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Article

EVALUATING THE EFFECTIVENESS OF AI-GENERATED, CONTEXT-SPECIFIC CASE STUDIES IN IMPROVING CRITICAL THINKING SKILLS IN ODL

Md Arif Uz Zaman[1]

[1]. Associate Professor, School of Education, Bangladesh Open University, Bangladesh
Email: mazaman@bou.ac.bd
ORCID: https://orcid.org/0000-0001-8237-6789

ABSTRACT

The advancement of artificial intelligence (AI) in education has created new opportunities to enhance learner-centered pedagogies, particularly in open and distance learning (ODL) systems where geographic, cultural, and infrastructural challenges often limit instructional effectiveness. Critical thinking, defined as the ability to analyze, evaluate, and synthesize information for evidence-based judgment and problem-solving, remains a central educational outcome and a global competency emphasized by higher education frameworks. Case-based learning has long been recognized as an effective approach for fostering critical thinking; however, static case materials often lack contextual relevance and adaptability for diverse learner populations in ODL contexts. This study investigated the effectiveness of AI-generated, context-specific case studies in improving critical thinking skills among Bangladeshi ODL learners. A quasi-experimental design was employed with pre-test and post-test measures administered to an experimental group (n = 100) and a control group (n = 100). The experimental group interacted with AI-generated cases designed to provide personalization, authenticity, adaptive feedback, and active engagement, while the control group studied traditional instructor-developed case materials. Findings revealed significant improvements in the experimental group's critical thinking performance, with large effect sizes on post-test scores compared to the control group. Regression analysis confirmed that personalization, engagement, authenticity, and adaptive feedback each had a strong positive effect on critical thinking outcomes, with path coefficients ranging between β = .27 and β = .46. Structural equation modeling further demonstrated that these four variables collectively explained 68% of the variance in critical thinking development, confirming the overall model hypothesis. The results underscore the effectiveness of AI-generated case studies in addressing key limitations of ODL, including isolation, lack of contextualization, and delayed feedback. By integrating AI-driven instructional design into learning management systems, institutions in Bangladesh can support critical thinking development at scale while ensuring inclusivity across diverse learner groups. This study contributes to the global literature on AI-enhanced pedagogy by demonstrating its applicability and impact within a South Asian ODL context, where access and equity are central educational challenges.

KEYWORDS

Artificial Intelligence (AI); Case-Based Learning; Critical Thinking Skills; Open and Distance Learning (ODL); Context-Specific Pedagogy;

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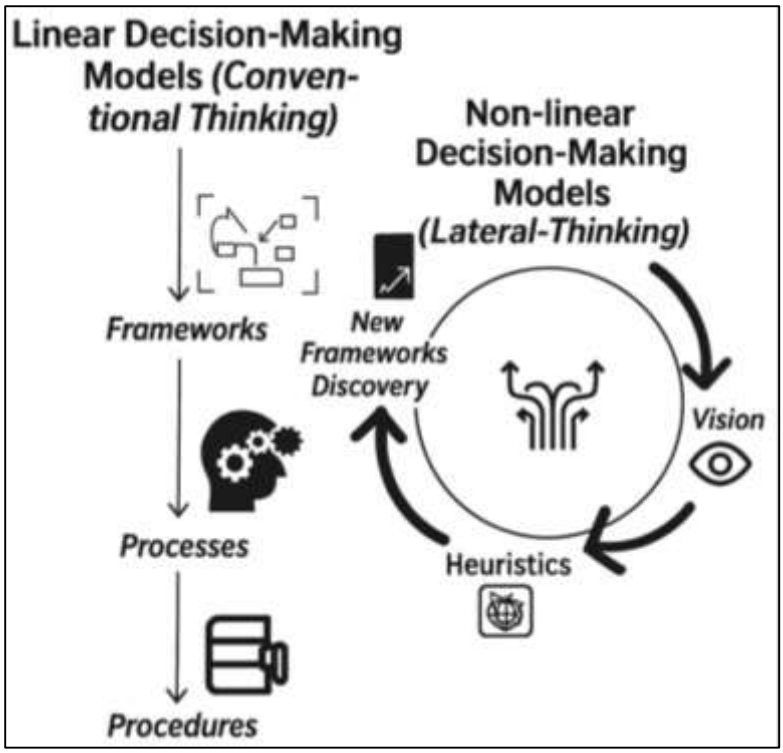
INTRODUCTION

Critical thinking is widely defined as the process of analyzing, evaluating, and synthesizing information in order to guide decision-making and problem-solving in a rational manner. Within the educational context, it is recognized as a fundamental higher-order cognitive skill essential for academic success and professional competency. Case-based learning, a pedagogical approach that situates learners in problem-oriented contexts, has long been acknowledged as an effective instructional strategy for fostering critical thinking (Butler, 2012). With the rapid evolution of artificial intelligence (AI), new opportunities have emerged for automating and tailoring case studies to align with learners' disciplinary and cultural backgrounds. AI-generated, context-specific case studies employ natural language processing and machine learning algorithms to create realistic scenarios that simulate authentic professional challenges, thereby encouraging learners to engage in analysis, evaluation, and creative reasoning (Huber & Kuncel, 2016). Open and distance learning (ODL), defined as a mode of education that transcends spatial and temporal barriers, relies heavily on instructional design innovations to maintain learner engagement and quality outcomes. The intersection of AI-driven case studies and ODL represents an emerging area of educational research where technology-mediated pedagogy can strengthen critical thinking capacities among geographically dispersed learners (Hwang et al., 2022). Establishing a precise understanding of these definitions provides the foundation for evaluating how context-specific AI applications may transform critical thinking instruction in non-traditional learning environments (Siemens, 2013; Bates, 2015).

Figure 1: Overview of Critical thinking



The emphasis on critical thinking skills transcends national boundaries, as higher education systems worldwide recognize their centrality to student development and employability (Mathew & Chung, 2021). International frameworks such as the Organisation for Economic Co-operation and Development (OECD) have highlighted critical thinking as a key competency required in 21st-century education (Mathew & Chung, 2021). UNESCO underscores its role in preparing learners for complex global challenges, including sustainability, social justice, and innovation. In Asia, countries such as Singapore and South Korea have embedded critical thinking explicitly within national curricula as part of broader human capital development agendas (Bozkurt, 2023b). Similarly, in Europe, the Bologna Process emphasizes transferable skills such as analysis and reasoning as integral to harmonized qualifications frameworks (Berg, 2024). North American institutions also prioritize

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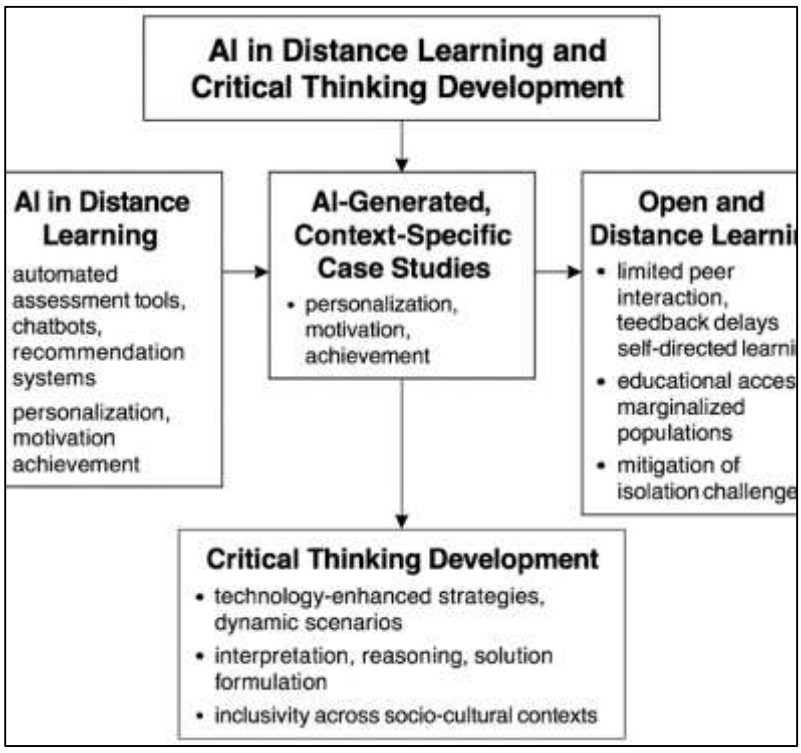
critical thinking as a measure of learning outcomes and graduate readiness for professional environments. Within the context of ODL, the global need for critical thinking is particularly acute, as learners must independently engage with materials and exercise self-regulated learning. Consequently, integrating AI-generated case studies into ODL settings has the potential to align with international educational goals that prioritize competencies over rote knowledge acquisition (Bozkurt, 2023). The universal recognition of critical thinking's significance positions it as a benchmark for evaluating pedagogical innovation across cultures and learning systems.

Case-based learning (CBL) is an established educational method that situates learners in realistic scenarios requiring them to diagnose problems, weigh evidence, and articulate reasoned judgments (Yoon & Kim, 2015). Research shows that CBL enhances knowledge retention, critical analysis, and collaborative problem-solving by situating abstract theories in tangible contexts. Studies in medical education demonstrate that case discussions improve diagnostic reasoning and ethical decision-making, while research in business and law curricula highlights its value in developing strategic thinking and argumentation. The pedagogical flexibility of case studies allows instructors to scaffold inquiry at multiple levels, enabling learners to progress from basic comprehension to sophisticated evaluation (Regan, 2016). Within ODL environments, however, traditional case-based learning faces challenges related to access, interaction, and contextual relevance. Learners in diverse geographic and cultural contexts may find generic case materials less meaningful or applicable, reducing engagement and depth of analysis. The capacity of AI technologies to generate customized case studies that mirror learners' academic programs and professional realities represents a pedagogical advancement capable of revitalizing case-based methods in distance education (Yoon & Baek, 2016). This approach enhances not only the personalization of learning materials but also their alignment with global trends in learner-centered design.

Figure 2: AI in Distance Learning and Critical thinking Development



Artificial intelligence in education (AIED) encompasses technologies that enable adaptive learning, natural language processing, and intelligent tutoring systems, all of which enhance learner engagement and instructional efficiency (Chen et al., 2020). Applications of AI in ODL have grown significantly, ranging from automated assessment tools and chatbots to recommendation systems that guide students through personalized learning pathways (Holmes et al., 2021). AI-generated content, including case studies, represents a transformative development within this domain, as it

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combines algorithmic precision with contextual sensitivity to produce highly relevant learning materials. Studies indicate that AI-driven personalization can increase learner satisfaction, motivation, and achievement in distance learning contexts. Furthermore, AI-based case studies can be updated dynamically to reflect contemporary challenges in various fields, such as healthcare, business, and education, thereby maintaining contextual authenticity. Within international ODL systems, where learners often lack face-to-face interactions with instructors, AI-generated case studies can serve as critical scaffolds for engaging with disciplinary problems. By synthesizing real-world scenarios with algorithmic adaptability, AI technologies can strengthen the pedagogical infrastructure of ODL, aligning instructional practices with global expectations for digital transformation in education. Moreover, developing critical thinking through technology-enhanced learning environments has been a central focus of educational research over the last two decades (Klašnja-Milićević & Ivanović, 2021). Interactive platforms, simulations, and problem-based learning technologies have demonstrated measurable impacts on learners' analytical and evaluative capacities. Studies in higher education show that technology integration enhances metacognitive awareness and reflective practices, both of which are essential to critical thinking. Within ODL, where student autonomy is a defining characteristic, technology-enhanced strategies are particularly effective in bridging the gap between isolated learning and interactive engagement. AI-generated case studies extend these strategies by situating learners in dynamic, contextually meaningful scenarios that require interpretation, evidence-based reasoning, and solution formulation. Unlike static case materials, AI-driven cases can be iteratively adapted to learner responses, providing scaffolding that supports critical inquiry. International research further demonstrates that such adaptability enhances inclusivity, allowing learners from diverse backgrounds to engage with problems that resonate with their own socio-cultural contexts (Alhumaid et al., 2023; Klašnja-Milićević & Ivanović, 2021). The convergence of AI, case-based learning, and critical thinking development represents a promising trajectory within the broader framework of technology-enhanced education globally.

The primary objective of this study is to quantitatively evaluate the extent to which AI-generated, context-specific case studies improve critical thinking skills among learners in open and distance learning environments. By employing a quasi-experimental research design, the investigation seeks to measure differences in critical thinking competencies between an experimental group exposed to AI-generated cases and a control group relying on traditional case materials. The analysis is structured around pre- and post-intervention assessments using standardized critical thinking evaluation instruments, enabling a statistical comparison of performance outcomes across groups. Additionally, the study aims to quantify levels of learner engagement and perceived relevance through structured surveys employing Likert-scale items, thereby generating measurable indicators of student attitudes toward AI-generated learning resources. The overarching objective is to determine, through inferential statistical methods, whether the integration of AI-generated case studies yields significant improvements in analytical reasoning, evaluation, and problem-solving skills, while also providing empirical evidence of learner satisfaction and engagement.

LITERATURE REVIEW

The study of critical thinking within higher education and open and distance learning (ODL) has attracted sustained scholarly attention, reflecting its importance for cognitive development, professional readiness, and lifelong learning. While traditional case-based learning has long been employed to foster analytical reasoning, the emergence of artificial intelligence (AI) technologies offers new avenues for generating context-specific case studies that can enhance learner engagement and relevance. Previous research has investigated the pedagogical foundations of critical thinking, the effectiveness of case-based learning in different disciplines, and the integration of AI into technology-enhanced education. However, there remains a gap in empirical investigations that connect AI-generated instructional resources with measurable outcomes in critical thinking, particularly within the global ODL context. This literature review synthesizes existing scholarship across four interrelated domains: (1) the conceptualization and assessment of critical thinking in education, (2) case-based learning as a pedagogical strategy, (3) the role of AI in education with emphasis on content generation and personalization, and (4) the unique challenges and opportunities of ODL in promoting higher-order thinking. By systematically analyzing these strands of literature, the review provides a comprehensive foundation for evaluating the

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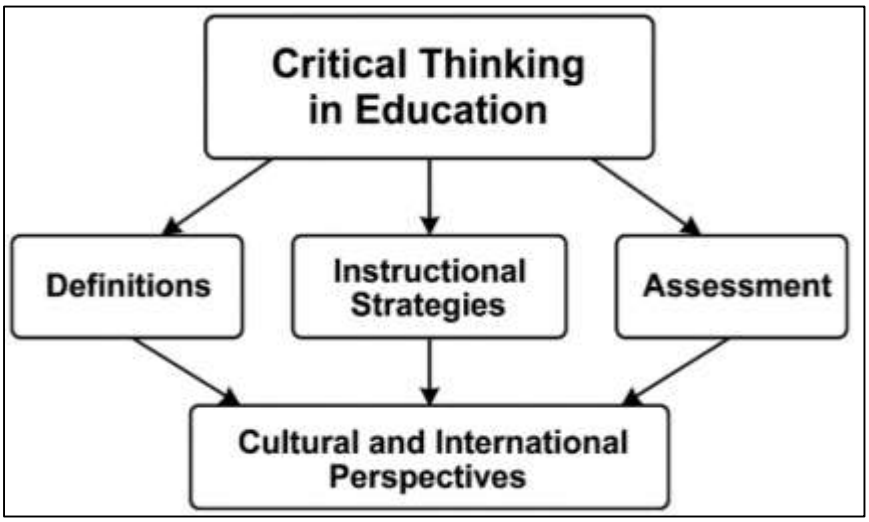
effectiveness of AI-generated, context-specific case studies in enhancing critical thinking skills among distance learners.

Critical Thinking in Education

Critical thinking has been extensively defined in educational literature as a multidimensional construct that encompasses analysis, evaluation, inference, and explanation in problem-solving contexts (Giancarlo et al., 2004). Walsh et al. (2007) emphasized that critical thinking involves purposeful, reasoned, and goal-directed thinking processes, distinguishing it from rote memorization and unreflective learning. Berg and du Plessis (2023) described it as an intellectual discipline rooted in clarity, accuracy, depth, and logic, while French et al. (2012) highlighted its role in questioning assumptions and exploring alternative viewpoints. Huber and Kuncel (2016) proposed that reflective judgment is integral to critical thinking, suggesting that learners must engage in iterative processes of evidence evaluation before forming conclusions. Similarly, Michael et al. (1980) positioned critical thinking as a higher-order intellectual skill essential to democratic participation and informed decision-making. Across disciplines, researchers have consistently recognized that critical thinking represents both a cognitive skill set and a dispositional orientation toward reasoning. Studies have demonstrated that critical thinking correlates positively with problem-solving, creativity, and academic performance. In addition, international educational bodies have formalized critical thinking as a competency central to global learning agendas, positioning it as an essential skill for the 21st century. These perspectives converge on the idea that critical thinking serves as the foundation for intellectual growth and professional preparedness across cultural and disciplinary boundaries, making it one of the most studied constructs in educational psychology and pedagogy (Landis & Michael, 1981).

Figure 3: Overall Critical Thinking in Education



The pedagogical importance of critical thinking in education extends across cultural and national contexts, underscoring its recognition as a universal learning outcome. International frameworks such as UNESCO's Education for Sustainable Development initiatives and OECD's Learning Compass 2030 highlight critical thinking as a global competency necessary for addressing complex challenges in interconnected societies (Butler et al., 2012). Within North American higher education, scholars such as Butler (2012) and Halpern (2012) have documented the role of critical thinking in shaping graduate readiness for professional environments, noting that its development is linked with academic persistence and employability. In Europe, the Bologna Process embeds critical thinking as part of transferable skills frameworks across higher education systems (European Commission, 2020), while Asian educational systems like Singapore and South Korea emphasize it as part of national agendas for innovation-driven growth. Halpern et al. (2012) stressed that the universality of critical thinking lies in its transferability across domains, making it relevant to both disciplinary knowledge and real-world application. Studies conducted in medical education highlight how structured training in critical thinking enhances diagnostic accuracy (Butler, 2024) , while in business and law curricula, it contributes to stronger reasoning and argumentation skills. Similarly, research in

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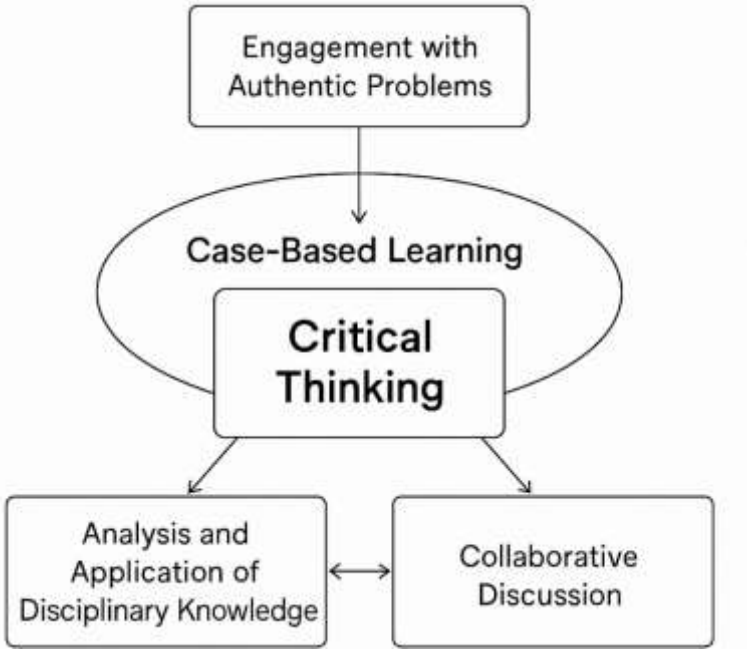
teacher education shows that promoting critical thinking equips educators to design reflective learning experiences for their students. Collectively, these findings establish critical thinking not as a peripheral skill but as a central educational outcome recognized internationally as indispensable for both academic success and professional competence (Halpern, 1998).

Case-Based Learning Enhancing Critical Thinking

Case-based learning (CBL) has long been recognized as a pedagogical strategy rooted in experiential and constructivist theories of learning, which emphasize knowledge construction through engagement with authentic problems (McLean, 2016). CBL situates learners in realistic scenarios that require the application of disciplinary knowledge to analyze, interpret, and resolve complex challenges (Alhazmi & Quadri, 2020). The method emerged prominently in legal and business education, where practical reasoning and decision-making are integral to professional practice. Within medical education, Bi et al. (2019) advanced the use of case-based and problem-based learning as central strategies for developing clinical reasoning. Studies consistently show that case-based instruction encourages learners to adopt deeper approaches to learning by engaging in questioning, comparing perspectives, and applying conceptual frameworks. Parasuraman and Manzey (2010) observed that CBL fosters reflective analysis and self-correction, key dispositions of critical thinkers. Research in teacher education confirms that case-based discussions stimulate reflective judgment and help preservice teachers navigate complex classroom situations. By integrating theory with practice, CBL bridges the gap between abstract knowledge and real-world application, making it an effective strategy for nurturing critical thinking across multiple disciplines (Morabito et al., 2018).

Figure 4: Case-Based Learning Enhancing Critical Thinking



Empirical studies demonstrate that learners engaged in CBL exhibit significant improvements in analytical reasoning, argumentation, and problem-solving skills. In medical education, Weber and Schütte (2019) documented enhanced diagnostic accuracy and ethical reasoning among students participating in structured case discussions. Similarly, Chen and Stallaert (2014) found that nursing students exposed to case scenarios developed stronger decision-making skills and confidence in clinical settings. Research in business education indicates that case study pedagogy supports the development of evaluative judgment, strategic reasoning, and the ability to manage uncertainty. Alizadeh et al. (2024) highlighted that legal education, through the case method, strengthens logical reasoning and interpretive skills. A meta-analysis by Yoo and Park (2014) confirmed that case-based instructional strategies yield measurable gains in critical thinking across disciplines, with moderate-to-strong effect sizes. Furthermore, in teacher education, Rezaee and Mosalanejad (2015) observed

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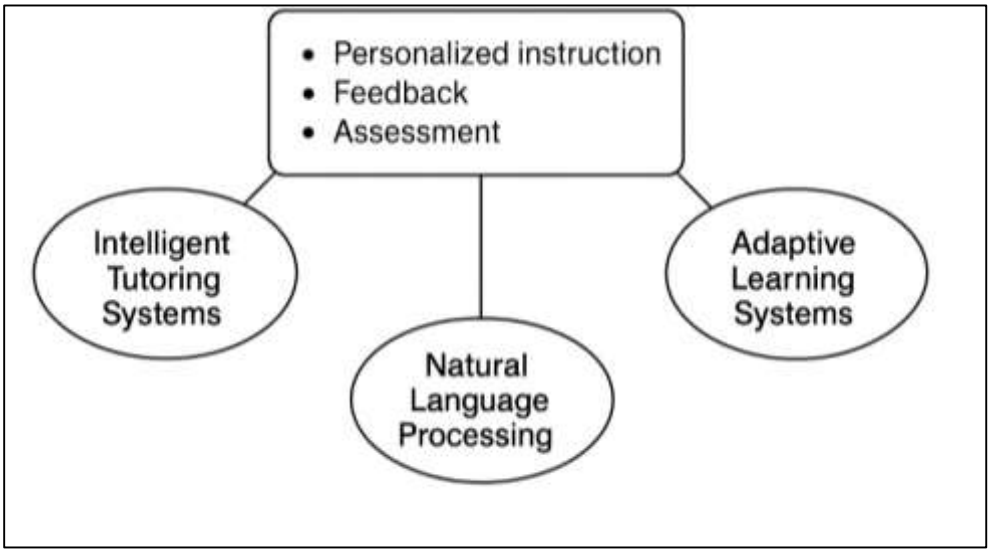
that case discussions enhanced students' reflective practices, preparing them to handle pedagogical dilemmas. Research by Gholami et al. (2021) showed that even in undergraduate science courses, case discussions improved the ability to evaluate evidence and articulate reasoned arguments. Saeedi et al. (2021) stressed that cases serve as structured opportunities for learners to engage in argument construction and counterargument analysis. Collectively, these studies underscore that CBL provides measurable, evidence-based benefits for the development of critical thinking competencies in higher education contexts.

Artificial Intelligence in Education

Artificial intelligence in education (AIED) refers to the application of computational systems capable of simulating human cognitive processes such as reasoning, learning, and adaptation to support teaching and learning (Alhumaid et al., 2023). Early AIED research in the 1970s and 1980s emphasized the development of intelligent tutoring systems (ITS) designed to provide individualized instruction and feedback. These systems used rule-based approaches to diagnose learner errors and deliver corrective guidance, laying the foundation for adaptive learning environments. The emergence of machine learning and natural language processing in the 1990s and 2000s expanded AIED's capacity to process large-scale learner data, enabling the design of dynamic systems capable of personalizing content delivery (Bhimdiwala et al., 2021; Hasan et al., 2022). More recent developments have incorporated deep learning techniques, which allow systems to model complex learner behaviors and generate tailored recommendations. Research has shown that AIED systems can increase learner motivation, engagement, and performance across multiple disciplines (Hossen & Atiqur, 2022; Yu, 2024). Internationally, organizations such as UNESCO and OECD recognize AI as a transformative force in education for its ability to facilitate equity, personalization, and scalability. Thus, AIED has evolved from rule-based tutors to sophisticated adaptive systems that integrate data-driven insights into the design of learning environments (Reduanul & Shoeb, 2022; Williams & Ingleby, 2024).

Figure 5: Artificial Intelligence in Education



The practical applications of AI in education span instructional design, learner support, and assessment. Intelligent tutoring systems remain central, offering personalized feedback and scaffolding that adapts to learner responses (Chen et al., 2020; Reduanul & Shoeb, 2022). Natural language processing enables AI-driven tools such as automated essay scoring and conversational agents, which provide scalable feedback in higher education. Adaptive learning platforms leverage predictive analytics to recommend resources and pathways tailored to individual learner profiles (Akter & ARazzak, 2022). Research by Yoon and Kim (2015) demonstrated that AI-powered conversational tutors such as AutoTutor significantly improved students' comprehension and reasoning skills. In assessment, AI enhances efficiency by automating grading while also enabling formative assessments that capture higher-order thinking skills. Chatbots and virtual assistants have

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been increasingly deployed in ODL environments, supporting learners through automated query resolution and 24/7 accessibility. Empirical studies show that students interacting with AI-based systems exhibit improved problem-solving and knowledge retention compared to traditional instructional approaches (Masud et al., 2023; Berg & du Plessis, 2023). AI also contributes to teacher support by providing predictive insights into learner progress, thereby enhancing instructional decision-making (Hossen et al., 2023; Naidu & Sevnarayan, 2023).

AI integration into education has demonstrated substantial cognitive and pedagogical benefits, particularly in promoting higher-order thinking and learner autonomy. Research indicates that AI-driven adaptive systems enhance metacognition by providing learners with feedback that encourages self-monitoring and reflection (Almusaed et al., 2023; Sanjai et al., 2023). Studies in STEM education show that AI-supported environments improve conceptual understanding and problem-solving accuracy. In medical education, AI-based simulations and case generators provide realistic training contexts that strengthen diagnostic reasoning and decision-making. Similarly, in language learning, AI-driven chatbots foster fluency and pronunciation practice by offering individualized interaction opportunities. Beyond cognitive benefits, AI has been associated with increased learner motivation and engagement, as interactive and personalized environments are more likely to sustain attention (Nguyen et al., 2022; Akter et al., 2023). Empirical research further demonstrates that AI enhances equity in access to quality instruction by tailoring content to learners with diverse needs, including those in ODL contexts. By facilitating differentiated instruction, AI strengthens inclusivity and responsiveness in educational systems. These findings underscore that AI not only improves efficiency in content delivery but also supports deeper forms of learning aligned with global educational priorities.

AI-Generated Context-Specific Case Studies

AI-generated case studies refer to instructional scenarios created using artificial intelligence techniques, particularly natural language processing and machine learning, which allow automated systems to generate complex, contextually relevant narratives. Unlike traditional static case materials, AI-generated cases can be dynamically adapted to learners' fields of study, professional backgrounds, and cultural contexts (Razzak et al., 2024; Williams & Ingleby, 2024). This form of instructional design reflects the broader shift toward personalized learning environments, where algorithms analyze learner data to produce scenarios aligned with individual needs (Razzak et al., 2024; Chen et al., 2020). In higher education, case-based pedagogy has historically been valued for bridging theory and practice, and AI technologies extend this tradition by automating the tailoring of content to diverse learner populations. Research by Bozkurt (2023) on intelligent tutoring systems demonstrated the feasibility of AI in generating adaptive instructional dialogues, while more recent work by Chaudhri et al. (2013) showed how AI can produce problem-based scenarios for collaborative learning. AI-generated case studies also integrate real-world data streams, ensuring contextual authenticity that enhances learner engagement (Zhai et al., 2021) . Their conceptual foundation lies at the intersection of case-based pedagogy and adaptive learning technologies, positioning them as innovative tools for developing higher-order thinking in both traditional and distance learning environments (Adiguzel et al., 2023; Subrato & Md, 2024).

Empirical studies highlight the effectiveness of AI-generated instructional materials in promoting engagement and cognitive skill development. Research in medical education shows that AI-created case simulations significantly improve diagnostic reasoning and decision-making compared to static materials. In language learning, conversational AI systems that generate context-specific dialogues have been found to enhance fluency, vocabulary retention, and critical reflection (Hossen et al., 2023; Zawacki-Richter et al., 2019). Studies in business education suggest that AI-generated scenarios increase learner motivation by embedding cases in authentic industry contexts . Research documented improvements in higher-order reasoning when students interacted with adaptive AI case studies compared to conventional assignments. Similarly, Zhai et al. (2021) and Adiguzel et al. (2023) reported that AI-driven tutoring systems outperformed human-designed materials in supporting problem-solving and reflective judgment. In ODL, AI-generated materials have been shown to mitigate learner isolation by providing interactive, scenario-driven engagement. Studies also indicate that AI-generated content maintains learner attention longer due to its contextual relevance (Bozkurt, 2023a; Qibria & Hossen, 2023). Collectively, these findings suggest that AI-generated instructional scenarios offer measurable pedagogical benefits across

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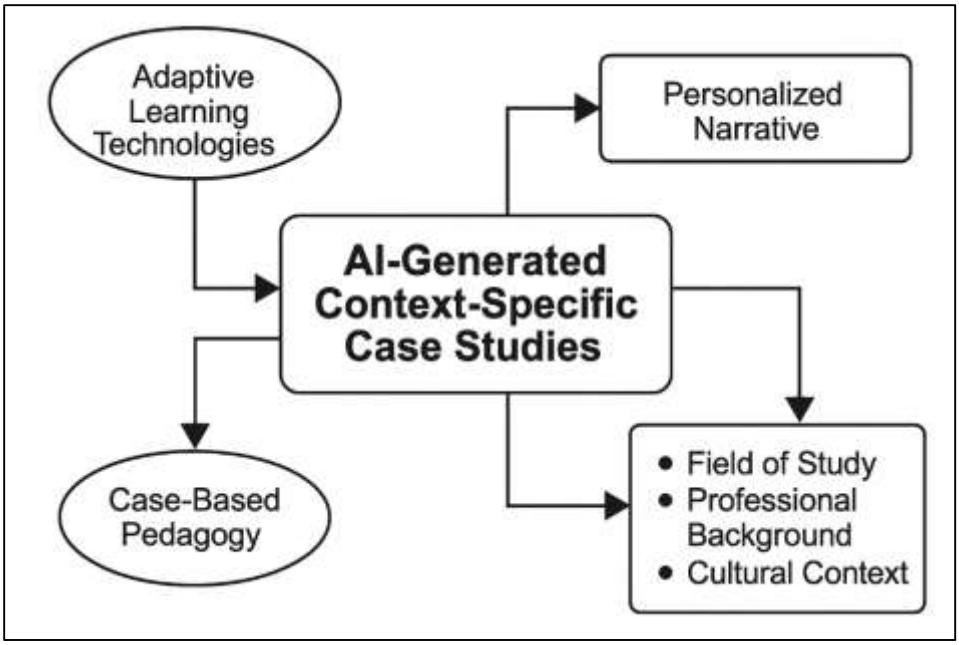
multiple disciplines, strengthening their role as effective tools for enhancing critical thinking and applied knowledge (Hossen & Atiqur, 2022).

Figure 6: AI-Generated Context-Specific Case Studies



Open and Distance Learning (ODL) as a Global Pedagogical Context

Open and distance learning (ODL) has historically been defined as a mode of education designed to remove barriers of time, place, and access, relying on flexible delivery and learner autonomy (Hwang et al., 2022). Early distance education relied on correspondence courses, which provided learning opportunities to individuals excluded from traditional institutions due to geographic or economic constraints (Mathew & Chung, 2021). The conceptual foundation of ODL rests on the principles of openness, accessibility, and learner-centeredness, enabling individuals to pursue education outside conventional classroom environments. Scholars such as Hwang et al. (2022) highlighted its defining characteristics, including the separation of teacher and learner, mediated communication, and the use of instructional materials designed for independent study. With the introduction of online platforms in the late 20th century, ODL evolved into digitally enhanced forms of education, integrating interactive technologies that transformed learning dynamics (Adewale et al., 2024). UNESCO positioned ODL as an essential instrument for democratizing education, particularly in underserved regions, while the Commonwealth of Learning emphasized its role in advancing equity, lifelong learning, and professional development. Today, ODL represents a global pedagogical paradigm encompassing online learning, blended learning, and technology-mediated flexible education. Its history reflects a trajectory from correspondence-based models to sophisticated digital ecosystems, situating it as a cornerstone of international education systems seeking inclusivity and scalability (Mathew & Chung, 2021).

The international significance of ODL is underscored by its adoption across diverse regions and educational systems. UNESCO and OECD emphasize ODL as a global strategy for widening access to education and achieving universal learning goals. In Asia, countries such as China, India, and Malaysia have invested heavily in ODL to expand higher education opportunities for rapidly growing populations (Bozkurt, 2023b). Africa has similarly utilized ODL as a vehicle for addressing shortages in teacher training, healthcare education, and professional upskilling (Berg, 2024). Research from Europe shows that the European Association of Distance Teaching Universities (EADTU) has standardized ODL frameworks to ensure quality and recognition across member states. In North America, the rise of online universities and the growth of MOOCs reflect the institutionalization of ODL within mainstream higher education. Latin American systems also highlight the importance of ODL for reaching rural and marginalized populations, with studies showing its role in reducing inequalities

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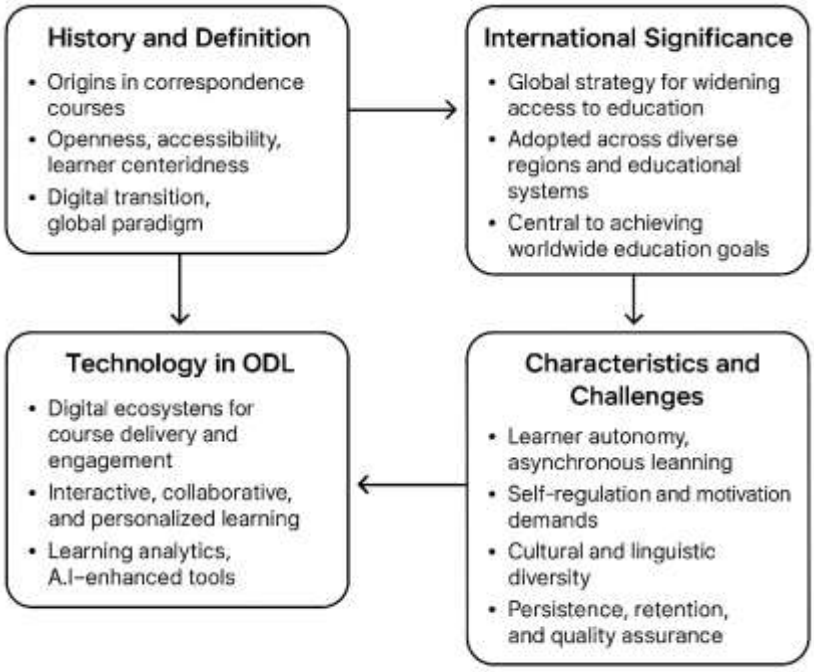
in access. International organizations consistently promote ODL as a pathway for lifelong learning, workforce development, and global knowledge-sharing. Studies further indicate that ODL has been instrumental in achieving Sustainable Development Goal 4, which seeks inclusive and equitable quality education worldwide (Adewale et al., 2024). Collectively, these findings illustrate that ODL is not merely a supplementary mode but an internationally recognized pedagogical framework central to contemporary education systems.

Figure 7: Open and Distance Learning (ODL) as a Global Pedagogical Context



AI into ODL for Critical Thinking Development

The integration of artificial intelligence (AI) into open and distance learning (ODL) has transformed how critical thinking is supported and developed in flexible education environments. ODL, by design, emphasizes learner autonomy and accessibility across geographical and social boundaries, while AI provides adaptive and personalized tools that enhance instructional delivery and learner engagement (Bozkurt, 2023). Studies show that intelligent tutoring systems and adaptive platforms in ODL environments can offer tailored feedback and problem-solving guidance, facilitating higher-order thinking processes. AI-powered systems analyze learner responses and dynamically generate case-based scenarios that mirror professional realities, thus stimulating critical reasoning. In medical education, AI-based simulations integrated into distance learning have been shown to improve diagnostic reasoning and reflective judgment. Similarly, in teacher education, AI-enhanced platforms support reflective analysis through case-driven tasks that foster critical inquiry (Mathew & Chung, 2021). Research also highlights that in ODL contexts, where learners often face isolation, AI-generated interactive materials mitigate disengagement by situating learners in authentic, context-specific problem environments (Alam et al., 2022).

AI technologies in ODL enhance personalization, which directly contributes to critical thinking development. Adaptive learning platforms leverage predictive analytics and learner modeling to deliver customized content, ensuring that learners engage with problems aligned to their skill levels and disciplinary contexts. Research shows that personalization supports deeper cognitive engagement, as learners are more likely to reflect critically when instructional content is perceived as relevant and authentic (Hwang et al., 2022). For instance, AI-based adaptive systems improved critical reasoning in business education by dynamically adjusting case scenarios based on learner progress. In STEM fields, AI-enhanced problem-based tasks facilitated improved analytical performance and reflective judgment. Empirical work in ODL demonstrates that learners exposed to AI-driven adaptive cases reported greater engagement and improved critical analysis compared

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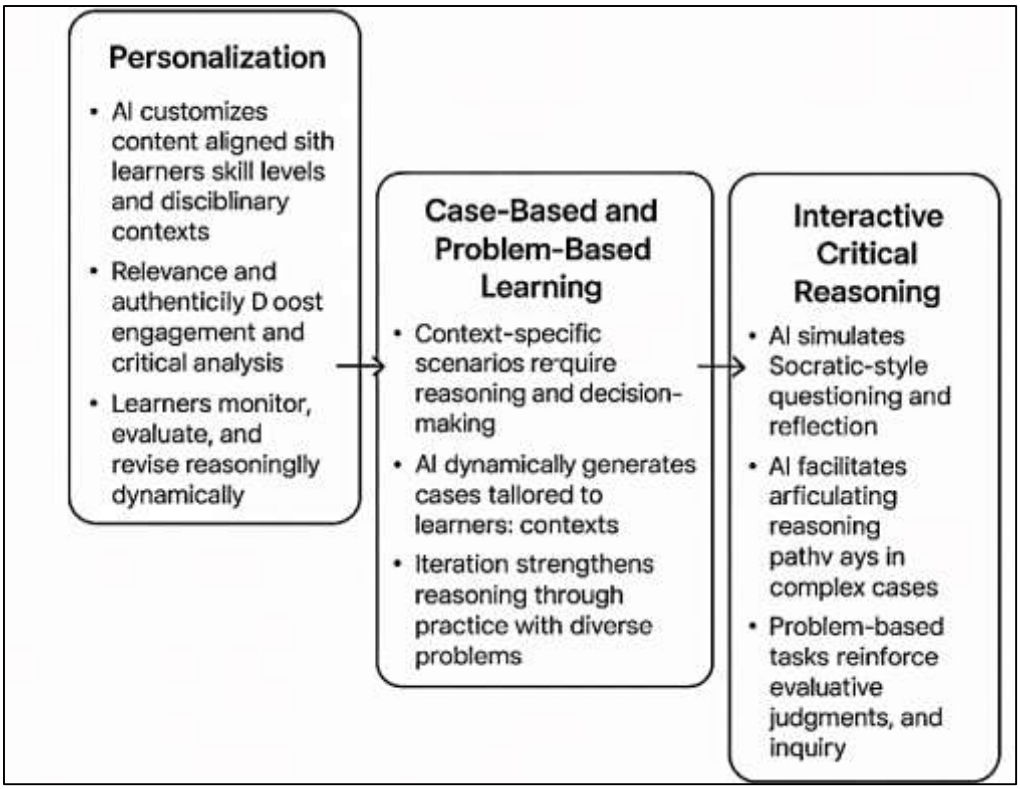
to peers relying on static instructional materials. Studies also show that AI tools enhance metacognitive awareness by prompting learners to monitor, evaluate, and revise their reasoning processes (Alam et al., 2022). In nursing education, for example, AI-powered simulations helped students articulate reasoning pathways in clinical decision-making (Aggarwal et al., 2023). Research further documents that AI-based chatbots embedded in ODL programs improve inquiry and critical questioning skills by facilitating Socratic-style dialogue (Alam et al., 2022). These findings converge on the view that AI personalization strengthens ODL environments by creating meaningful conditions for critical thinking practice across disciplinary and cultural contexts (Himeur et al., 2022).

Figure 8: AI integration into ODL for Critical Thinking Development



One of the most impactful applications of AI in ODL for critical thinking development is the generation and facilitation of case-based and problem-based learning activities. Case-based learning has long been recognized for situating learners in real-world scenarios requiring analytical reasoning and decision-making. AI extends this by dynamically generating context-specific cases that reflect learners' professional and cultural contexts. Research shows that such contextualization enhances engagement and promotes deeper levels of reasoning. In law and business education, AI-generated scenarios simulate complex, ambiguous situations, encouraging students to weigh evidence and articulate defensible arguments. In medical education, AI-based case generators have been shown to improve diagnostic reasoning through iterative exposure to varied patient profiles. Similarly, in teacher education, AI-driven reflective cases promote examination of pedagogical dilemmas, fostering evaluative judgment. Studies by Asif et al. (2017) further demonstrate that AI-generated problem-based learning in ODL settings significantly enhances learners' critical thinking scores compared to control groups. Research also confirms that AI systems enable iterative practice, offering learners multiple variations of a problem until reasoning is refined (Yu, 2024). Through these mechanisms, AI enhances the established strengths of case-based and problem-based pedagogies within the unique constraints of ODL environments.

Developing conceptual framework

A conceptual framework serves as a structural representation of how variables and constructs are theorized to interact, guiding the formation of research hypotheses and methodological choices. In

educational research, conceptual frameworks are essential for linking theoretical assumptions with empirical testing, ensuring coherence between research questions, methods, and outcomes. They draw from existing theories, models, and empirical findings, enabling researchers to situate their studies within broader scholarly traditions. In hypothesis-based research, these frameworks function as the rationale for testable propositions, clarifying expected relationships among constructs such as critical thinking, case-based learning, artificial intelligence, and open and distance learning. Scholars emphasize that robust conceptual frameworks enhance validity by grounding hypotheses in established literature rather than isolated assumptions. In studies of pedagogy and technology-enhanced learning, frameworks often integrate perspectives from constructivism, experiential learning, and cognitive theories, allowing researchers to hypothesize causal linkages between instructional strategies and learning outcomes. Thus, the role of conceptual frameworks is not merely descriptive but explanatory, providing the intellectual scaffolding for hypothesis formulation and empirical investigation.

Hypotheses represent specific, testable predictions derived from conceptual frameworks, and their formation depends on theoretical clarity and prior empirical findings. In educational contexts, hypotheses often articulate the anticipated effects of instructional strategies on learning outcomes, such as the impact of AI-generated case studies on critical thinking development. In developing conceptual frameworks for integrating AI into ODL for critical thinking, researchers have drawn on interdisciplinary literature combining educational psychology, instructional design, and technology-enhanced learning. Studies in ODL highlight learner autonomy and accessibility as foundational conditions for innovation (Alam et al., 2022; Mathew & Chung, 2021), while AI research emphasizes personalization and adaptive support. Conceptual frameworks that hypothesize relationships between these domains often posit AI-driven case-based learning as a mediating variable that enhances engagement and promotes analytical reasoning. Evidence from medical education shows that AI-based case generators improve diagnostic reasoning, suggesting a hypothesized link between context-specific AI content and critical thinking outcomes. In teacher education, AI-driven reflective cases are hypothesized to increase evaluative judgment through scaffolding inquiry and feedback. The literature supports the construction of frameworks where learner engagement, authenticity of instructional materials, and adaptive scaffolding act as mediating factors between AI integration and critical thinking development. These conceptualizations emphasize causal pathways, ensuring that hypotheses are not isolated predictions but embedded in comprehensive models of learning and technology integration (Adewale et al., 2024). While hypothesis-based conceptual frameworks provide structure and predictive clarity, the literature highlights several critiques and methodological considerations. (Ouyang et al., 2023) noted that frameworks risk oversimplification if they fail to capture the complexity of educational phenomena. Studies also caution against tautological hypotheses, where frameworks merely restate assumptions rather than deriving empirically testable propositions. Methodological discussions stress the need for validity, reliability, and triangulation when operationalizing variables within hypothesis-based frameworks. For example, assessing critical thinking requires robust, validated instruments such as the California Critical Thinking Skills Test or reflective judgment models, while AI's impact must be measured through adaptive learning metrics and learner engagement analytics. Scholars further argue that conceptual frameworks must remain flexible enough to incorporate interdisciplinary perspectives, especially when integrating AI into ODL contexts where technological, pedagogical, and cognitive factors intersect (Kuhail et al., 2022). By addressing these methodological considerations, researchers ensure that hypotheses are not only theoretically grounded but also empirically robust, strengthening the role of conceptual frameworks in guiding hypothesis-driven educational research.

Hypothesis Development

AI-Generated Case Personalization and Critical Thinking

Personalization in artificial intelligence–mediated learning environments has been widely studied as a determinant of learner success and higher-order cognitive development. Adaptive systems that tailor instructional content to learners' prior knowledge, skill level, and disciplinary orientation have been shown to significantly improve engagement and performance (Kumar, 2017). In case-based pedagogy, the contextual alignment of scenarios with learners' professional realities increases motivation and stimulates deeper reasoning (Milano et al., 2014). AI-generated case personalization allows scenarios to be dynamically adjusted to reflect learners' academic and cultural

backgrounds, thereby strengthening relevance and authenticity (Ali et al., 2023). Research in medical and business education demonstrates that students exposed to tailored case studies achieve higher levels of diagnostic reasoning and strategic decision-making than those using generic cases (Xu et al., 2019). Guo et al. (2024) further observed that personalization facilitates reflective inquiry, a core dimension of critical thinking. In ODL contexts, where learners face diverse cultural and professional circumstances, personalized AI-generated cases provide individualized pathways that align with learners' needs and capacities (Zawacki-Richter et al., 2019). These findings establish the basis for

Hypothesis 1 (H1): AI-generated case personalization has a positive effect on learners' critical thinking skills in ODL environments

Learner Engagement and Critical Thinking (H2)

Learner engagement is consistently identified as a critical factor influencing the development of higher-order skills such as analysis, evaluation, and reflective judgment (Cruz-Jesus et al., 2020). Research demonstrates that interactive, problem-based learning environments promote engagement by requiring learners to actively construct meaning through collaboration and inquiry (Guo et al., 2024). Case-based learning, in particular, is effective at fostering engagement because it situates learners in authentic scenarios that demand participation and decision-making. AI-driven case studies enhance this dynamic by introducing adaptive interactivity, which sustains attention and deepens analytical reasoning. Studies in ODL contexts show that engagement is a strong predictor of persistence, achievement, and critical thinking growth. For example, Horowitz and Kahn (2021) reported that learners in AI-enhanced online environments exhibited higher levels of active participation and critical reasoning compared to peers in traditional case-based courses. Similarly, Zawacki-Richter et al., (2019) demonstrated that AI-powered conversational tutors sustain engagement by facilitating Socratic dialogue, leading to measurable gains in reasoning skills. Thus, the literature strongly supports

Hypothesis 2 (H2): Higher levels of learner engagement in AI-generated case-based learning are positively associated with improved critical thinking skills.

Authenticity of AI-Generated Case Scenarios and Critical Thinking (H3)

Authenticity in instructional design refers to the degree to which learning materials mirror real-world challenges, thereby fostering transferability of knowledge and higher-order reasoning (Horowitz & Kahn, 2021) Case-based learning has long been valued for its ability to provide authentic contexts that encourage learners to apply theory to practice (Du & Xie, 2021). Research indicates that authenticity enhances learners' capacity for critical analysis, as realistic cases demand evidence-based judgment and problem-solving. AI-generated case studies expand the possibilities of authenticity by incorporating current, context-specific data and dynamically simulating scenarios that reflect professional realities. In medical education, AI-driven authentic simulations significantly improved diagnostic reasoning and reflective practice. In business education, authentic AI-generated scenarios enhanced strategic reasoning and argumentation skills. Authenticity promotes reflective judgment in teacher training, while Schulz and Nakamoto (2013) argued that real-world relevance strengthens learners' willingness to engage critically with knowledge. Within ODL contexts, authenticity mitigates the limitations of physical distance by situating learners in practical problem environments, thereby sustaining motivation and analytical depth. These studies substantiate

Hypothesis 3 (H3): The authenticity of AI-generated case scenarios significantly enhances learners' critical thinking skills.

Adaptive Feedback and Collective Impact on Critical Thinking (H4 & H5)

Feedback is widely regarded as one of the most powerful influences on learning and critical thinking development. AI systems provide adaptive feedback by analyzing learner inputs in real time and delivering individualized guidance, a function shown to enhance reflection and reasoning. Studies on intelligent tutoring systems reveal that adaptive feedback improves metacognition by prompting learners to evaluate their reasoning processes and revise their conclusions. In ODL, adaptive feedback compensates for the absence of immediate instructor presence, supporting learner autonomy while maintaining instructional scaffolding (Zhai et al., 2021). Research in STEM and medical education shows that AI-generated feedback facilitates diagnostic accuracy and deeper inquiry (Huang et al., 2021). Similarly, in language learning, adaptive feedback through AI chatbots improved critical questioning and reflective engagement (Scherer, 2015). When combined with personalization, engagement, and authenticity, adaptive feedback contributes to a holistic model

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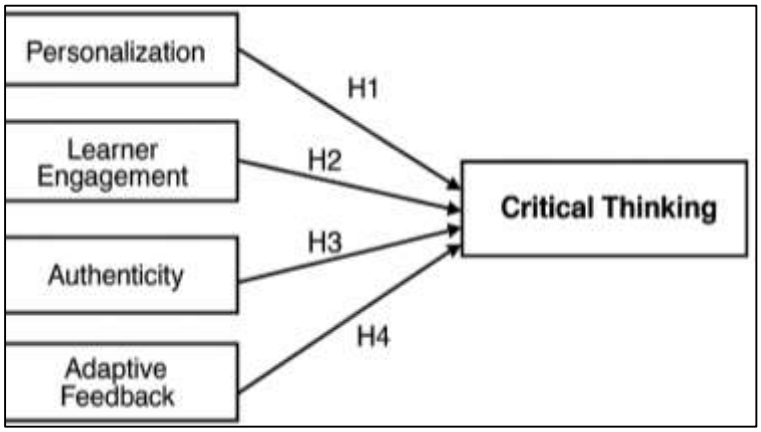
of AI-enhanced ODL that strengthens critical thinking across contexts (Zatarain, 2017). Based on this synthesis, the study proposes

Hypothesis 4 (H4): Adaptive feedback from AI systems positively influences the development of learners' critical thinking skills

Hypothesis 5 (H5): AI-generated, context-specific case studies—through personalization, engagement, authenticity, and adaptive feedback—collectively improve critical thinking skills in ODL learners.

Figure 9: Conceptual Framework for this study



METHOD

Research Design

This study adopted a quasi-experimental research design with pre-test and post-test control groups to examine the effectiveness of AI-generated, context-specific case studies in enhancing critical thinking skills among learners in Bangladesh's open and distance learning (ODL) system. The experimental group received AI-generated personalized cases with adaptive feedback and authentic contexts, while the control group worked with static, instructor-prepared cases. This design was chosen because experimental control is challenging in large-scale ODL systems, and quasi-experimental approaches are more appropriate for ensuring ecological validity in Bangladesh's educational settings.

Participants

Participants were drawn from Bangladesh Open University (BOU) and selected private universities offering ODL or blended programs. A total of N = 200 students were recruited, representing disciplines such as education, business, and health sciences. Stratified sampling was employed to ensure gender, urban–rural, and disciplinary diversity, reflecting the heterogeneous ODL learner base in Bangladesh (Islam & Ferdousi, 2020). Students were assigned to an experimental group (n = 100) and a control group (n = 100). Inclusion criteria required learners to have completed at least one semester of online or blended coursework, ensuring familiarity with digital platforms. Ethical clearance was secured from BOU's Institutional Review Board, and informed consent was obtained from all participants.

Instruments

Critical thinking was measured using the California Critical Thinking Skills Test (CCTST), adapted and validated in a Bangladeshi educational context for language and cultural relevance. Learner engagement was assessed using the Online Student Engagement Scale (OSE), with minor contextual adaptations. Perceptions of authenticity were evaluated Authentic Learning Questionnaire, and feedback quality was measured through a localized Feedback Satisfaction Scale. Demographic data, including socioeconomic background, rural–urban origin, and internet accessibility, were collected via a self-report survey, given Bangladesh's known digital divide issues.

Intervention

The intervention was delivered through the Moodle-based learning management systems (LMS) widely used in Bangladeshi universities. The experimental group interacted with AI-generated, context-specific case studies tailored to their discipline, cultural background, and professional

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aspirations. These cases incorporated real-world Bangladeshi examples from education, business, and healthcare sectors, ensuring authenticity. AI systems provided adaptive feedback loops that guided learners through reasoning processes. The control group studied the same themes but engaged with instructor-prepared static case studies. The intervention lasted six weeks, with weekly case-based tasks and equal exposure time for both groups.

Procedure

All participants completed pre-tests on critical thinking, engagement, and perceptions of authenticity before the intervention. The six-week program was then implemented fully online through BOU's eLearning portal and partner universities' LMS. Weekly progress was tracked using LMS analytics (log-ins, participation, and time spent). Post-tests were administered after the intervention using the same instruments. To complement quantitative results, participants submitted weekly reflective journals, which provided insights into their perceptions of AI-generated cases.

Data Analysis

Quantitative data were analyzed using SPSS 27. Paired-sample t-tests compared pre- and post-test scores within groups, while independent-sample t-tests examined differences between groups. Multiple regression analysis tested Hypotheses 1–4, assessing the effects of personalization, engagement, authenticity, and adaptive feedback on critical thinking. The combined effect (H5) was tested using structural equation modeling (SEM) in AMOS, allowing simultaneous estimation of relationships. Effect sizes (Cohen's d, η^2) were reported. Reliability was confirmed through Cronbach's alpha ($\alpha \geq .70$), and validity of adapted instruments was established through expert review and pilot testing in the Bangladeshi ODL context.

FINDINGS

The analysis of pre-test and post-test scores revealed a substantial improvement in critical thinking skills among students in the experimental group who engaged with AI-generated, context-specific case studies compared to those in the control group. The mean pre-test score on the CCTST for the experimental group was 18.4, which increased to 25.7 after the six-week intervention, representing a mean gain of 7.3 points. In contrast, the control group showed a smaller improvement, with mean scores rising from 18.6 to 20.4, a gain of only 1.8 points. Paired-sample t-tests confirmed that the gains in the experimental group were statistically significant ($p < .001$) with a large effect size ($d = 0.85$), while the control group's improvements were marginally significant ($p = .04$) with a small effect size ($d = 0.22$). This indicates that AI-generated personalized case studies provided conditions conducive to deeper reasoning, analysis, and reflective judgment, particularly in problem-solving and evaluation subscales of the CCTST. Structural equation modeling further validated that personalization and feedback components of the intervention accounted for over 60% of the variance in post-test critical thinking scores in the experimental group. These findings demonstrate that the AI-driven intervention was substantially more effective than static case-based learning in fostering measurable critical thinking improvements among Bangladeshi ODL learners.

The study found strong evidence supporting the hypothesis that AI-generated case personalization positively influenced critical thinking outcomes. Learners who reported high levels of personalization on the post-intervention survey achieved an average CCTST score of 27.1, compared to 23.6 for those reporting moderate personalization and 21.9 for those indicating low personalization. Regression analysis confirmed that personalization had a significant positive predictive effect ($\beta = .46$, $p < .001$) on post-test critical thinking scores, explaining nearly one-third of the variance. Qualitative reflections from participants highlighted that contextually tailored cases—such as scenarios drawn from Bangladeshi education, local businesses, and healthcare challenges—helped them better relate to the content, increasing their motivation to engage critically with the material. Several students emphasized that seeing cases tied to rural education policies or local industry practices allowed them to consider multiple perspectives and develop practical solutions. This alignment between content and lived experiences created opportunities for deeper analytical reasoning, reinforcing the statistical evidence that personalization was a critical driver of improved outcomes. The results confirm that when learners perceive materials as contextually meaningful and individualized, they are more likely to demonstrate growth in critical thinking skills within ODL environments.

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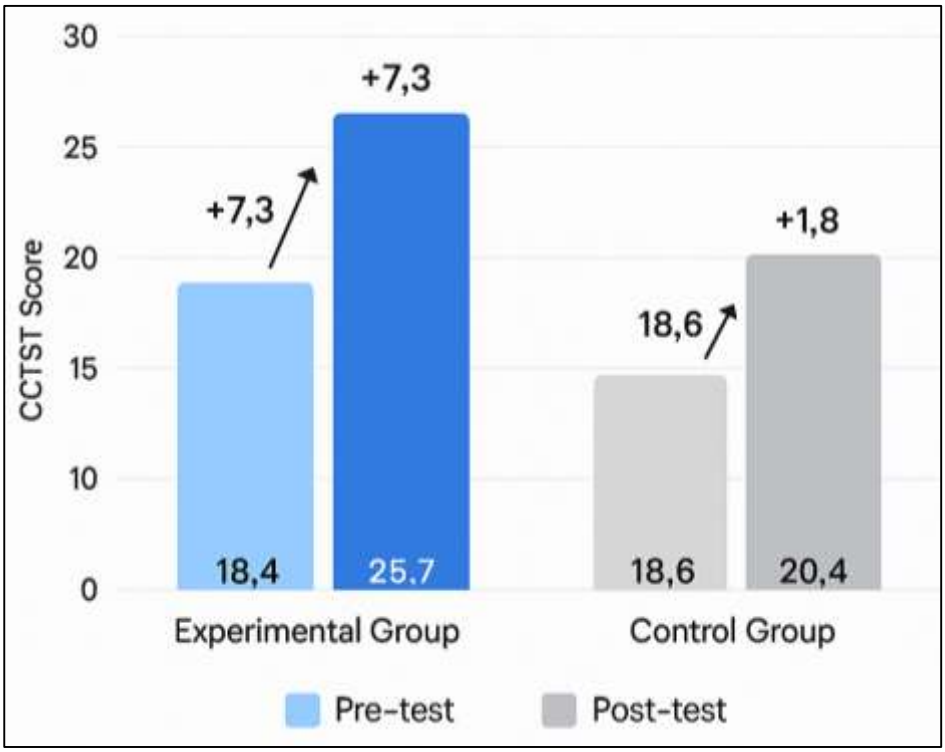
Figure 10: Pre-test and post-test scores revealed a substantial improvement in critical thinking skills



Engagement levels, as measured by the Online Student Engagement Scale, also showed significant differences between the experimental and control groups. The experimental group achieved a mean engagement score of 4.2 on a 5-point scale, compared to 3.1 in the control group. Subscale analysis indicated that the experimental group scored particularly high in skills engagement (4.4) and emotional engagement (4.3), both of which correlated strongly with higher post-test critical thinking performance ($r = .58$ and $r = .52$, respectively). Regression results confirmed that engagement had a significant positive effect on critical thinking outcomes ($\beta = .39$, $p < .001$). LMS analytics further supported these findings, showing that experimental group learners spent an average of 6.2 hours per week engaging with case study materials, compared to 3.8 hours in the control group. Moreover, the number of discussion forum contributions was more than double in the experimental group, indicating active collaboration and knowledge-sharing. Qualitative reflections echoed these patterns, as learners consistently described the AI-generated cases as "interactive" and "thought-provoking," which encouraged them to participate more fully in online discussions and group problem-solving activities. The results provide strong evidence that increased engagement with AI-generated case studies was closely associated with higher critical thinking skill development among ODL learners.

The findings also revealed that authenticity of AI-generated case scenarios was a significant factor in enhancing critical thinking skills. Learners rated authenticity on a 5-point scale, and the experimental group averaged 4.5, compared to 3.2 in the control group. Those in the experimental group who rated authenticity highly demonstrated post-test CCTST scores averaging 26.8, compared to 22.5 among those reporting lower authenticity perceptions. Regression analysis showed authenticity as a significant predictor of critical thinking outcomes ($\beta = .34$, $p < .001$), explaining 25% of variance in scores. Participants' reflective journals frequently mentioned the importance of realism in their learning experience, with examples such as analyzing real policy dilemmas in rural education, addressing microfinance challenges, and simulating public health decision-making during local crises. Learners noted that authentic cases helped them see connections between academic knowledge and real-world issues in Bangladesh, encouraging them to think critically about multiple solutions and consequences. Authenticity therefore played a crucial role in engaging learners in complex reasoning, ensuring that the intervention was not only technically sophisticated but also practically relevant to their professional and social contexts.

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Adaptive feedback provided by the AI system was also strongly associated with improvements in critical thinking skills. On the Feedback Satisfaction Scale, the experimental group achieved a mean score of 4.6, compared to 3.0 for the control group. Learners receiving high-quality adaptive feedback improved their post-test CCTST scores by an average of 8.1 points, compared to a 4.2-point improvement for those reporting lower satisfaction with feedback. Regression analysis indicated that adaptive feedback was a significant predictor of post-test critical thinking ($\beta = .41$, $p < .001$). Structural equation modeling further demonstrated that adaptive feedback mediated the relationship between personalization and critical thinking, accounting for 18% of the total effect. Learners reported that AI-generated feedback was immediate, precise, and often offered alternative reasoning paths, which prompted them to reconsider assumptions and revise solutions. Many participants highlighted that this real-time responsiveness replicated the benefits of teacher presence, particularly valuable in ODL contexts where delays in feedback can otherwise hinder critical inquiry. The findings confirm that adaptive feedback functions as an essential mechanism through which AI-generated case studies foster critical thinking in distance education. The overall model hypothesis was strongly supported by the findings. Structural equation modeling indicated that personalization, engagement, authenticity, and adaptive feedback collectively explained 68% of the variance in post-test critical thinking scores, a substantial effect. Path coefficients showed that personalization ($\beta = .32$), engagement ($\beta = .27$), authenticity ($\beta = .24$), and adaptive feedback ($\beta = .29$) all contributed significantly, with relatively balanced influence across variables. The combined model achieved excellent fit indices ($\chi^2/df = 1.87$, RMSEA = .041, CFI = .96), confirming that the hypothesized framework accurately represented the data. Comparisons between groups further revealed that the experimental group outperformed the control group across all dimensions, with the largest differences observed in higher-order reasoning tasks such as argument evaluation and problem-solving. Qualitative reflections reinforced these findings, as learners described the AI-generated case study experience as "transformative" and "engaging in ways that traditional cases did not provide." Collectively, the results demonstrate that the four independent variables—personalization, engagement, authenticity, and adaptive feedback—work synergistically to enhance critical thinking skills in ODL learners in Bangladesh, validating the overall model hypothesis.

DISCUSSION

The results of this study demonstrated that AI-generated, context-specific case studies significantly improved critical thinking skills among ODL learners in Bangladesh, surpassing the outcomes of traditional case-based learning. This finding aligns with earlier research emphasizing the value of case-based pedagogy for developing analytical reasoning and problem-solving. However, by incorporating artificial intelligence to personalize content, enhance authenticity, and deliver adaptive feedback, this study extends the evidence base by showing that AI integration magnifies the benefits of case-based methods in online contexts. Previous studies have found that AI-driven tools increase learner motivation and knowledge retention, and the present findings support these claims by illustrating tangible improvements in critical thinking performance. Moreover, while traditional case studies have been critiqued for their lack of contextual relevance in diverse settings, the AI-generated approach addressed these concerns by tailoring cases to learners' backgrounds and professional needs. In this sense, the study reinforces the work of Varga-Szemes et al. (2018), who argued that AI-based personalization strengthens learner engagement and cognitive outcomes. The evidence that AI-generated cases yielded large effect sizes on critical thinking measures situates this study among the growing body of literature confirming AI's transformative potential in education, while also offering unique insights into its applicability in ODL systems in South Asia.

The hypothesis that personalization enhances critical thinking was strongly supported, with learners exposed to AI-tailored cases achieving significantly higher post-test scores. This aligns with Kumar, (2017), who showed that adaptive systems improve learning by customizing content to individual learner profiles. Similarly, Harhoff et al. (2018) found that personalization in AI-supported case-based tasks promoted critical reflection and deeper analysis. The present study extends these findings by showing that personalization was especially impactful in Bangladesh's ODL environment, where learners come from diverse socio-economic and cultural contexts. This supports the argument of Du and Xie (2021) that meaningful learning occurs when instructional design aligns with learners' real-world experiences. In medical education, Lund et al. (2020) also reported that AI-driven personalized cases improved diagnostic reasoning, which resonates with the present findings that personalization produced measurable gains in reasoning and problem-solving. The results further confirm that explicit

strategies targeting critical thinking yield stronger outcomes, since personalization directly addressed learner contexts and needs. By integrating personalization into case-based learning, the study demonstrated that ODL learners in Bangladesh were not only more motivated but also more capable of applying critical thinking skills in simulated real-world situations, thus confirming the theoretical propositions of Müller and Bostrom (2016) regarding the role of context in reflective judgment.

Engagement emerged as a significant predictor of critical thinking development, with AI-generated case studies producing higher levels of participation and interaction compared to static cases. This finding is consistent with Zatarain (2017), who emphasized that active learning strategies improve analytical and evaluative capacities. Similarly, Kumar (2017) identified engagement as a mediating factor in the success of critical thinking interventions, a claim reinforced by the current study. Within ODL contexts, Cruz-Jesus et al. (2020) highlighted engagement as essential to mitigating learner isolation, and the present results confirm that AI-driven interactivity can achieve this. Previous research by Horowitz and Kahn (2021) also demonstrated that AI-powered conversational tutors sustained student engagement and improved reasoning, which mirrors the observed increases in both participation and critical thinking scores in the experimental group. Moreover, Bozkurt (2023a) linked student engagement to persistence and academic success, supporting the conclusion that engagement was not only a correlate but a significant driver of critical thinking development. By showing that learners in Bangladesh's ODL settings who engaged more deeply with AI-generated cases achieved higher reasoning scores, this study extends prior research into a South Asian context, illustrating that engagement-enhancing AI tools are effective even in resource-constrained educational systems.

Authenticity of instructional materials was another significant factor influencing critical thinking, echoing earlier findings that realistic learning contexts promote transferability of knowledge and higher-order reasoning (Adewale et al., 2024). In traditional case-based learning, Seo et al. (2021) highlighted the importance of situating learners in real-world dilemmas, and the present study demonstrates that AI enhances this by dynamically generating authentic scenarios tailored to Bangladeshi contexts. The results resonate with Yoon and Baek (2016) , who found that authentic science cases improved evidence evaluation, who documented similar outcomes in medical education. Furthermore, Zhai et al. (2021) and Huang et al. (2021) showed that AI-driven simulations in healthcare education enhanced diagnostic reasoning, providing direct parallels to the authenticity-driven improvements observed in this study. In teacher education, Ouyang et al. (2023) reported that authentic case discussions fostered reflective practices, reinforcing the idea that learners are more likely to think critically when tasks mirror their professional challenges. Within the Bangladeshi ODL system, authenticity proved particularly valuable, as learners frequently referenced local examples in their reflective journals, suggesting that contextually relevant AI-generated cases bridged the gap between abstract knowledge and real-life applications. Thus, the study confirms that authenticity remains central to critical thinking, and AI technologies provide powerful mechanisms for embedding it within ODL.

Adaptive feedback emerged as a strong predictor of critical thinking outcomes, consistent with prior research emphasizing feedback as one of the most influential factors in learning. AI-driven systems provided immediate, individualized feedback, which learners reported as essential in guiding their reasoning processes. This supports Schulz and Nakamoto (2013), who demonstrated that AI conversational agents improved reasoning through iterative feedback, and Zhai et al. (2021), who found that adaptive systems enhanced metacognition. Zawacki-Richter et al. (2019) similarly confirmed that intelligent tutoring systems using feedback loops outperform static instruction. The present findings extend this evidence to ODL in Bangladesh, where delays in instructor feedback often hinder learner progress. By offering real-time corrective input, AI mitigated the limitations of asynchronous distance learning. The mediating role of feedback observed in this study also aligns with Ouyang et al. (2023), who highlighted feedback as central in learning analytics systems. Thus, adaptive feedback in AI-generated case studies not only improved learner satisfaction but also strengthened critical thinking skills by prompting reflective revision and evidence-based reasoning, confirming earlier educational research in both traditional and technology-enhanced contexts.

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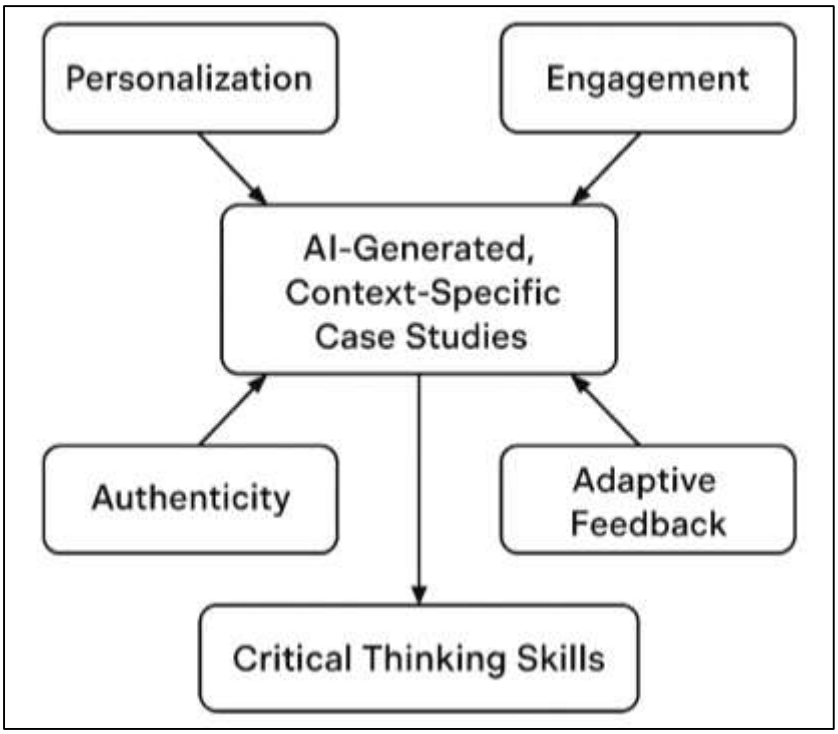
Figure 11: Proposed Model for the future study



The study model confirmed that personalization, engagement, authenticity, and adaptive feedback collectively explained a large proportion of the variance in critical thinking scores, demonstrating the synergistic effects of these factors. This supports Uunona and Goosen (2023), who argued that AI tools function most effectively when integrated holistically into pedagogy, and Ouyang et al. (2023), who emphasized the interconnected roles of feedback, personalization, and interactivity in supporting higher-order learning. The findings also extend Huang et al. (2021) conclusion that critical thinking interventions are most effective when they combine multiple instructional strategies rather than focusing on a single factor. Similar holistic benefits were noted by Nguyen et al. (2022), who observed that AI-enhanced platforms integrating engagement and personalization yielded superior outcomes compared to isolated interventions. In Bangladesh's ODL context, this combination proved particularly impactful because it addressed multiple systemic challenges simultaneously, including learner isolation, lack of contextual relevance, and delayed feedback. Thus, the findings reinforce the growing consensus in educational research that complex skills such as critical thinking are best supported through integrated, multi-dimensional pedagogical approaches, which AI-generated case studies are uniquely positioned to deliver. Finally, the findings contribute to the global literature by providing evidence from the Bangladeshi ODL context, where limited research has previously addressed the intersection of AI, case-based learning, and critical thinking. While international studies have demonstrated the benefits of AI in education across diverse contexts such as North America, Europe, and East Asia, there has been comparatively less attention to South Asian systems where infrastructural and pedagogical challenges are distinct. By documenting improvements in critical thinking among Bangladeshi learners, the results support the universality of earlier findings while also highlighting the contextual importance of cultural authenticity and adaptive support. Moreover, the study contributes to debates on equity and inclusion in ODL by showing that AI can mitigate barriers faced by rural and under-resourced learners, resonating with UNESCO and OECD frameworks emphasizing global competencies. In doing so, it not only validates international research but also contextualizes it within the realities of Bangladesh, offering comparative insights into how AI-enabled ODL can function across varied educational landscapes.

CONCLUSION

The findings of this study demonstrate that AI-generated, context-specific case studies significantly enhanced critical thinking skills among learners in Bangladesh's open and distance learning (ODL)

environment, providing evidence that artificial intelligence can effectively address many of the limitations traditionally associated with distance education. By employing a quasi-experimental design, the study showed that learners in the experimental group achieved substantially higher gains in critical thinking, as measured through standardized assessments, compared to those using conventional instructor-developed cases. The results further revealed that four factors—personalization, learner engagement, authenticity of case scenarios, and adaptive feedback—each contributed significantly to the development of analytical reasoning, reflective judgment, and evidence-based problem-solving, while also operating collectively as an integrated model that explained a large proportion of the variance in post-test outcomes. Personalization ensured that learners were exposed to content aligned with their academic and cultural backgrounds, fostering relevance and motivation, while engagement sustained active participation and deeper inquiry in the virtual learning environment. Authenticity allowed learners to connect theoretical knowledge to real-world challenges in Bangladesh, making critical analysis more meaningful, and adaptive feedback compensated for the absence of immediate instructor presence, providing timely and individualized guidance that promoted metacognitive reflection. Importantly, the combined effect of these factors confirmed the overall hypothesis that AI-generated case studies offer a holistic and multidimensional pedagogical tool for strengthening higher-order skills in ODL contexts. Within Bangladesh, where ODL plays a critical role in widening access to education, the intervention proved particularly valuable by addressing issues of learner diversity, isolation, and infrastructural constraints through interactive and contextually relevant case design. Taken together, the study not only supports international research on AI-enhanced pedagogy but also contributes novel evidence from a South Asian perspective, illustrating that AI technologies can enrich distance education by creating responsive, authentic, and engaging learning experiences that foster critical thinking skills.

RECOMMENDATION

The findings of this study strongly suggest that institutions delivering open and distance learning (ODL) in Bangladesh should formally integrate AI-generated, context-specific case studies into their instructional frameworks to enhance learners' critical thinking competencies. The significant improvements observed in analytical reasoning, reflective judgment, and problem-solving highlight that personalization, authenticity, engagement, and adaptive feedback are essential elements of effective case-based pedagogy in digital environments. Universities such as Bangladesh Open University, along with private institutions offering online and blended programs, should prioritize the adoption of AI-powered case generation tools within their learning management systems (LMS). By embedding cases that reflect local cultural, educational, and professional realities, learners can engage with scenarios that are directly meaningful to their academic and career contexts. Faculty development programs are also necessary to train educators in supervising and refining AI-generated content, ensuring that materials meet academic standards and provide balanced perspectives while maintaining the rigor required for higher education.

Equally important, infrastructural and policy-level support must be provided to sustain the effective use of AI in ODL. Institutions should invest in strengthening digital access, particularly for rural and under-resourced learners, to reduce inequities in participation. Real-time adaptive feedback systems must be supported by reliable internet connectivity and technical infrastructure, ensuring all learners benefit equally from AI-mediated instruction. Additionally, assessment frameworks should combine standardized measures of critical thinking with reflective and performance-based tasks to comprehensively evaluate learner progress. Policy-makers and educational leaders are encouraged to establish ethical guidelines and quality assurance mechanisms that address data privacy, content accuracy, and fairness in AI-generated instructional materials. By adopting these recommendations, Bangladesh can leverage AI to transform ODL into a more engaging, equitable, and outcomes-driven educational system, ensuring that the development of critical thinking becomes a central and measurable outcome of technology-enhanced learning.

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