provided their application is transparently documented and relevant to the academic work.
2.3 Text Creation Standards	Direct use of AI-generated text is prohibited. AI tools should support but not replace personal academic effort and intellectual engagement.
2.4 Visual and Audio Integration	AI-generated visuals and audio are accepted with proper citation and detailed descriptions of their role and creation in academic projects.
2.5 Comprehensive Recording	Requires detailed documentation of AI tool usage in an appendix, including the type of AI used, its application, critical analysis, and specific manuscript sections.
3 Prohibitions	Emphasizes that verbatim use of AI-generated content or external sources without appropriate modification or citation is prohibited and considered academic dishonesty.
4. Special Considerations	Outlines conditions under which deviations from these guidelines may be permitted, depending on unique project needs or faculty approval.
5. Implementation Timeline	Details the commencement date for these guidelines, starting from September 1, 2024, aligning with the institute's academic policies and procedures.

4.2 Challenges with Implementing AI Guidelines

The main policy adopted by this institution to support the management of AI-generated content in academic assignments was the introduction of a set of guidelines for the use of AI. While these guidelines were an important step toward regulating the use of AI, there were a number of problems associated with their actual application. First and foremost, and inevitably, a major problem is that the policy relies on student compliance, which cannot always be guaranteed. Since these documents are to be read voluntarily, there is always the possibility that some students will ignore them, which in

turn would lead to inconsistent understanding and compliance. It also lacks a comprehensive course/training for students on AI capabilities. Guidelines will not serve the purpose of creating an in-depth understanding of AI technology. Without proper training, students may misuse these AI tools. In some cases, they may not know how to use such technology correctly in their assignments. Monitoring the extent to which AI is used in operations is also challenging. The use of AI tools is not easily controlled due to the advanced nature of their functionality; therefore, compliance with rules and regulations at the level of preventing unfair advantage is problematic. One of the biggest challenges facing this particular technology is the disparity in students' knowledge of how to use it responsibly. Many students may be unaware of the full extent of AI's limitations; thus, there is a likelihood that they will rely on AI-generated content without critical analysis. This laxity compromises both the quality and integrity of any academic work and deprives students of the opportunity to develop their critical thinking skills.

4.3 Addressing the Challenges: Towards a Holistic Approach

A more holistic approach to AI integration would therefore be a prerequisite for shedding light on such challenges and providing effective solutions. Establishing an institutional "AI culture" will create the right platform where AI is not regulated, but embraced and critically evaluated. This can be achieved through a number of strategies:

1. Comprehensive Training Programs: Organize workshops and periodic training sessions for the students and faculty members to give them understanding regarding AI technology. These programs must contain information on the up-to-date technological development of AI, associated ethics, and practical applications in hands-on life. This way, the academic community will always be updated on and proficient in the management of tools and concepts associated with AI through the engagement in AI topics.

2. Integrate AI Across the School Curriculum: Integrate AI-related topics into a number of academic modules to provide students with continuous exposure to AI across different disciplines. This will enable students to realize the importance of AI in various fields and prepare them for the future in which AI becomes a component of professional settings.

3. Compulsory AI Education: Introduce compulsory courses on AI, which shall focus on at least the basics and advanced applications of AI and the ethics associated with these. Every student shall have baseline knowledge in AI, whatever their majoring may be, and each shall be familiar with the guidelines pertaining to AI by the institution.

4. Joint Initiatives: Last but not least, foster AI collaborations with field experts, tech companies, and other educational institutions to bridge the disconnection between theory comprehension and practical application. Such partnerships will provide meaningful resources and engagement that can enrich students' understanding of AI's real-world implications.

5. AI Student-Led Projects: Focus on AI student clubs/projects with hands-on activities that allow students to further their learning. Such activities will act as a drive toward innovation and practical application, enhancing the development of critical thinking and problem-solving within AI.

By putting these suggestions in place, this institution might go beyond mere regulation and provide an enabling environment that actively participates, understands, and critically evaluates the use of AI in general. Such a strategy, therefore, is likely to enhance compliance with the guidelines and promote a responsible culture of using AI at the academic level.

4.4 AI's Role in Classroom Innovation

Artificial intelligence has significant potential beyond academic writing, offering opportunities to transform the classroom experience. Although widespread adoption is still in its early stages, some educators have begun to integrate AI into their teaching methods, exploring innovative ways to use this technology in their lectures and coursework. Figure 1 illustrates innovative applications of AI in Moroccan classrooms, showing different implementation scenarios and the lessons learned from their evaluation to improve the educational experience, along with the challenges shown in Figure 2.

Figure 1: Benefits of AI Applications in Moroccan Education and Culture

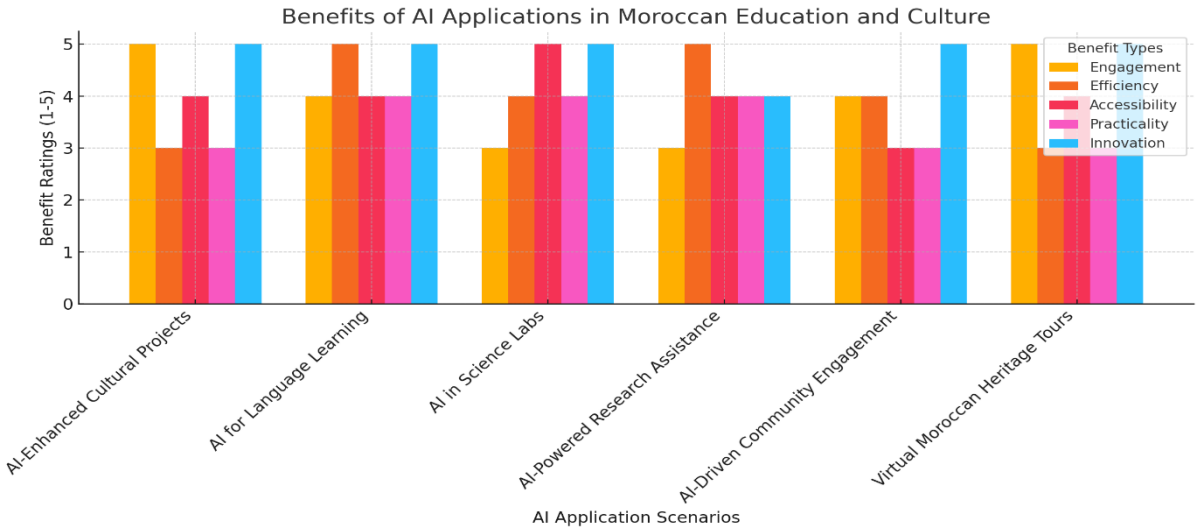
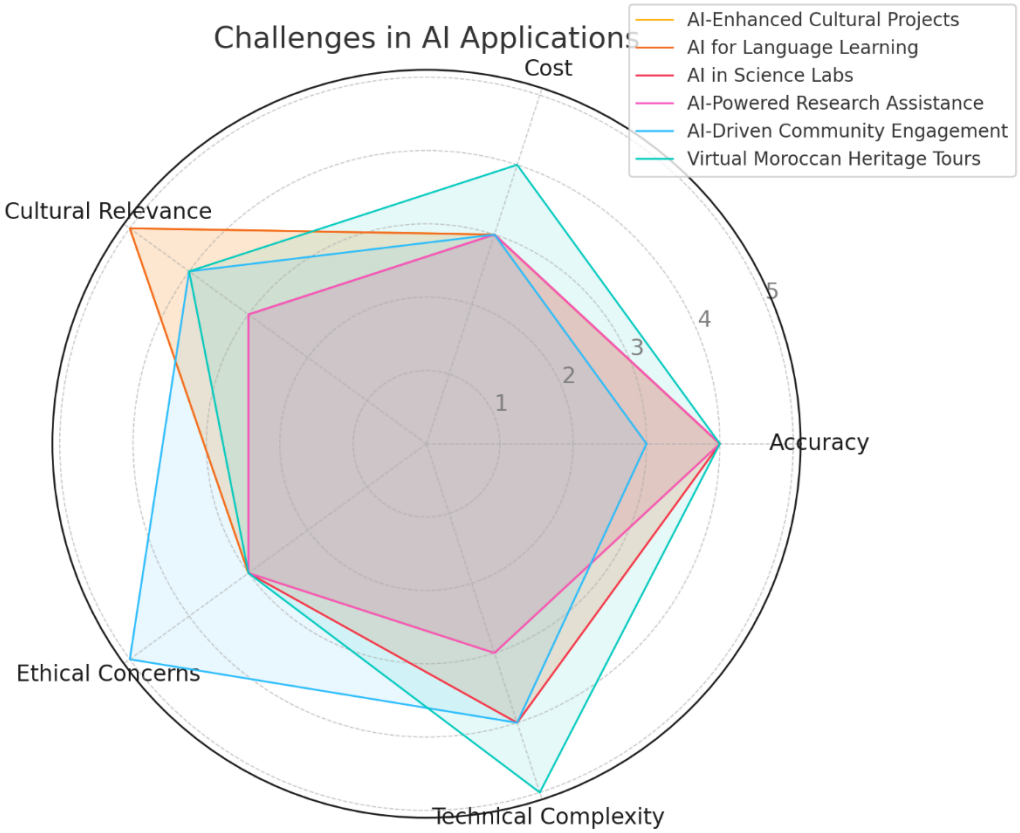


Figure 2: Challenges in AI Applications



5. Challenges and Recommendations for Enhancing AI Integration in the Classroom

5.1 Overview of Challenges

Discussions with teachers reveal that perhaps one of the biggest barriers to implementing AI tools in the classroom is a common fear of misusing these technologies. The root of this fear is largely unfamiliarity with AI tools and a fear of making mistakes. In many cases, students were also unfamiliar with how to use AI, which compounded the problem when the instructors themselves were not equipped. Although the importance of human-computer interaction is well recognized and appreciated in academic circles, it remains poorly implemented in the institution, where there are no workshops or training programs to address these issues. The increasingly rapid development of digital and AI technologies exacerbates the problem, leaving educators and students struggling to keep up. In addition, there is no one person or group formally responsible for the integration of artificial intelligence, so the current approach to AI adoption remains piecemeal, with multiple staff members struggling to complete related tasks in their spare time without financial support.

5.2 Proposed Solutions

1. Tailored Training Sessions

The institution could offer specialized training sessions designed to familiarize teachers with AI technologies and their applications in the classroom. These workshops would focus on practical uses of AI, addressing common concerns and providing hands-on experience.

2. Continuous Information Flow

Establish regular updated channels through newsletters, casual meetings, or virtual events. These updates should bring staff up-to-date on the latest AI tools, applications, and best practices to keep them engaged and confident in using AI.

3. Amount Allocated to Training AI

Introduce a specific budget to support AI professional development. Much like literacy or numeracy skills, being credentialed in AI should be seen as a core outlay and not assume the burden of staff expenses. This would give educators an opportunity to participate in formal education opportunities regarding AI and its integration.

4. Complete Guidelines and Resources

Develop and distribute a set of good practice guidelines for using AI within academic settings. This will include practical advice, examples of successful AI integrations, and strategies for surmounting common challenges.

5. Establishment of Expert Roles

Establish formal AI integration and support positions. These positions would drive the culture of AI within the institution, provide expert guidance on its application, and ensure effective use of the tools. This recommendation addresses the need for a structured, well-supported AI strategy. While this set of recommendations is a good starting point, more research is needed to further develop and refine our understanding of how AI literacy can be developed in educational settings. Research should focus on how prompt engineering can make pedagogical practices more efficient and how AI can be used to enhance students' critical thinking skills. A literature review and case studies of some kind will need to be detailed in order to develop viable, broadly applicable strategies for integrating AI into the classroom.

5.3 AI Literacy: A Modern Educational Imperative

AI literacy has become the focus of modern education, representing a significant paradigm shift in students' relationship with technology. The concept is more than just technical skills; it refers to a deep knowledge of the ethical, social, and economic implications of AI. In this regard, 21st century learners need AI literacy as much as they need reading and math skills in today's classrooms, because it will eventually help them maneuver and use AI in life and work (Zhang et al., 2023).

5.4 Current Landscape and Challenges

AI literacy has yet to find a place in the school curriculum. While educators and policymakers are increasingly aware of the need for AI education at scale, implementation is still in its infancy. (Bhimdiwala et al., 2022). Schools are grappling with how to educate about this dynamic field. Challenges range from the breadth of technical knowledge to making explicit an understanding of AI's impact on society. Initial assessments to measure AI literacy are being developed to gauge students' understanding of the topic. (Kong et al., 2023).

5.5 Core Components of AI Literacy

To effectively teach AI literacy, several key areas need to be addressed:

1. Concepts of fundamental AI

Overview of AI: Introduce to students the very basic concepts of AI with related definitions, history, and evolution. This would include an understanding of the various types of AI, including Narrow AI, General AI, and Superintelligent AI.

2. Machine Learning and Technical Insights

Machine Learning Essentials: This would explain the principles of Machine Learning in relation to various types, such as Supervised, Unsupervised, and Reinforcement Learning, along with the basic algorithms. A small primer on AI programming would further help in building technical understanding.

3. Data Management

Importance of Data: This could be in terms of how the data are used within AI systems, particularly setting the need for protection of data privacy from potential misuse.

4. Applications in Practice

AI at Work: The multifarious applications of artificial intelligence in healthcare, finance, education, and entertainment underscore benefits along with the challenges.

5. Human-AI Collaboration

Human-AI interaction: How AI systems and humans can communicate effectively with one another and how to accomplish this in order to achieve some task; related ideas include human-in-the-loop and AI augmentation.

6. Creativity and Innovation

AI and Creativity: How AI can aid creative processes, such as in art, music, and writing, and the implications brought out by the content generated through AI.

7. Critical Thinking and Analysis

critically assess AI: Acquiring the ability to critically understand news, research, and claims about AI, able to separate what is actual capability from hype.

8. Ethical and Societal Implications

AI Ethics: Good understanding of ethical concerns within AI: bias, privacy, societal impact. Feeling of responsibility while using or developing AI itself is highly needed.

5.6 Key Challenges in AI Literacy

Several challenges that students and educators should be aware of associated with AI are:

- AI Overconfidence: confidence that AI systems bestow on information may mislead.

- Explainability Issues: Most AI models are "black box" in nature and obscure their decision-making process.
- Ethical Concerns: AI deployment definitely gives way to ethical concerns like biases and unintended societal implications.
- Data Dependency: AI effectiveness heavily relies on the quality and representation of the training data.
- Scalability Issues: AI solutions are often tough to scale both technically and operationally.

5.7 Implementing AI Literacy Programs

To foster comprehensive AI literacy, educational programs should include the following components (Casal-Otero et al., 2023; Laupichler et al., 2022; Zhang et al., 2023).

1. Basic AI knowledge: With the basics, it lays the foundation for definitions and types of AI in a historical context.

2. Machine Learning Insights*:* This course introduces types and algorithms of machine learning with optional basics of programming.

3. Data Handling Skills: Knowledge of the role of data in AI and privacy and security measures for the same.

4. Applications of AI in real-life: Case studies in different sectors, focusing on how it works in practice.

5. Human-AI interaction*:* The concept of human-AI collaboration.

6. Artificial Intelligence and Creativity: Role of AI in the creative domains, Implications of AI Content Creation.

7. Critical Evaluation*:* This involves the ability to critically review and evaluate information about AI.

8. Ethical Considerations*:* The tenets for responsible use of Artificial Intelligence, including bias and societal impact.

9. Future Trends*:* Description of the future trend of research and development of AI technology.

10. Hands-On Experience: Use AI concepts through practical exercises and projects on real-world problems.

11. Ethical AI Design*:* Design AI that inherits in it ethical considerations and societal impacts.

12. Inclusive Education: This would imply access to AI literacy for students coming from diverse backgrounds.

13. Adaptive Learning Technologies: How AI-driven systems can be used and harnessed in the creation of learning experiences for students, based on diverse individual needs and performance.

As artificial intelligence pervades many aspects of life, it becomes very important to develop AI literacy among students. This knowledge will not only improve their academics but will also set the pedestal for future careers in a technology-driven world. Current efforts are underway to place AI literacy as part of school curricula so that students can engage in responsible and effective ways with AI (Ng et al., 2023).

6. Adaptive Learning Technologies as Pedagogical Tools with AI Integration

Adaptive learning technologies are highly influential pedagogical tools that provide learners with personalized learning experiences. In essence, these technologies dynamically adjust the presentation of educational content based on the learner's performance, preferences, and pace. Most adaptive learning systems use algorithms and artificial intelligence to examine data about students and produce relevant resources that maximize learning efficiency and engagement.

6.1 Types of Adaptive Learning Systems

Adaptive learning technologies can be broadly categorized into three main types: (i) content-based adaptation, (ii) learner-driven adaptation, and (iii) data-driven adaptation.

(i) ***Content-Based Adaptation***: Basically, this approach relies on the selection of instructional content based on a set of predetermined rule- or model-based decisions. It selects and displays instructional material at a level appropriate to the learner's current understanding. For example, if a student is struggling with one of the concepts, it can provide more examples, explanations, or alternative instructional methods for further review to complete the understanding. Content-based methods work very well in areas where there is a clear hierarchical structure of knowledge, such as mathematics or language learning. The ALEKS system, for example, presents an extremely fine-grained mapping of mathematical concepts against which students are guided through individual learning paths (Doignon & Falmagne, 1999).

(ii) Learner-Driven Adaptation: In this model, there is increased learner control over what is learned. The system provides a variety of choices while the student selects the resources or activities that best suit his or her learning style or interests. This approach leverages students' self-awareness and allows for active participation in the learning process, especially in situations where motivation and engagement are key, such as creative or exploratory learning environments. One example is Smart Sparrow, an interactive e-learning platform that allows learners to explore different pathways and receive customized feedback based on their choices. (Kaw et al., 2019)..

(iii) Data-Driven Adaptation: This form of adaptation relies heavily on data analytics and AI algorithms to make real-time adjustments to the learning process. Such systems continuously collect data on student interaction, performance, and behavior to make predictions about future needs so that a situation can be optimized for learning purposes as needed. Data-driven systems are highly dynamic, allowing for deep personalization of the learning process, often leading to better retention and comprehension. Knewton Alta is a paradigm of data-driven adaptive learning. It uses vast amounts of data to personalize content delivery for each student. (Jones & Bomash, 2018). Table 3 summarizes the various applications of AI to enhance cultural projects, highlighting the implementation strategies and educational benefits derived from these initiatives.

Table 3: Overview of Adaptive Learning Technologies: Types, Applications, and Key References

Acronym	Description	Application Example Task	Key reference
ALEKS	Assessment and Learning in Knowledge Spaces: A content-based adaptive learning system that uses a detailed map of concepts to determine a student's knowledge gaps.	Provides personalized learning paths in mathematics by identifying what the student knows and doesn't know.	(Doignon & Falmagne, 1999).
Knewton Alta	A data-driven adaptive learning platform that uses AI algorithms to analyze student data and personalize content delivery.	Adapts the sequence of learning materials based on real-time analysis of student performance, predicting the next best learning activity.	(Jones & Bomash, 2018)
Smart Sparrow	A learner-driven adaptive learning platform that allows educators to create adaptive lessons where students can choose their learning paths.	Enables students to navigate through customized biology lessons based on their preferences, receiving tailored feedback based on their choices.	(Kaw et al., 2019)

6.2 Challenges for Students Using Adaptive Learning Technologies

Adaptive learning technologies have many benefits; they can effectively help tailor educational content to the needs of individual students. On the other hand, these technologies pose several challenges that a student may face when using them. What follows is a critical analysis of these challenges, supported by practical examples from personal life, and strategies for overcoming them.

1. Content-Based Adaptation Challenges

Example Technology: ALEKS (Assessment and Learning in Knowledge Spaces)

Challenge: Over-reliance on system guidance: It is often the case that content-based adaptation systems, especially ALEKS, take a very structured and rule-based approach to tailoring educational content. While this methodology seems to enforce learning at an absolute level, it may actually lead to an over-reliance on system guidance. In other words, students become more passive about their learning processes and wait passively for the system to chart their learning paths, thus reducing critical thinking and solution finding skills.

Personal example: Consider a student named Nora who uses ALEKS to engage in meaningful algebra practice. The system repeatedly presents her with problems at her skill level, providing hints and explanations for those that are too difficult. After some time, Nora begins to realize that she has become incredibly dependent on these hints. When faced with similar problems outside of ALEKS, she can't seem to apply the concepts independently.

Overcoming the challenge: She can set a goal to solve a certain number of problems without hints. Teachers can also encourage reflection on the strategies used within the system and application to new, unsupported scenarios. This can be done by embedding traditional problem-solving activities outside of the system to help build confidence in one's ability to learn independently.

2. Learner-Driven Adaptation Challenges

Example Technology**:** Smart Sparrow

Challenge: Overwhelm from Excessive Choices: Learner-driven adaptive systems, like Smart Sparrow, put students at the helm of their choices. This freedom sometimes feels overwhelming to the students, more so to those who are less aware of their learning preferences or capability for self-discipline. This may result in decision fatigue, whereby a learner has reduced ability in making decisions because there are too many options; this would mean making suboptimal choices that eventually negatively impact student progress.

Personal Example: Karem is a second-year university student working through a number of topics in a biology course using Smart Sparrow. The system is providing multiple pathways with various resources and activities. On the first day, though excited by the choices he has, he becomes overwhelmed and flips from one path to the other, never mastering any particular topic.

Overcoming the Challenge: To overcome this obstacle, Karem can start by making explicit learning goals with the help of his teacher. He would be in a position to reduce choices and remove material that is not pertinent after specifying exactly what he expects to achieve from every session. Tutors, with their experience, may also be able to provide recommendations regarding how to navigate the system effectively; this could include using at least some predefined routes initially and perhaps only providing free choices as the student gains confidence.

3. Data-Driven Adaptation Challenges

Example Technology: Knewton

Challenge: Privacy Concerns and Data Anxiety: For example, data-driven adaptation systems, like Knewton, require constant gathering of student data to personalize learning. This approach could be very effective in improving learning outcomes, but it gives very dismal privacy concerns and can result in data anxiety. Students may feel a bit uncomfortable regarding the amount of data collected and analyzed; hence, they may not have trust in the system or will not engage full throttle with the technology.

Personal Example: Salma is a junior student at the university using Knewton in her calculus class. The more she used it, the more she appreciated the individualized content and recommendations but became increasingly concerned about the amount of data that this system was recording on her learning behavior. She worries about how this data might be used beyond her course, causing her to limit her interactions with the system, which in turn reduces its effectiveness.

*Overcoming the Challenge***:** To address privacy concerns, Salma can first study the platform's policy on privacy to observe how her data is being used and what protections are in place. Educators and institutions must also adopt transparent ways of communicating how they use students' data and ensure control where possible at the student level. Building confidence within the system by teaching about data security may help students be more comfortable and willing to really engage fully.

Therefore, adaptive learning technologies offer great tools for personalized education but also present challenges that may alter the learning experiences of students. Among these are situational problems of over-reliance on guidance from the system, overwhelm from too many choices raised, or concerns about privacy. Recognizing and resolving the potential issues with these learning tools, while setting clear goals, providing structured guidance, and ensuring transparency in data use, will help students and make these tools more usable for educators.

6.3 AI as a Catalyst for Advancing Critical Thinking in the Classroom.

Effectively fostering critical thinking that takes full advantage of AI requires the strategic integration of AI technologies into educational practices. The effective use of AI-powered tools, such as adaptive learning platforms, can present students with intricate and personalized challenges to truly engage them in deep analysis and critique of information. The instrumental use of AI in scenario design that allows students to apply reasoning, debate perspectives, and solve complex problems can foster more robust analytical dispositions. AI can facilitate the creation of interactive simulations and dynamic problem sets that engage students in critical thinking and reflective learning. According to Ruiz-Rojas et al. (2024)As these AI tools are rapidly evolving, they offer new opportunities for students to practice and develop their critical thinking skills, enabling them to face and succeed in a world that is changing at an unprecedented rate. Table 4: Integrating AI to Enhance Critical Thinking - Challenges and Practical Suggestions Table 5 outlines the key challenges in integrating AI, along with practical suggestions for addressing these challenges.

Table 4: Practical Suggestions for AI Integration to Foster Critical Thinking

Challenge	Description	Practical Suggestion	Refernce
Personalized Challenges	A student using an adaptive learning platform like ALEKS may be presented with increasingly difficult math problems. If the system misjudges their ability level, the student might feel overwhelmed, leading to frustration and disengagement	Ensure AI systems are designed to accurately assess student abilities and adjust difficulty levels accordingly	(Chen et al., 2020)
Interactive Simulations	In a history session, students using AI-driven simulations to reenact historical events may excel in the simulated environment but struggle to apply these critical thinking skills in traditional exams or real-world discussions.	Combine AI simulations with real-world problem-solving activities to reinforce learning outcomes	(Dai & Ke, 2022)
Dynamic Problem Sets	In a science class, an AI tool might generate problem sets that evolve as a student progresses. However, if these problems don't align well with the curriculum, the student may become confused about key concepts, leading to gaps in understanding.	Regularly review and adjust AI-generated problem sets to ensure they align with educational goals	(Alasadi & Baiz, 2023)
Balanced Integration	A school implementing AI tools across subjects may notice that teachers rely heavily on AI for instruction, potentially reducing the emphasis on traditional, discussion-based critical thinking exercises.	Use AI to complement, not replace, traditional instruction, allowing educators to focus on facilitating critical thinking	(Alam, 2021)
Educator Involvement	Teachers might be unsure how to interpret data provided by AI systems, leading to missed opportunities for targeted interventions that could help struggling students.	Train teachers to use AI-generated data for targeted interventions and support	(Ghimire et al., 2024)
Ethical Considerations	A school uses an AI platform that collects extensive data on student behavior and performance. If this data is not handled carefully, there could be breaches of student privacy, or biases in AI algorithms could unfairly disadvantage certain students.	Educators should be aware of ethical issues and ensure AI tools are used fairly and transparently	(Nguyen et al., 2023)

The integration of AI technologies into educational practices has the potential to revolutionize the way critical thinking is cultivated in the classroom. However, this transformation is not without its challenges, which require careful consideration and strategic response.

6.4 Misalignment Between AI Assessments and Student Needs

One of the major challenges is that AI-driven assessments may not be truly aligned with real-world needs. While ALEKS and similar technologies are very powerful in personalizing the learning experience for students, they can sometimes make incorrect approximations about a student's ability level. For example, if a second grader is struggling with certain concepts, the material may be far too easy, which can be frustrating and lead to a complete disengagement from learning. This problem stems from a reliance on algorithms that may not fully capture the nuances of a student's learning trajectory. Some scholars, such as Zhang et al. (2020), postulate that to address this challenge, AI systems should be designed with mechanisms for continuous feedback and recalibration. In simple terms, analysis will depend not only on a student's current performance, but also on long-term learning patterns and behaviors. More advanced data analytics would enable an AI platform to provide more accurate and adaptive learning paths so that students receive the right level of challenge and support.

6.5 Transferability of Skills Developed in AI-Driven Environments

Another challenge is the extent to which skills developed in AI-driven environments transfer to traditional academic environments. Although AI tools-such as interactive simulations-are much more likely to engage students in critical thinking tasks, some of these same skills may not transfer as easily to non-digital contexts. For example, a first-year student who performs well in an AI-driven problem-solving simulation may struggle to apply such critical thinking skills in a traditional exam or classroom debate. Zezheng (2021) argues that this challenge can be mitigated by integrating AI tools with traditional pedagogical approaches. They present a blended learning model in which AI-driven exercises are complemented by in-class discussions and written assignments. The model provides opportunities for students to practice critical thinking skills in a variety of formats and contexts, strengthening the robustness of cognitive development.

7. Ethical Considerations and Data Privacy

Another critical challenge is the ethical dimension of AI in education, considering privacy and potential bias. AI systems require extensive collection and analysis of student data in order to individualize learning experiences. This raises questions about how this data is used and who has access to it, with the potential for algorithmic bias against some categories of students. Akgun and Greenhow (2019) called for robust ethical frameworks around the use of AI in educational contexts. They called for transparent AI systems, where educators and students know how data is being used and have the ability to question or challenge decisions made by AI. They also encouraged the development of privacy and non-discrimination policies, such as anonymizing student data and regularly auditing AI systems for fairness.

7.1 Practical Suggestions from Scholars

To navigate these challenges, several scholars have offered practical suggestions:

1. **Hybrid Learning Models**: Almusaed et al. (2023) recommend that there should be a hybrid learning model combining these AI-driven learning tools with traditional teaching methods. That way, the benefits of AI will balance against the tested power of face-to-face instruction in enhancing the all-round learning experience.
2. **Ongoing Educator Training**: Abulibdeh et. al (2024) emphasize the fact that teachers have to undergo continuous professional development. With the potential and competence to deploy AI in their classrooms, educators will be better placed to freely pass through complexities or difficulties related to these technologies.
3. **Ethical Guidelines and Frameworks**: Schiff (2022) postulates clear ethical guidelines and regulatory frameworks on the use of AI in education. On these grounds, this can be very instrumental in protecting student data, guaranteeing fairness in AI-driven decisions, and engendering trust among both educators and students themselves in such technologies.

By addressing these challenges through considered implementation and reflections tallied together, AI can indeed serve as a trigger for the progression of critical thinking in education. However, doing so does require serious cooperation from all—stakeholders, educators, researchers, and policymakers—to ensure such technologies are used both equitably and effectively toward the betterment of broader goals for education.

Conclusion

The integration of artificial intelligence into educational settings presents a multidimensional landscape of challenges and opportunities. On the one hand, as AI technologies continue their promising development track record, they provide fertile

ground for new learning experiences that will be fueled by individualized instruction, engaging feedback, and interactive learning tools. On the other hand, these developments also bring challenges, such as addressing privacy concerns, equity of access, and developing AI literacy among educators and students. A response to such challenges would therefore need to be strategic in nature, seeking a balance between innovation and caution. It is suggested that the ethical use of AI by educational institutions should be at the forefront of their agendas at this time, perhaps already ensuring privacy and security. It should therefore be one of the priority goals of professional development activities to focus on the development of AI literacy and, in particular, the integration of AI tools into teaching practice. Equitable access to these AI resources must be ensured to avoid a digital divide. Opportunities range from individualized learning experiences at the most basic level to AI-powered tools that can assist with administrative tasks and empower researchers. By using these technologies safely, educators can create more engaging and effective learning environments and prepare students for a future increasingly shaped by AI. In other words, while AI offers radical prospects for education, it is crucial to adopt a well-thought-out strategy in its implementation. Academic institutions can therefore take advantage of the various benefits of AI and modulate a more vibrant, inclusive, and effective learning experience for all learners if they face the challenges head-on.

Finally, I would like to add some Suggestions for Future Investigations: the growing role of AI in education points to key areas for future research. Long-term studies could track its impact on how students learn and stay engaged. Comparing schools that use AI with those that don't could reveal what works best and why. To use AI responsibly, we need to address its ethical challenges, such as data privacy and bias in algorithms. Teaching AI literacy to students and educators could help them understand and use these tools wisely. This will require cross-disciplinary research that shows how AI is shaping different fields of study. Listening to students through qualitative studies will reveal how they see this shift. Together, these efforts could reveal the true power of AI in education and how to use it well.

References

Abulibdeh, A., Zaidan, E., & Abulibdeh, R. (2024). Navigating the confluence of artificial intelligence and education for sustainable development in the era of industry 4.0: Challenges, opportunities, and ethical dimensions. Journal of Cleaner Production, 437, 140527. https://doi.org/10.1016/J.JCLEPRO.2023.140527

Akgun, S., & Greenhow, C. (2021). Artificial intelligence in education: Addressing ethical challenges in K-12 settings. AI and Ethics 2021 2:3, 2(3), 431–440. https://doi.org/10.1007/S43681-021-00096-7

Alam, A. (2021). Should Robots Replace Teachers? Mobilisation of AI and Learning Analytics in Education. 2021 7th IEEE International Conference on Advances in Computing, Communication and Control, ICAC3 2021. https://doi.org/10.1109/ICAC353642.2021.9697300

Alasadi, E. A., & Baiz, C. R. (2023). Generative AI in Education and Research: Opportunities, Concerns, and Solutions. Journal of Chemical Education, 100(8), 2965–2971. https://doi.org/10.1021/ACS.JCHEMED.3C00323/ASSET/IMAGES/MEDIUM/ED3C00323_0002.GIF

Almusaed, A., Almssad, A., Yitmen, I., & Homod, R. Z. (2023). Enhancing Student Engagement: Harnessing "AIED"'s Power in Hybrid Education—A Review Analysis. Education Sciences, 13(7). https://doi.org/10.3390/educsci13070632

Ayeni, O. O., Hamad, N. M. Al, Chisom, O. N., Osawaru, B., Adewusi, O. E., Ayeni, O. O., Hamad, N. M. Al, Chisom, O. N., Osawaru, B., & Adewusi, O. E. (2024). AI in education: A review of personalized learning and educational technology. Https://Gsconlinepress.Com/Journals/Gscarr/Sites/Default/Files/GSCARR-2024-0062.Pdf, 18(2), 261–271. https://doi.org/10.30574/GSCARR.2024.18.2.0062

Baker, R. S., Martin, T., & Rossi, L. M. (2016). Educational data mining and learning analytics. The Wiley handbook of cognition and assessment: Frameworks, methodologies, and applications, 379-396.

Bhimdiwala, A., Neri, R. C., & Gomez, L. M. (2022). Advancing the Design and Implementation of Artificial Intelligence in Education through Continuous Improvement. International Journal of Artificial Intelligence in Education, 32(3), 756–782. https://doi.org/10.1007/S40593-021-00278-8/METRICS

Carnegie Learning. (2020). The impact of personalized learning on student achievement. Retrieved from Carnegie Learning.

Casal-Otero, L., Catala, A., Fernández-Morante, C., Taboada, M., Cebreiro, B., & Barro, S. (2023). AI literacy in K-12: a systematic literature review. International Journal of STEM Education 2023 10:1, 10(1), 1–17. https://doi.org/10.1186/S40594-023-00418-7

Chen, L., Chen, P., & Lin, Z. (2020). Artificial Intelligence in Education: A Review. IEEE Access, 8, 75264–75278. https://doi.org/10.1109/ACCESS.2020.2988510

Creswell, J. W., & Creswell, J. D. (2017). Research design: Qualitative, quantitative, and mixed methods approaches. Sage publications.

Dai, C. P., & Ke, F. (2022). Educational applications of artificial intelligence in simulation-based learning: A systematic mapping review. Computers and Education: Artificial Intelligence, 3, 100087. https://doi.org/10.1016/J.CAEAI.2022.100087

Dimitriadou, E., & Lanitis, A. (2023). A critical evaluation, challenges, and future perspectives of using artificial intelligence and emerging technologies in smart classrooms. Smart Learning Environments, 10(1), 1–26. https://doi.org/10.1186/S40561-023-00231-3/TABLES/7

Doignon, J.-P., & Falmagne, J.-C. (1999). Knowledge Spaces. Knowledge Spaces. https://doi.org/10.1007/978-3-642-58625-5

El-Sabagh, H. A. (2021). Adaptive e-learning environment based on learning styles and its impact on development students' engagement. International Journal of Educational Technology in Higher Education, 18(1), 1–24. https://doi.org/10.1186/S41239-021-00289-4/TABLES/4

Ghimire, A., Prather, J., & Edwards, J. (2024). Generative AI in Education: A Study of Educators' Awareness, Sentiments, and Influencing Factors. Proceedings of (Pre-Print 2024), 1. https://arxiv.org/abs/2403.15586v1

Gligorea, I., Cioca, M., Oancea, R., Gorski, A. T., Gorski, H., & Tudorache, P. (2023). Adaptive Learning Using Artificial Intelligence in e-Learning: A Literature Review. Education Sciences 2023, Vol. 13, Page 1216, 13(12), 1216. https://doi.org/10.3390/EDUCSCI13121216

Goel, A. K., & Polepeddi, L. (2018). Jill Watson: A virtual teaching assistant for online education. In Learning engineering for online education (pp. 120-143). Routledge.

Huang, Z. (2023). IoT-inspired teaching for legal education: AI-based learning based on decision tree algorithm. Soft Computing 2023 28:2, 28(2), 1609–1631. https://doi.org/10.1007/S00500-023-09451-8

Jones, A., & Bomash, I. (2018). Validating Mastery Learning: Assessing the Impact of Adaptive Learning Objective Mastery in Knewton Alta. Lecture Notes in Computer Science (Including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), 10948 LNAI, 433–437. https://doi.org/10.1007/978-3-319-93846-2_81

Kaw, A., Clark, R., Delgado, E., & Abate, N. (2019). Analyzing the use of adaptive learning in a flipped classroom for preclass learning. Computer Applications in Engineering Education, 27(3), 663–678. https://doi.org/10.1002/CAE.22106

Kong, S. C., Cheung, W. M. Y., & Tsang, O. (2023). Evaluating an artificial intelligence literacy programme for empowering and developing concepts, literacy and ethical awareness in senior secondary students. Education and Information Technologies, 28(4), 4703–4724. https://doi.org/10.1007/S10639-022-11408-7/METRICS

Laupichler, M. C., Aster, A., Schirch, J., & Raupach, T. (2022). Artificial intelligence literacy in higher and adult education: A scoping literature review. Computers and Education: Artificial Intelligence, 3, 100101. https://doi.org/10.1016/J.CAEAI.2022.100101

Lincoln, Y. S. (1985). Naturalistic inquiry (Vol. 75). sage.

Mamun, M. A. Al. (2022). Fostering self-regulation and engaged exploration during the learner-content interaction process: the role of scaffolding in the online inquiry-based learning environment. Interactive Technology and Smart Education, 19(4), 482–509. https://doi.org/10.1108/ITSE-11-2021-0195/FULL/XML

Mirata, V., Hirt, F., Bergamin, P., & van der Westhuizen, C. (2020). Challenges and contexts in establishing adaptive learning in higher education: findings from a Delphi study. International Journal of Educational Technology in Higher Education, 17(1), 1–25. https://doi.org/10.1186/S41239-020-00209-Y/TABLES/3

Ng, D. T. K., Su, J., Leung, J. K. L., & Chu, S. K. W. (2023). Artificial intelligence (AI) literacy education in secondary schools: a review. Interactive Learning Environments. https://doi.org/10.1080/10494820.2023.2255228

Nguyen, A., Ngo, H. N., Hong, Y., Dang, B., & Nguyen, B. P. T. (2023). Ethical principles for artificial intelligence in education. Education and Information Technologies, 28(4), 4221–4241. https://doi.org/10.1007/S10639-022-11316-W/TABLES/1

Patton, M. Q. (2014). Qualitative research & evaluation methods: Integrating theory and practice. Sage publications.

Pedro, F., Subosa, M., Rivas, A., & Valverde, P. (2019). Artificial intelligence in education : challenges and opportunities for sustainable development. MINISTERIO DE EDUCACIÓN. https://repositorio.minedu.gob.pe/handle/20.500.12799/6533

Roshanaei, M., Olivares, H., & Lopez, R. R. (2023). Harnessing AI to Foster Equity in Education: Opportunities, Challenges, and Emerging Strategies. Journal of Intelligent Learning Systems and Applications, 15(04), 123–143. https://doi.org/10.4236/JILSA.2023.154009

Ruiz-Rojas, L. I., Salvador-Ullauri, L., & Acosta-Vargas, P. (2024). Collaborative Working and Critical Thinking: Adoption of Generative Artificial Intelligence Tools in Higher Education. Sustainability 2024, Vol. 16, Page 5367, 16(13), 5367. https://doi.org/10.3390/SU16135367

Schiff, D. (2022). Education for AI, not AI for Education: The Role of Education and Ethics in National AI Policy Strategies. International Journal of Artificial Intelligence in Education, 32(3), 527–563. https://doi.org/10.1007/S40593-021-00270-2/METRICS

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? International Journal of Educational Technology in Higher Education 2019 16:1, 16(1), 1–27. https://doi.org/10.1186/S41239-019-0171-0

Zhang, H., Lee, I., Ali, S., DiPaola, D., Cheng, Y., & Breazeal, C. (2023). Integrating Ethics and Career Futures with Technical Learning to Promote AI Literacy for Middle School Students: An Exploratory Study. International Journal of Artificial Intelligence in Education, 33(2), 290–324. https://doi.org/10.1007/S40593-022-00293-3/TABLES/5

Zhang, Y., Vera Liao, Q., & Bellamy, R. K. E. (2020). Effect of confidence and explanation on accuracy and trust calibration in AI-assisted decision making. FAT* 2020 - Proceedings of the 2020 Conference on Fairness, Accountability, and Transparency, 295–305. https://doi.org/10.1145/3351095.3372852