The Use of Artificial Intelligence Tools in Instructional Approaches to Enhance Tertiary Students' Critical Thinking Skills

Siti Noor Aneeis Hashim[1] and
Nur Azlinda Kasma Azizan Kamal
Abdul Nasir[2]
[1,2] Universiti Utara Malaysia, 06010 Kedah, Malaysia
aneeis@uum.edu.my

Abstract. Artificial intelligence (AI) offers transformative potential to develop critical thinking skills in higher education. However, effective pedagogical integration remains a challenge. This study investigates how AI tools are utilized to foster critical thinking in undergraduate classrooms across diverse disciplines. Eight lecturers participated in semi-structured interviews, classroom observations, and instructional artefact analysis. Data were analyzed in three phases: (1) case-by-case analysis, identifying AI-mediated practices per participant; (2) cross-case synthesis, extracting common strategies; and (3) theory-to-practice integration, aligning findings with Bloom's Taxonomy, Tyler's curriculum design principles, and the SAMR model to formulate a comprehensive AI-Critical Thinking Pedagogical Model. Findings indicate that effective AI integration relies on four interrelated strategies: cognitive scaffolding, inquiry-based learning, reflective feedback, and instructor mediation. The resulting framework provides practical guidance for lecturers to systematically enhance students' higher-order thinking skills through AI-supported instruction.

Keywords: Artificial Intelligence, Critical Thinking, Higher Education, Instructional Design, AI–Pedagogy, Multiple Case Study.

1.Introduction

Critical thinking is increasingly recognized as a crucial competency for higher education graduates to navigate complex real-world problems, including problem-solving, ethical decision-making, and innovation [1,2]. Despite its importance, global assessments reveal persistent gaps in higher-order cognitive skills. The OECD [3,4] reported that many students struggle with critical reasoning and problem-solving in technology-mediated environments, while UNESCO [5] emphasizes that insufficient critical thinking preparation limits graduates' adaptability in emerging knowledge economies. According to the World Inequality Database on Education, UNESCO [6], disparities in access to high-quality learning tools exacerbate these gaps, particularly in developing countries.

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Traditional higher education pedagogy often prioritizes content acquisition over cognitive skill development, resulting in graduates who may possess knowledge but lack the analytical and evaluative capacities necessary for complex decision-making [7,8]. In response, Artificial Intelligence (AI) presents an opportunity to scaffold and enhance critical thinking through generative AI, intelligent tutoring systems, and automated feedback applications [9,10,11]. AI can personalize learning, provide immediate feedback, and stimulate reflective thinking, aligning with constructivist and learner-centered pedagogies [12,13].

However, the integration of AI in higher education remains largely tool-driven rather than pedagogically structured, leading to concerns that AI may reinforce superficial engagement instead of fostering deeper cognitive processes [14–16]. Moreover, there is limited empirical evidence on how lecturers systematically implement AI to enhance critical thinking across disciplines [17,18]. In addition, despite the growing adoption of AI in higher education, there is a lack of structured pedagogical models that guide lecturers in effectively integrating AI to develop students' critical thinking skills.

Interrelated to the identified gap in the pedagogical integration of artificial intelligence (AI) for fostering higher-order thinking, this study seeks to systematically examine how AI can be meaningfully embedded within higher education teaching practices. Specifically, the study aims to: (1) examine how lecturers implement AI tools to develop students' critical thinking in classroom practice; (2) identify the pedagogical strategies and theoretical frameworks that underpin effective AI-mediated critical thinking; and (3) develop an integrated pedagogical framework that aligns AI use with cognitive development and instructional design principles.

In addressing these objectives, the study is guided by three research questions. First, how do lecturers implement artificial intelligence (AI) tools to develop students' critical thinking skills in higher education classroom practice? Second, what pedagogical strategies and theoretical frameworks underpin effective AI-mediated critical thinking in higher education? Third, how can an integrated pedagogical framework be developed to align AI use with cognitive development and instructional design principles for critical thinking? Collectively, these questions provide a coherent structure for investigating current practices, identifying effective pedagogical approaches, and translating empirical insights into a comprehensive framework that addresses the existing disconnect between AI adoption and critical thinking development.

2.Literature Review

2.1 Critical Thinking in Higher Education

Critical thinking is a multidimensional cognitive process involving analysis, evaluation, synthesis, and reflection, essential for higher-order learning outcomes [1], [19]. Hajmási et al. [2] highlight that globally, higher education institutions are challenged to equip students with these skills, particularly in STEM and language learning contexts where problem-solving and creativity are key. UNESCO [5] emphasizes that graduates with weak critical thinking skills face limitations in professional adaptability and innovation capacity.

2.2 AI as a Catalyst for Critical Thinking

AI tools, including generative AI, automated assessment platforms, and adaptive learning environments, can scaffold critical thinking by providing real-time feedback, prompting reflective engagement, and personalizing learning experiences [8,9,10]. For example, Mayasari et al. [11] demonstrated that AI-enhanced curriculum interventions significantly improved Indonesian undergraduates' analytical and evaluative abilities. Similarly, Khalabuzar & Shymanovych [13] showed that AI-mediated language learning fosters structured reasoning and higher-order cognitive engagement.

2.3 Pedagogical Considerations in AI Integration

The effectiveness of AI in fostering critical thinking is highly dependent on pedagogical alignment rather than technological availability alone or superficial and biased learning outcomes [14]. Studies emphasize that AI must be embedded within structured instructional strategies that promote cognitive engagement, including scaffolding, inquiry-based learning, and reflective feedback [12]. Furthermore, integrating AI with established educational frameworks such as Bloom's Taxonomy, the SAMR model, and objective-driven curriculum design enhances its capacity to support higher-order thinking [15,19,20]. Without such alignment, AI risks functioning as a productivity tool rather than a cognitive catalyst.

2.4 Challenges and Gaps

Despite promising evidence, challenges persist, including lecturer preparedness, curriculum constraints, and variability in students' digital literacy [16], [21,22]. Shahzad et al. [17] note that unstructured AI adoption may lead to superficial engagement rather than meaningful cognitive development, highlighting the need for systematic pedagogical models that integrate AI strategically across courses.

3.Methodology

3.1 Research Design

This study employed a qualitative multi-phase case study design to explore how lecturers integrate AI to foster critical thinking in higher education contexts [23,24]. The design enabled in-depth examination of pedagogical practices across multiple cases, allowing for both contextual understanding and cross-case comparison.

Phase 1 Case-by-Case Analysis: Eight lecturers from diverse higher education disciplines were purposefully selected to explore how AI is used in teaching critical thinking [9,10]. Semi-structured interviews, classroom observations, and AI-mediated lesson artifacts were collected to generate detailed individual case reports.

Phase 2 Cross-Case Synthesis: Data from the eight participants were thematically analyzed to identify common strategies, patterns, and challenges in AI integration [12],[25]. Cross-case synthesis facilitated the identification of pedagogical principles and emerging frameworks for AI-supported critical thinking.

Phase 3 Theoretical-to-Practice Integration: Findings were triangulated with established cognitive and pedagogical theories, including Bloom's Taxonomy, constructivist learning, SAMR, Tyler's objective-driven framework for curriculum development and the TPACK framework [19],[26], to develop the AI–Critical Thinking Pedagogical Model. This phase ensures practical applicability of theoretical insights for curriculum design and teaching practices.

3.2 Participants

The study involved eight lecturers from higher education institutions representing a variety of disciplines including language, STEM, and social sciences. Participants were selected using purposive sampling to ensure a range of AI integration experiences, pedagogical approaches, and institutional contexts [23].

3.3 Data Collection

Data for this study were collected through three complementary qualitative methods to ensure a comprehensive and triangulated understanding of how lecturers integrated artificial intelligence into instructional practices aimed at enhancing students' critical thinking. First, semi-structured interviews were conducted with the eight participating lecturers to explore their experiences, perceptions, and pedagogical strategies related to AI-supported teaching. The interviews enabled participants to discuss how they selected AI tools, designed instructional activities, and scaffolded students' higher-order thinking processes. The flexible format of semi-structured interviews also allowed the researcher to probe deeper into participants' reflections on the effectiveness of AI-mediated learning environments and the challenges associated with integrating emerging technologies in higher education. Such interviews are widely recognized as an effective approach in qualitative case study research for capturing rich, contextualized insights from participants' lived experiences [23].

Second, classroom observations were conducted during AI-mediated teaching sessions to capture authentic instructional practices and student engagement with AI tools. The observations focused on how lecturers facilitated critical thinking activities, structured AI-assisted learning tasks, and guided students in evaluating and interpreting AI-generated responses. Particular attention was given to the pedagogical strategies used to encourage analysis, reasoning, and reflective thinking when interacting with AI technologies. Observational data also allowed the researcher to examine how AI tools such as generative AI platforms, intelligent tutoring systems, and AI-supported analytics dashboards were embedded within teaching practices to support inquiry-based learning and higher-order cognitive development [10,11].

Third, artifact analysis was conducted to examine instructional materials and learning outputs associated with AI-supported pedagogy. These artifacts included lesson plans, course syllabi, AI-generated prompts, instructional guides, and samples of student work produced through AI-assisted activities. Reviewing these materials provided valuable insights into how lecturers structured AI-integrated learning experiences and aligned them with instructional objectives and assessment strategies aimed at fostering critical thinking. Artifact analysis also helped reveal how AI tools were incorporated into curriculum design and student evaluation processes [8], [13].

By combining interviews, classroom observations, and artifact analysis, the study employed methodological triangulation, strengthening the credibility and depth of the findings. This multi-source approach enabled the researcher to compare lecturers' reported practices with observed instructional activities and documented teaching materials, thereby providing a holistic understanding of AI-mediated pedagogical strategies in higher education [23].

3.4 Data Analysis

Thematic analysis was employed in a three-step iterative process:

1. Phase 1 – Case-by-case coding of individual lecturer data [25]
2. Phase 2 – Cross-case synthesis identifying common themes and pedagogical strategies.
3. Phase 3 – Integration with theoretical frameworks to construct the AI–Critical
   Thinking Pedagogical Model [9,10],[19]. Credibility and trustworthiness were ensured through triangulation, member checking, and audit trails [24], and ethical approval was obtained from all participating institutions.

4. Results and interpretation

4.1 Phase 1 – Individual Case Analysis

Eight lecturers from diverse disciplines provided rich insights into AI-mediated critical thinking practices. The Phase 1 analysis demonstrates that AI tools can scaffold a wide range of critical thinking skills across disciplines when paired with deliberate learning activities.

Simulation and Intelligent Tutoring in STEM (P1 & P4)

Tools like *Labster, PhET, Smart Sparrow* and *ALEKS* allow students to engage in virtual experiments, adaptive problem sets, and iterative hypothesis testing, fostering higher-order reasoning and analytical skills. For example, Participant 1 noted "*that students were able to predict outcomes, test assumptions, and refine solutions iteratively, which strengthened their problem-solving skills".*

Generative AI and Writing Tools in Language Studies (P2 & P8):

Applications like *ChatGPT, Grammarly* and *AI Essay Coach* provide real-time feedback on essays, peer-reviewed writing, and question-generation exercises, stimulating reflection, analytical reasoning, and logical questioning. Participant 2 observation showed students improved their essay structure and argument depth after multiple AI-assisted revisions.

AI for Peer Feedback and Discussion Analytics in Social Sciences (P3 & P7):

Platforms like *Kialo Edu, Peergrade* and *CritiqueIt* enhance argument evaluation, evidence-based reasoning, and logical consistency by analyzing discussions and providing structured AI feedback. Participant 3 noted that "*AI dashboards revealed inconsistencies in reasoning, prompting students to critically reassess their positions".*

AI-Assisted Writing Prompts and Case Analysis in EFL & Business (P5 & P6):

AI-generated prompts and scenario simulations encourage inference-making, synthesis, reflective analysis, and critical evaluation, aligning with Bloom's higher-order cognitive levels. Participant 6 highlighted that *"combining AI with reflective journaling helped students critically assess case studies and justify decisions"*.

Across all participants, AI facilitated immediate feedback, adaptive scaffolding, reflective thinking, and enhanced engagement (see Table 1). However, participants warned that over-reliance on AI without explicit guidance may result in superficial engagement, confirming the need for structured pedagogical mediation. Phase 1 thus provides a rich foundation of individual experiences and tools, setting the stage for Phase 2 cross-case synthesis, which identifies emergent patterns in AI-mediated critical thinking strategies.

Table 1. Details of AI tools, activities, and observed critical thinking outcomes, including examples from each participant's teaching.

Participant	Discipline	AI Tools / Approach	Activities to Promote Critical Thinking	Critical Thinking Focus	Excerpt from Participant
1	STEM	AI-driven simulation tools (e.g., Labster, PhET)	Virtual lab experiments, iterative problem-solving, hypothesis testing	Problem-solving, hypothesis testing, analytical reasoning	"Students iteratively tested multiple scenarios using the simulation, which helped them refine their reasoning and anticipate outcomes" (Obaje, 2025).
2	Language Studies	Generative AI (e.g., ChatGPT, Grammarly, QuillBot)	Essay drafting and AI-assisted feedback cycles, peer-reviewed revisions	Reflection, analytical reasoning, argument evaluation	"AI feedback highlighted gaps in argumentation, prompting students to revise their essays and consider alternative perspectives" (Szmyd & Mitera, 2024; Ho, 2024).
3	Social Sciences	AI discussion analytics tools (e.g., Kialo Edu, CritiqueIt)	Analysis of online forum discussions, argument mapping, logic consistency checks	Logical reasoning, argument quality, evidence-based evaluation	"The discussion dashboard revealed patterns in reasoning, allowing students to identify inconsistencies in their arguments" (Fasahat et al., 2025).
4	STEM	Intelligent tutoring systems (e.g., Smart Sparrow, ALEKS)	Adaptive exercises, scaffolded problem sets, gamified challenges	Higher-order reasoning, adaptive thinking, metacognition	"The system adapted the difficulty of problems according to students' skills,

					encouraging them to think beyond standard solutions" (Mayasari et al., 2024).
5	EFL	AI-assisted writing prompts (e.g., Write & Improve, AI Essay Coach)	Inference-making, synthesis exercises, collaborative writing	Inference, synthesis, critical language use	"Prompts generated by AI challenged students to connect ideas, draw inferences, and synthesize information in coherent texts" (Yulduz, 2025; Khalabuzar & Shymanovych, 2024).
6	Business & Accounting	AI tools reflective exercises (e.g., CaseCrunch, ChatGPT for scenario analysis)	Case study evaluations, reflective journals, scenario planning	Evaluation, critical analysis, decision justification	"AI-assisted case studies encouraged students to critically examine evidence and justify their decisions" (AL-Sendy et al., 2025).
7	Social Sciences	AI-facilitated peer feedback (e.g., Peergrade, Eli Review)	Structured peer review, AI-guided rubrics, argument improvement	Argumentation, evidence-based reasoning, collaboration	"Peer feedback generated through AI highlighted gaps in evidence use, promoting deeper discussion" (Shahzad et al., 2025).
8	Language Studies	AI text-generation tools (e.g., ChatGPT, Jasper AI)	Question-generation tasks, logical reasoning exercises, hypothesis debates	Questioning, logical reasoning, critical evaluation	"Students used AI-generated texts to pose questions and critically examine assumptions in arguments" (Rahman et al., 2025; Aljuaid, 2024).

As a result, the data in Phase 1, revealed AI-mediated practices across cases demonstrate that technology alone does not enhance critical thinking; rather, its effectiveness depends on how lecturers design learning activities that require analysis, evaluation, and iterative reasoning.

4.2 Phase 2: Cross-Case Synthesis

The cross-case synthesis of eight lecturers' experiences reveals three overarching themes in AI-mediated critical thinking; 1) adaptive scaffolding, 2) reflective and analytical reasoning, and 3) collaborative evidence-based engagement. Across disciplines, AI tools were consistently leveraged to provide immediate feedback, personalized learning paths, and reflective prompts that scaffolded students' higher-order thinking skills.

Theme 1: Adaptive Scaffolding and Personalized Learning

Theme 1 emerged prominently among STEM lecturers. Participant 1 reported that "*the use of Labster and PhET simulation tools enabled students to iteratively test hypotheses and explore problem scenarios"*, noting that *"students could experiment with different variables, immediately seeing the effects and refining their approaches"*. Similarly, Participant 4 employed intelligent tutoring systems such as Smart Sparrow and ALEKS, which adapted problem difficulty to individual student proficiency, fostering higher-order reasoning and encouraging learners to *"develop strategies for increasingly complex problems rather than merely applying rote solutions"*. These cases demonstrate that AI scaffolding aligns with Bloom's higher-order cognitive processes, enabling students to engage in analysis, evaluation, and synthesis rather than passive knowledge acquisition.

Theme 2: Reflective and Analytical Reasoning

Reflective and Analytical Reasoning (Theme 2) was a central theme in Language Studies, EFL, and Business courses. Participant 2 described using ChatGPT and AI essay coaches for feedback, stating, *"Students revised essays multiple times, reflecting on argument coherence and critically evaluating sources"*. Participant 5 leveraged AI-assisted writing prompts, which promoted inference-making and synthesis skills, reporting that *"students could generate counter-arguments and alternative perspectives, which they then critically analyzed in class discussions"*. Participant 6 combined AI scenario analysis tools with reflective journaling, observing that students *"evaluated case study outcomes and justified decisions based on critical reasoning, rather than relying on descriptive summaries"*. Collectively, these practices illustrate that AI can mediate reflective and analytical cognition, guiding learners to move from surface-level responses to evaluative and inferential thinking.

Theme 3: Collaborative and Evidence-Based Engagement

Collaborative and Evidence-Based Engagement theme was particularly evident in Social Sciences and interdisciplinary courses. Participant 3 applied AI discussion analytics to track argument quality and logical consistency, noting that *"the system highlighted gaps in reasoning, prompting students to restructure arguments with stronger evidence"*. Participant 7 implemented AI-facilitated peer feedback platforms like *Kialo Edu* and *Peergrade*, observing that students *"critically evaluated peers' submissions and defended their positions using evidence-based reasoning"*. Participant 8 experimented with AI text-generation tools, finding that students *"questioned assumptions and refined logical structures after comparing AI-generated suggestions with their own reasoning"*. These instances confirm that AI can enhance collaborative cognitive processes by supporting structured argumentation, critical questioning, and evaluation of evidence.

Across all participants, immediate feedback and adaptive learning emerged as key enablers of critical thinking. AI provided personalized cues and reflections, allowing students to iteratively refine their work and thought processes [14], [16]. However, lecturers also emphasized that unstructured AI use sometimes led to superficial engagement, where students relied on AI outputs without critical evaluation [15]. Participant experiences underscore that the pedagogical framing of

AI tools is essential: AI is most effective when paired with scaffolding strategies that explicitly prompt analysis, evaluation, and synthesis [2],[10].

In summary, the cross-case synthesis demonstrates that AI integration in higher education can simultaneously support personalized learning, foster reflective and analytical reasoning, and enhance collaborative argumentation. The findings suggest that effective critical thinking development is contingent not merely on AI availability but on intentional pedagogical design**,** structured scaffolding, and alignment with learning objectives [27,28].

4.3 Phase 3: Theory-to-Practice Integration

Phase 3 of the analysis synthesizes the cross-case insights into a comprehensive AI-Critical Thinking Pedagogical Framework (AI-CTPF), which translates empirical findings into a structured instructional model for higher education. The AI-CTPF advances existing literature by integrating cognitive theory, curriculum design, and technological frameworks into a unified pedagogical model for AI-mediated critical thinking. Whereas Phase 1 examined individual lecturer practices and Phase 2 identified recurring patterns across cases, Phase 3 bridges these insights with established educational theories to produce a coherent and practical pedagogical framework. The resulting model operationalizes how artificial intelligence can be meaningfully embedded in instructional design to enhance students' critical thinking capabilities.

Grounded in constructivist learning theory, the AI-CTPF positions students as active constructors of knowledge rather than passive recipients of information. AI tools are thus conceptualized as mediating artefacts that support inquiry, exploration, and knowledge co-construction through interaction, reflection, and collaboration. This aligns with the view that learning occurs through engagement with meaningful tasks, where students critically interpret, negotiate, and refine their understanding in AI-supported environments.

The AI-CTPF conceptualizes AI integration as a dynamic interaction between cognitive development, instructional design, and technological mediation. Rather than positioning AI tools merely as productivity aids, the framework emphasizes their pedagogical function as cognitive scaffolds that guide students through progressively higher levels of reasoning. In doing so, the model aligns with Bloom's Taxonomy, which conceptualizes learning as a progression from remembering and understanding toward higher-order processes such as analysis, evaluation, and creation. Across the eight cases, lecturers consistently used AI tools to move students beyond information retrieval toward analytical interpretation, argument evaluation, and evidence-based synthesis.

In addition, the framework is informed by Tyler's objective-driven curriculum model**,** which emphasizes the alignment between instructional objectives, learning experiences, and assessment. Within the AI-CTPF, clearly defined critical thinking objectives guide the selection and use of AI tools, ensuring that instructional activities are purposefully designed to achieve higher-order learning outcomes. AI-supported tasks, therefore, are not incidental but are systematically aligned with intended cognitive goals, reinforcing coherence between teaching, learning, and evaluation processes.

From a technological integration perspective, the framework incorporates both the TPACK framework and the SAMR model to explain how AI can be effectively embedded in pedagogy. TPACK (Technological Pedagogical Content Knowledge) emphasizes the intersection of technology, pedagogy, and disciplinary knowledge. Findings from the eight lecturers demonstrate that the most effective AI-supported learning occurs when instructors intentionally align AI tools with disciplinary inquiry practices for example, STEM lecturers using AI simulations for hypothesis testing, language lecturers employing generative AI for iterative argument refinement, and social science lecturers utilizing analytics tools to evaluate discourse quality. These practices illustrate that technological affordances must be meaningfully integrated with pedagogical strategies and subject content to support higher-order thinking.

Complementing this, the SAMR model (Substitution, Augmentation, Modification, Redefinition) provides a lens to understand the depth of AI integration. The findings suggest that AI use in these cases moves beyond substitution and augmentation toward modification and redefinition, where learning tasks are transformed. For instance, AI-enabled simulations, real-time feedback systems, and collaborative analytics platforms allow students to engage in complex problem-solving, iterative reasoning, and evidence-based argumentation in ways that were previously not possible. This transformation is critical in fostering authentic critical thinking experiences.

From the cross-case synthesis, three interconnected pillars emerged as the core pedagogical mechanisms through which AI supports critical thinking development. The first pillar, Adaptive Scaffolding and Personalized Learning, reflects lecturers' use of AI systems to adjust task complexity and provide targeted feedback based on student performance. Intelligent tutoring systems, simulation platforms, and adaptive assessment tools enable students to experiment with multiple problem-solving pathways while receiving immediate formative feedback. This adaptive process reflects constructivist scaffolding principles, supporting students as they transition from guided learning toward independent critical analysis.

The second pillar, Reflective and Analytical Reasoning, highlights the role of AI in promoting metacognitive engagement. Lecturers utilized generative AI platforms such as ChatGPT and AI-assisted writing tools to facilitate reflective revision processes. Rather than passively accepting AI outputs, students were required to critique responses, identify logical inconsistencies, and refine their arguments. Such practices encourage deeper analytical reasoning and align with higher-order cognitive processes in Bloom's Taxonomy, particularly evaluation and creation.

The third pillar, Collaborative and Evidence-Based Engagement, emphasizes the role of AI in supporting social constructivist learning processes. AI-enabled discussion analytics, peer feedback systems, and collaborative platforms facilitate dialogue, argumentation, and evidence-based reasoning. These tools allow lecturers to monitor discourse quality and guide students in constructing well-supported arguments, thereby strengthening disciplinary literacy and critical evaluation skills.

Collectively, these three pillars illustrate how AI can function as an instructional catalyst for higher-order thinking when embedded within structured pedagogical frameworks. The AI-CTPF conceptualizes AI not as an autonomous teaching agent but as a mediating layer that enhances lecturers' instructional intentions. Within the framework, instructional objectives (Tyler) guide AI integration, pedagogical strategies (constructivist and TPACK-informed) shape learning experiences, and technological transformation (SAMR) enables deeper cognitive engagement.

Importantly, the framework also acknowledges the pedagogical risks identified in earlier phases of the study. Several lecturers observed that unstructured AI use may lead to surface-level engagement, where students rely excessively on AI-generated outputs without critical evaluation. This concern aligns with prior research emphasizing that AI adoption without explicit scaffolding may weaken critical inquiry. Consequently, the AI-CTPF emphasizes instructor-guided AI use, structured reflective tasks, and assessment designs that require students to justify reasoning rather than merely produce answers.

In practical terms, the framework provides a systematic pathway for designing AI-enhanced instruction. Teaching begins with clearly defined critical thinking objectives (Tyler), followed by AI-supported learning experiences that promote inquiry, reflection, and collaboration (constructivist pedagogy). These activities are carefully aligned with disciplinary knowledge (TPACK) and designed to transform learning experiences (SAMR). Assessment, in turn, evaluates not only the final outputs but also the reasoning processes demonstrated by students across cognitive, affective, and psychomotor domains.

By integrating theoretical constructs with empirical classroom practices, the AI-CTPF offers a holistic and scalable model for embedding artificial intelligence in higher education pedagogy. It ensures that AI is used not merely as a technological tool, but as a catalyst for meaningful, higher-order critical thinking development.

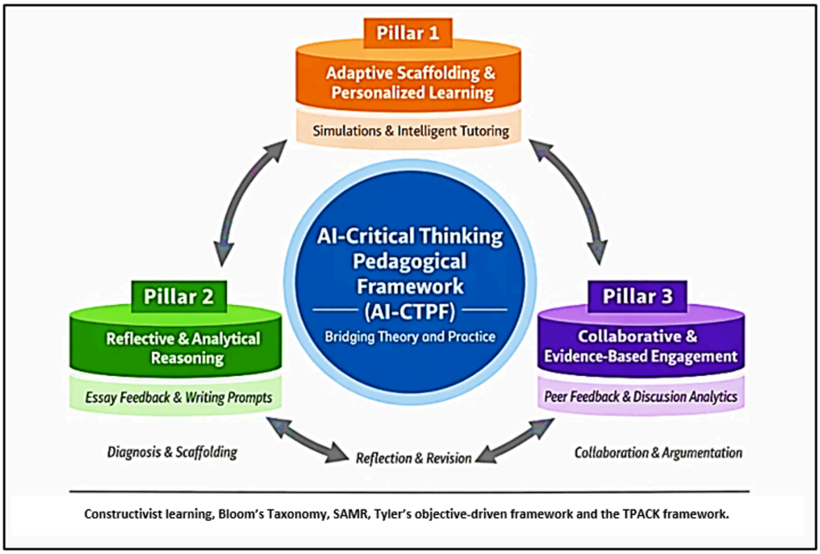

Fig. 1. AI-Critical Thinking Pedagogical Framework

Implications

The findings of this study extend both theoretical understanding and practical implementation of artificial intelligence in higher education pedagogy, particularly in relation to the development of critical thinking. By synthesizing lecturer practices into the AI-Critical Thinking Pedagogical Framework (AI-CTPF), the study demonstrates how AI technologies can be intentionally aligned with instructional objectives, learning activities, and assessment strategies to support higher-order cognitive development. The implications therefore contribute to instructional theory, curriculum design, and classroom practice. The AI-CTPF also advances existing literature by integrating cognitive theory, curriculum design, and technological frameworks into a unified pedagogical model for AI-mediated critical thinking.

Implication for Educators

The framework provides practical strategies for lecturers to integrate AI into instruction while preserving students' independent reasoning processes. Rather than treating AI platforms simply as automated content generators, the findings suggest that educators should design structured learning tasks that require students to critique, interpret, and validate AI-generated outputs. Examples include prompting students to evaluate the logic of AI-generated responses, compare alternative solutions produced by AI systems, and justify revisions through evidence-based reasoning. Such practices transform AI into a cognitive scaffold that supports inquiry-based learning and reflective engagement. This approach aligns with the work of Crompton and Burke [16], who emphasize that AI technologies should function as pedagogical enhancers rather than substitutes for human reasoning and instructional guidance. The AI-CTPF therefore supports educators in designing AI-mediated learning experiences that maintain the central role of critical thinking in higher education. This key element will become the guidance in enhancing other educators teaching skills to become innovative future teachers.

Implication for Curriculum Designers

Intended for curriculum developers and academic program planners, the framework offers a systematic model for embedding AI-supported critical thinking activities across disciplines. The findings demonstrate that AI integration can be successfully implemented in diverse fields including STEM, social sciences, business, and language studies when aligned with clear learning outcomes and disciplinary inquiry practices. By integrating AI-supported simulations, intelligent tutoring systems, generative writing assistants, and collaborative analytics tools into coursework, curricula can be redesigned to support higher-order cognitive processes such as analysis, evaluation, and synthesis. This aligns with the hierarchical learning progression conceptualized in Bloom's Taxonomy, which emphasizes the development of advanced reasoning skills beyond simple knowledge recall. Lubbe et al. [19] further argue that curriculum structures must evolve to incorporate AI-mediated learning environments that promote analytical inquiry, evidence-based argumentation, and interdisciplinary problem-solving. The AI-CTPF therefore provides curriculum designers with a coherent framework for aligning AI technologies, learning activities, and assessment strategies within academic programs which also touch on the three main domains to fulfil the curriculum and education philosophies.

Implication for Students

The framework also meant for students thinking development and growth, the integration of AI within the AI-CTPF creates opportunities for personalized, reflective, and collaborative learning experiences that strengthen critical thinking competencies and humanity values. Adaptive AI systems can provide immediate feedback and adjust task complexity based on individual learning progress, enabling students to develop reasoning skills at an appropriate cognitive pace. At the same time, AI-supported collaborative platforms encourage peer dialogue, argument evaluation, and evidence-based discussion, all of which are essential for developing intellectual independence and academic literacy. Studies by Hao et al. [7] and Patrick et al. [29] highlight that such environments foster adaptive reasoning, metacognitive awareness, and problem-solving abilities, preparing students to navigate complex real-world challenges in an AI-driven knowledge economy. Within the AI-CTPF, students are therefore positioned not as passive consumers of AI-generated information but as active evaluators and co-constructors of knowledge, capable of critically engaging with both human and machine-generated insights. Overall, these implications suggest that the effective use of AI in higher education requires intentional pedagogical design, curriculum alignment, and learner-centered engagement strategies. When guided by structured frameworks such as the AI-CTPF, artificial intelligence can serve as a powerful catalyst for cultivating the critical thinking skills that are increasingly essential for graduates in the digital era to become innovative future leaders.

5. Discussion

The findings reinforce that the integration of artificial intelligence (AI) tools in instruction does not inherently enhance critical thinking; rather, its impact is contingent upon pedagogical mediation and structured cognitive engagement. The three-phase analysis revealed how lecturers employed AI to facilitate adaptive scaffolding, reflective reasoning, and collaborative engagement, ultimately leading to the development of the AI-Critical Thinking Pedagogical Framework.

Phase 1 findings illustrated the diverse ways lecturers used AI tools across disciplines to promote higher-order thinking. For instance, STEM lecturers leveraged simulation platforms and intelligent tutoring systems to encourage hypothesis testing and iterative problem-solving. These practices align with the higher levels of analysis, evaluation, and synthesis in Bloom's taxonomy, which emphasize students' ability to examine complex problems and generate solutions [1]. The use of AI simulations and adaptive platforms allowed learners to test ideas dynamically and receive immediate feedback, supporting the development of analytical reasoning [10,11].

Similarly, lecturers in language and social science disciplines used generative AI tools and AI-assisted writing platforms to stimulate reflective and analytical reasoning. Students engaged in iterative writing processes where AI-generated feedback helped them identify weaknesses in argumentation and evidence use. These practices resonate with findings by Szmyd and Mitera [8] and Ho [22], who argue that AI-supported feedback can enhance reflective learning by enabling students to critically evaluate their reasoning and revise their work accordingly. AI-generated prompts also encouraged students to examine multiple perspectives and construct more sophisticated arguments, strengthening inferential and evaluative thinking skills [13],[18].

Phase 2 cross-case synthesis further highlighted the importance of collaborative and evidence-based learning environments supported by AI tools. Platforms such as AI-enabled peer feedback systems and discussion analytics allowed students to analyze argument quality, evaluate peer contributions, and refine their reasoning through dialogue. This finding aligns with research by Shahzad et al. [17] and Fasahat et al. [9], which indicates that AI-supported peer learning environments enhance critical engagement by encouraging students to justify claims with evidence and respond to alternative viewpoints. Additionally, AI text-generation tools enabled students to question assumptions and compare multiple lines of reasoning, strengthening their logical thinking processes [28],[30].

The integration of these practices culminated in Phase 3, where empirical findings were translated into the AI-Critical Thinking Pedagogical Framework. The framework illustrates how AI tools can support critical thinking through three interconnected pedagogical dimensions: adaptive scaffolding, reflective reasoning, and collaborative engagement. This model reinforces the argument that AI should not function merely as a technological aid but as a pedagogically mediated tool embedded within intentional instructional design [16].

However, the findings also highlight potential challenges associated with AI integration. Several lecturers observed that students occasionally relied on AI-generated outputs without critically evaluating the information provided. This concern is consistent with Airaj [14], who cautions that unstructured AI usage may lead to superficial learning rather than deeper cognitive engagement. Consequently, the study underscores the need for teacher mediation and explicit scaffolding strategies to ensure that AI tools foster critical thinking rather than replace it. Overall, the findings confirm that AI integration has the potential to transform instructional approaches by creating learning environments that promote active inquiry, reflective thinking, and collaborative knowledge construction. When guided by sound pedagogical frameworks, AI can serve as a powerful catalyst for developing the cognitive competencies required in contemporary knowledge societies.

6. Conclusion

This study explored how tertiary lecturers integrate AI tools into instructional practices to enhance undergraduate students' critical thinking skills. Using a qualitative multi-phase case study design involving eight lecturers from diverse disciplines, the research examined individual practices, synthesized cross-case patterns, and translated the findings into a practical pedagogical framework. The results demonstrate that AI tools can significantly enhance critical thinking development when integrated into structured learning activities [31,32] that integrate technology into teaching to enhance or transform student learning [26],[31],[33]. Across the cases, lecturers used AI simulations, generative AI tools, intelligent tutoring systems, and peer feedback platforms to support problem-solving, reflective reasoning, and collaborative argumentation [26], [31,32,33]. These practices enabled students to engage in higher-order cognitive processes such as analyzing complex problems, evaluating evidence, and synthesizing ideas [37,38]. Besides that, through reflective reasoning, they build their inner value through critical self-awareness and examination of how the input, background, biases, and the presence elements influence their knowledge they produce, Hence, the actions they reflect to the problems enhance the validity of their decisions which made them different to each other especially on their level of critical thinking and humanity values. It involves them not only analyzing one's own role in shaping the output, but also critically shape and create their personality and the choices they made to suit the situations.

The study contributes to the growing body of research on AI in education by proposing the AI-Critical Thinking Pedagogical Framework, which integrates theoretical principles with practical teaching strategies and integration of humanity value through reflexivity. The framework provides educators with a structured approach to integrating AI into lessons, ensuring that technological tools align with instructional objectives and support meaningful cognitive development. Ultimately, the findings suggest that AI can play a transformative role in higher education by enabling more adaptive, reflective, and collaborative learning environments. These become the guidance to all practitioners in enhancing their teaching skills among and become innovative future educationalists. However, the effectiveness of AI depends largely on intentional pedagogical design and instructor guidance, which ensure that AI tools serve as catalysts for deeper thinking rather than substitutes for human reasoning.

Limitations

This study demonstrates that artificial intelligence (AI) has the potential to play a transformative role in higher education when it is purposefully embedded within structured pedagogical frameworks that prioritize the development of critical thinking. The proposed AI-Critical Thinking Pedagogical Framework (AI-CTPF) advances this agenda by offering a systematic and integrative model that bridges cognitive theory, curriculum design, and technological affordances. By positioning AI as a mediating tool rather than a standalone solution, the framework underscores that meaningful learning outcomes emerge from the interplay between technology, pedagogy, and disciplinary knowledge. Importantly, the findings reinforce that AI cannot replace human reasoning or instructional expertise; instead, its effectiveness is contingent upon intentional pedagogical design, active lecturer facilitation, and the incorporation of reflective and inquiry-based learning strategies that promote higher-order cognitive engagement.

Despite these contributions, several limitations should be acknowledged. First, the study involved a relatively small sample of eight lecturers, which constrains the generalizability of the findings across broader higher education contexts. Although participants were drawn from diverse disciplines, future research involving larger and more heterogeneous samples would enhance the external validity and transferability of the results. Second, the study relied primarily on qualitative data derived from interviews, classroom observations, and instructional artefacts. While these methods provided rich, contextualized insights into pedagogical practices, the research did not include direct measurement of students' critical thinking outcomes using standardized or quantitative assessment tools. Incorporating such measures in future studies would allow for a more robust evaluation of the impact of AI-mediated instruction.

Third, the rapidly evolving nature of AI technologies presents an inherent limitation. The tools examined in this study represent a snapshot within a continuously advancing technological landscape. As new AI platforms and functionalities emerge, ongoing research will be necessary to examine their pedagogical affordances, limitations, and implications for critical thinking development.

Future Research

Future studies can extend this research in several directions. First, researchers could conduct large-scale quantitative or mixed-method studies to evaluate the impact of AI-mediated instruction on measurable improvements in students' critical thinking skills. Such studies would complement the qualitative insights presented in this research. Second, longitudinal research could examine how sustained exposure to AI-supported learning environments influences students' cognitive development over time. Tracking students across multiple semesters would provide deeper insights into how AI integration shapes long-term learning outcomes. Third, future research could explore discipline-specific AI pedagogies, investigating how different academic fields may require distinct approaches to integrating AI for critical thinking development. Finally, studies focusing on AI literacy and ethical AI use in education would be valuable. As AI becomes increasingly embedded in academic environments, students must develop the skills to critically evaluate AI-generated information and understand its limitations.

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