Journal of Curriculum Studies Research

https://curriculumstudies.org

E-ISSN: 2690-2788

Volume: 7 Issue: 2 2025

pp. 498-521

Redesigning Instructional Design with an AI-Incorporated ADDIE Model for 21st Century Education

Gulzhamal Ussainova[a], Angyssyn Seitmuratov[a], Gulnara Issayeva*[b], Gulsairan Shamsudinova[c] & Lyazzat Zhanseitova[d]

* Corresponding author
Email: guka_issaeva@mail.ru
a. Department of "Physics and Mathematics", Korkyt Ata Kyzylorda University, Kyzylorda, Kazakhstan
b. Department "Methods of Teaching Mathematics, Physics and Computer Science", Abai Kazakh National Pedagogical University, Almaty, Kazakhstan.
c. Department of "Mathematics and information technologies", Kyzylorda University "Bolashak", Kyzylorda, Kazakhstan
d. Faculty of "Mathematics, physics and computer science", Abai Kazakh National Pedagogical University, Almaty, Kazakhstan

Article Info
Received: May 17, 2025
Accepted: October 19, 2025
Published: November 19, 2025

10.46303/jcsr.2025.31

How to cite
Ussainova, G., Seitmuratov, A., Issayeva, G., Shamsudinova, G., & Zhanseitova, L. (2025). Redesigning Instructional Design with an AI-Incorporated ADDIE Model for 21st Century Education. *Journal of Curriculum Studies Research*, 7(2), 498-521.
https://doi.org/10.46303/jcsr.2025.31

ABSTRACT

The growing integration of artificial intelligence (AI) in education presents new opportunities and challenges for instructional design (ID). This study aims to develop and validate an AI-Incorporated Analyze, Design, Develop, Implement, and Evaluate (ADDIE) Instructional Model that embeds AI functionalities into the five phases—Analyze, Design, Develop, Implement, and Evaluate. The model is designed to enhance instructional planning through learner diagnostics, content generation, adaptive assessments, and automated feedback. To examine the perceived necessity and applicability of AI integration in each ADDIE phase, a survey-based research design was employed. A total of 167 mathematics educators, including 143 pre-service and 24 in-service teachers, participated by responding to Likert-scale items and open-ended questions. Results indicate strong support for AI integration, especially in the Design, Develop, and Evaluate phases. Pre-service teachers prioritized support in the Implement phase, while in-service teachers emphasized the value of AI in the Evaluate phase. Despite this broad enthusiasm, participants raised concerns about data privacy, ethical implications, and the potential loss of human creativity. These findings underscore the need for balanced, ethical, and pedagogically grounded AI integration in education. The proposed model offers a structured, adaptable framework for instructional designers and educators aiming to leverage AI for learner-centered and technology-enhanced teaching.

KEYWORDS

ADDIE model; AI in education; artificial intelligence; instructional design; teacher perspectives.

INTRODUCTION

Instructional design (ID) models provide systematic frameworks for creating effective, learner-centered educational experiences across institutions. Among these, the widely used ADDIE model (Branch, 2009)—comprising the Analyze, Design, Develop, Implement, and Evaluate phases—has long served as a foundational approach in both K–12 and higher education. Today, the rapid integration of artificial intelligence (AI) into education has introduced new possibilities for enhancing each stage of ID with data-driven, adaptive, and personalized capabilities. As educators face growing demands for inclusivity, scalability, and differentiation, embedding AI into ID frameworks is increasingly seen as essential rather than optional (Holmes et al., 2019).

Advances in generative AI, machine learning, and learning analytics now enable educators to analyze learner data more effectively, automate instructional content creation, adapt learning pathways in real time, and conduct more nuanced evaluations of student progress (Balta, 2025; Chen et al., 2020; Zawacki-Richter et al., 2019). These innovations are transforming traditional instructional practices and reshaping the educator's role into that of a facilitator of personalized learning environments. Despite the growing interest in AI-supported education, however, few studies have proposed systematic frameworks that show how AI tools can be purposefully integrated into each phase of an established ID model, such as ADDIE.

There is growing evidence that integrating AI into instructional models improves learning outcomes, especially in areas such as learner engagement, content adaptability, and real-time feedback (Baytak, 2024; Lin et al., 2023; Ogurlu & Mossholder, 2023; Xie et al., 2019). AI technologies, including intelligent tutoring systems, predictive analytics, and adaptive content delivery mechanisms, have demonstrated measurable benefits in tailoring the pace, format, and level of instruction to individual learners. These capabilities align closely with the core objectives of the ADDIE model but require intentional reconfiguration of its stages to meaningfully incorporate AI affordances. As Skvorchevsky and Dyatlova (2024) contend, the future of instructional design must be both intelligent and adaptive—qualities made possible through AI integration.

Despite the growing interest in AI-supported education, there is a notable lack of research that systematically integrates AI functionalities into established instructional design models. Existing literature often focuses on isolated applications of AI, such as intelligent tutoring systems or adaptive assessments, without embedding these tools into a cohesive, phase-based design framework like ADDIE. Moreover, while some conceptual papers and reviews discuss the potential of AI in education (Holmes & Tuomi, 2022; Zhai et al., 2021), there is limited empirical research that evaluates how educators perceive the value and applicability of AI across different phases of instructional design. This creates a critical gap between theoretical potential and practical implementation. To bridge this divide,

This study introduces an AI-Incorporated ADDIE Model that explicitly illustrates how AI technologies can be embedded into each phase of the ADDIE framework. The purpose is to bridge the gap between traditional ID models and AI-supported educational practice, offering educators, instructional designers, and institutions a practical, research-informed guide for leveraging AI to design and deliver more effective, inclusive, and adaptive learning experiences.

Figure 1.

AI-Incorporated ADDIE Instructional Design Model

Figure 1 illustrates the AI-Incorporated ADDIE Model, which embeds AI into each phase of the traditional instructional design framework. This enhanced model demonstrates how AI can support and augment instructional design by automating data analysis, generating adaptive learning pathways, assisting with content creation, supporting implementation through intelligent tools, and enabling real-time evaluation of learning outcomes.

In the Analyze phase, AI identifies learner needs and knowledge gaps through data-driven diagnostics. The Design phase is enhanced by AI-generated recommendations for learning activities and assessments tailored to individual learner profiles. During the Develop phase, AI supports the creation of instructional content, including assistance with multimedia production, translation, and accessibility. Implementation is strengthened through AI tools such as chatbots and virtual tutors that provide real-time instructional support. Finally, in the Evaluate phase, AI enables continuous monitoring and assessment of learning outcomes, delivering immediate feedback and actionable insights for improvement. This model highlights the transformative potential of AI to make instructional design more responsive, efficient, timely, and learner centered.

Research Questions

1. How do pre-service and in-service teachers perceive the necessity of integrating artificial intelligence into each phase of the ADDIE instructional design model?

2. In which phases of the ADDIE model do teachers consider AI most and least useful, and what differences exist between pre-service and in-service teacher perspectives?
3. What perceived benefits, concerns, and ethical considerations do teachers express regarding the use of AI in instructional design?

LITERATURE REVIEW

The Evolution of ID in the Age of AI

The integration of AI into education represents a profound shift in how teaching and learning are conceptualized, designed, and delivered. As education systems worldwide increasingly adopt digital technologies, AI tools such as machine learning algorithms, natural language processing engines, and generative models are reshaping core instructional functions, from content generation to real-time learner feedback and personalized support (Chen et al., 2020; Holmes et al., 2019). These technologies enable adaptive learning environments that respond dynamically to learners' behaviors and needs, moving beyond the traditional "one-size-fits-all" paradigm (Yang et al., 2019) that has long characterized conventional education.

In parallel with this technological evolution, ID, the field focused on the systematic development of learning experiences—has also undergone transformation. While traditional ID approaches are methodical and goal-oriented, they often struggle to meet contemporary demands for personalization, scalability, and real-time analytics. The ADDIE model, one of the most widely used ID frameworks, illustrates this challenge. Developed in the 1970s as a linear, phase-based approach to instructional systems design, ADDIE remains foundational for its clarity and structure (Branch, 2009). However, as Molenda (2015) notes, ADDIE was created in a context far removed from today's dynamic, technology-infused learning environments.

We hypothesize that the rise of AI provides an opportunity to modernize the ADDIE model by embedding intelligence into each of its phases. AI offers affordances such as learner clustering in the Analyze phase, generative lesson planning in the Design phase, automated content development in the Develop phase, real-time adaptive delivery in the Implement phase, and predictive learning analytics in the Evaluate phase (Lin et al., 2023; Zawacki-Richter et al.). These capabilities complement and extend the original goals of the ADDIE model: to ensure instructional quality, effectiveness, and learner-centered design. Furthermore, integrating AI into ADDIE responds to the pressing need for a cohesive framework that connects pedagogical intent with algorithmic decision-making—an element often missing from current AI applications in education (Skvorchevsky & Dyatlova, 2024).

In short, while AI has the potential to transform education in powerful ways, its integration must remain grounded in pedagogically sound models. The AI-Incorporated ADDIE model represents a deliberate, research-informed response to this need, preserving the theoretical strengths of the ADDIE framework while leveraging the adaptability and personalization enabled by AI. This synthesis ensures that ADDIE remains both rigorous and relevant in 21st-century learning environments.

AI Integrated ADDIE Model

Analyze Phase: AI-Supported Needs Diagnosis

The Analyze phase of the ADDIE model centers on identifying instructional problems, understanding learner characteristics, and clarifying goals. With AI integration, this phase gains greater diagnostic precision and efficiency. AI-powered systems can analyze pre-assessment data, historical performance metrics, and behavioral indicators to uncover patterns in learner understanding, cognitive readiness, and engagement levels (Holmes et al., 2019). These tools allow instructional designers to move beyond surface-level observations and generate deeper insights into learner needs. In addition, AI-driven analytics enable early detection of misconceptions and risk factors, supporting proactive intervention and more informed instructional planning (Chen et al., 2020).

Incorporating machine learning techniques, AI enables the classification of learners into distinct clusters based on learning styles, preferences, or cognitive traits, thereby facilitating differentiated instruction. For instance, algorithms can infer whether a learner leans toward visual, auditory, or kinesthetic modalities and adjust instructional strategies accordingly (Essa et al., 2023). This data-driven personalization ensures that learning experiences are closely aligned with individual learner profiles from the outset. Unlike traditional needs analyses, which are often time-consuming and limited in scale, AI systems can rapidly process complex data sets and uncover latent learner characteristics, allowing designers to create more targeted and effective instructional interventions (Guvercin, 2025; Zawacki-Richter et al., 2019).

Design Phase: AI-Supported Instructional Planning

In the Design phase of the ADDIE instructional model, educators establish learning objectives, structure instructional content, and select appropriate strategies and media to achieve targeted outcomes. The integration of AI greatly enhances this stage by providing data-driven recommendations and automation to support instructional planning. AI-powered tools can generate scaffolded lesson outlines by analyzing curriculum standards and prior instructional designs, thereby reducing teachers' planning workload and ensuring stronger alignment with educational goals (Alshammari & Al-Enezi, 2024; Ma, 2024). In addition, these tools can recommend differentiated instructional strategies based on previously analyzed learner profiles, offering a high degree of personalization during the design process.

AI technologies also support the alignment of learning outcomes with cognitive taxonomies such as Bloom's Taxonomy. Digital assistants and AI-driven curriculum planners now include features that help educators formulate measurable objectives across cognitive levels, including remembering, analyzing, and creating (AlAfnan & Al, 2024; Chauke et al., 2024; Makeleni et al., 2023). In addition, AI tools recommend appropriate multimedia and interactive resources—such as simulations, games, or video content—based on learner preferences and engagement analytics. This functionality enables designers to rapidly prototype diverse learning activities that improve accessibility, interactivity, and learner motivation. Collectively, the integration of AI in the Design phase makes instructional planning more adaptive, efficient, and learner-centered.

Develop Phase: AI-Enhanced Content Creation and Accessibility

The Develop phase of the ADDIE model focuses on creating and assembling learning materials and instructional content based on prior design specifications. AI enhances this stage by accelerating content development, improving personalization, and ensuring accessibility. AI-powered platforms can produce a wide range of instructional materials, including presentations, quizzes, assignments, and multimedia resources, enabling educators to efficiently create content that aligns with curriculum standards and learner needs. As noted by Edutopia (2023) and the University of Cincinnati Online (2023), AI tools can automate many aspects of instructional development, reducing preparation time and allowing educators to focus more on pedagogical quality and learner individualization.

Beyond efficiency, AI plays a crucial role in advancing educational equity and accessibility. AI technologies can automatically generate captions, transcribe lectures, translate instructional materials into multiple languages, and adapt content to different reading levels and learning preferences. As highlighted by Tereshenok (2025), these capabilities foster inclusive learning environments that meet a wide range of cognitive and sensory needs. Furthermore, the Digital Learning Institute (2025) notes that AI supports the principles of Universal Design for Learning by providing flexible content formats and interactive engagement modes, such as visual, auditory, and gamified materials.

Recent research has also showed AI's broader role in improving accessibility for learners with disabilities and underserved communities. Gibson (2024) observes that AI-driven personalization tools can help remove systemic barriers in education by addressing the specific needs of learners with physical or cognitive impairments. Likewise, Hongli and Leong (2024) show that AI-enabled platforms promote inclusive learning in low-resource settings by optimizing the access, delivery, and usability of instructional content. Taken together, these capabilities position AI as an essential tool for developing equitable and adaptable educational resources.

Implement Phase: AI-Supported Delivery of Instruction

The Implement phase of the ADDIE model focuses on the delivery of instruction, including the deployment of materials, facilitation of learning activities, and interaction with learners. AI enhances this phase by enabling more responsive, adaptive, and data-informed instructional delivery. A key application in this stage is the use of intelligent tutoring systems (ITS) and AI-powered chatbots, which provide learners with real-time feedback, personalized support, and content scaffolding based on their ongoing performance. These systems act as virtual teaching assistants, answering questions, guiding students through learning tasks, and promoting self-regulated learning (Roll & Wylie, 2016). In addition, AI-embedded ITSs have demonstrated strong adaptability by responding to students' real-time learning progress and intervening promptly to deliver targeted assistance (Lin et al., 2023).

AI also enables the real-time adaptation of instruction through learning management systems integrated with machine learning algorithms. These systems analyze learner behavior and adjust pacing, sequencing, or difficulty to meet individual needs. For example, AI-enabled platforms can suggest alternative materials for struggling learners or enrichment tasks for advanced students, thereby enhancing differentiation and engagement (Zawacki-Richter et al., 2019). Systematic reviews of AI-driven adaptive learning systems further highlight their potential to personalize learning experiences and improve educational outcomes (Kabudi et al., 2021).

In addition, AI supports educators by automating logistical and administrative tasks. It can handle grading, schedule personalized reminders, and track attendance, which reduces teachers' cognitive load and allows them to dedicate more attention to instructional interactions and student mentoring (Holmes et al., 2019). By streamlining administrative processes, AI integration improves the overall learning experience, providing real-time analytics that help educators identify student strengths, weaknesses, and learning patterns, and adapt teaching strategies accordingly.

Evaluate Phase: AI-Driven Assessment and Continuous Improvement

The Evaluate phase of the ADDIE model focuses on assessing the effectiveness of instructional interventions, identifying areas for improvement, and informing future instructional cycles. AI enhances this phase by enabling real-time analysis of learner performance data, generating diagnostic feedback, and supporting both formative and summative assessment processes.

Through AI, instructional designers and educators can analyze large volumes of learning behavior data to identify achievement gaps, monitor progress over time, and refine instructional strategies based on evidence. Learning analytics dashboards powered by machine learning algorithms provide timely, actionable insights, allowing instructors to track student engagement, mastery levels, and interactions with content (Chen et al., 2020; Zawacki-Richter et al., 2019). These tools are especially valuable in adaptive learning environments, where content is continuously adjusted in response to performance. As El-Sabagh (2021) demonstrates, AI-supported systems not only increase engagement but also provide more accurate measures of instructional effectiveness by aligning content delivery with individual learning styles.

In inclusive or underserved learning contexts, evaluation systems must also emphasize equity. Gibson (2024) explains that AI enhances accessibility and evaluation by monitoring student interactions and providing tailored feedback to learners with disabilities. Similarly, Hongli and Leong (2025) show that adaptive digital platforms embedded with AI mechanisms improve outcomes in under-resourced settings by tracking students' learning behaviors and adjusting instruction accordingly. Along these lines, Skvorchevsky and Dyatlova (2024) note that intelligent learning systems use real-time feedback loops and dynamic learner models to enable continuous evaluation of both student performance and instructional strategy effectiveness. These systems enhance precision and support long-term instructional refinement. By leveraging

AI-driven tools and frameworks, the Evaluate phase shifts from a retrospective process to a proactive, iterative mechanism of instructional improvement grounded in data, equity, and personalization.

METHODS

Design of the Study

This study employed a mixed-methods research design (Creswell & Plano Clark, 2017) to validate the AI-integrated ADDIE model in the context of mathematics education. The goal was to collect both quantitative and qualitative data (Johnson & Christensen, 2024) from two participant groups: pre-service and in-service mathematics teachers. Before data collection, all participants received structured training on ID principles, with an emphasis on the ADDIE model (Molenda, 2003) and its integration with AI. This preparatory stage ensured that participants clearly understood each phase of the ADDIE model and the potential benefits and risks of AI integration (Weng et al., 2024). The survey was administered separately to each group and consisted of a five-item Likert-type scale assessing the perceived necessity of AI integration at each ADDIE phase, along with four open-ended items designed to capture deeper perspectives and practical applications. A total of 143 pre-service teachers and 24 in-service teachers completed the survey.

Participants

This study employed a purposive-convenience sampling strategy to recruit participants. Pre-service teachers were selected from mathematics education departments at two universities where the researchers had access and institutional permission to conduct the study. These participants were purposefully chosen because they were actively engaged in coursework related to instructional design and had received foundational training on the ADDIE model, making them well-suited to evaluate the proposed AI-incorporated framework.

In-service teachers were similarly selected based on accessibility and relevance. The researchers reached out to practicing mathematics teachers who had prior exposure to instructional planning and showed interest in AI-related pedagogy through professional development events or institutional networks. Although participation was voluntary, the selection was targeted toward individuals who could meaningfully reflect on the integration of AI within the ADDIE model.

The pre-service teacher sample consisted of 143 valid responses collected from undergraduate mathematics teacher education students. The survey was initially distributed to 168 students, with 149 responding. After data cleaning—removing incomplete and patterned responses—a final sample of 143 was retained for analysis. Most participants were between 18 and 24 years old, with a smaller proportion under 18. Gender distribution was relatively balanced, with 74 identifying as male and 69 as female. Participants were enrolled in two institutions: the majority from Korkyt Ata Kyzylorda University, Kyzylorda, Kazakhstan (KAKU, 80.4%) and the remainder from Kazakh National Pedagogical University (KazNU, 19.6%). In addition, 24 in-service teachers participated in the study. Half of them (n = 12, 50%) were between the ages of 25 and 34, while 10 teachers (41.7%) were above 35. Two participants (8.3%) were in the 18–24 age group. In terms of gender, 75% (n = 18) were female and 25% (n = 6) were male. With respect to institutional affiliation, most in-service teachers (83.3%, n = 20) were from KAKU, while 16.7% (n = 4) were from KazNU.

Data Collection Tools

To examine the necessity and applicability of AI integration across the ADDIE instructional design model a survey was developed and validated. This tool was designed to provide both quantitative and qualitative results from pre-service and in-service mathematics teachers. The Likert-type survey comprised two sections: a five-item scale assessing the perceived necessity of AI integration at each ADDIE phase, and four open-ended questions eliciting deeper perspectives, benefits, concerns, and training needs.

The instrument was developed following a comprehensive literature review on AI in instructional design. The initial draft was reviewed by three experts in educational technology and instructional design for relevance, clarity, and alignment with the research objectives. Their feedback led to revisions that enhanced item precision. The revised version was then pilot tested with a small sample of three pre-service teachers and 3 in-service teachers. Think-aloud protocols were employed to check clarity and response accuracy. The internal consistency of the Likert scale was found to be excellent, with a Cronbach's alpha of .88. Based on expert feedback, the initial seven open-ended items were revised and narrowed to four final questions that reflected the most salient and actionable themes.

Prior to survey administration, all participants completed a structured training module to ensure a shared understanding of both the ADDIE model and AI's potential roles in instructional design. The training included a 90-minute session that featured a lecture on the ADDIE model with practical K–12 examples, a workshop exploring AI tools aligned with each ADDIE phase, a video walkthrough of instructional use cases, and a Q&A session. To ensure consistency, all training sessions were delivered using standardized materials and facilitation scripts by trained facilitators. A short formative quiz was administered after the training to confirm participants' comprehension before they proceeded to the survey.

Data Analysis Techniques

Quantitative Analysis

Quantitative data were derived from the five-point Likert-type survey that measured perceived necessity of AI integration in each ADDIE phase. Descriptive statistics, a bar graph, were generated for each phase to identify general trends and differences between pre-service and in-service teacher responses.

To examine whether differences between the two participant groups were statistically significant, a Mann–Whitney U test was conducted for each of the five ADDIE phases. This non-parametric test was selected due to the ordinal nature of the Likert scale and the unequal group sizes. The effect size for each comparison was calculated using the rank-biserial correlation coefficient to determine the magnitude of group differences, with thresholds interpreted as small (r ≈ .10), medium (r ≈ .30), or large (r ≥ .50).

Prior to full analysis, responses were screened for patterned or careless responding. Specifically, cases with identical responses across all items were removed to improve data quality.

Qualitative Analysis

Qualitative data were collected from four open-ended survey questions addressing teachers' views on the most beneficial ADDIE stages for AI integration, perceived risks, examples of effective AI use, and training needs. Qualitative responses were analyzed using a directed content analysis approach, guided by the structure of the four open-ended questions, which correspond to the study's research questions. Responses were grouped deductively based on each question, and patterns were identified within each set. For example, responses to the first question were categorized according to which ADDIE phase participants found most beneficial, while responses to the second question were coded into themes such as data privacy, misinformation, or ethical concerns. Illustrative quotes were selected to support the most frequently cited views, and descriptive comparisons were made between pre-service and in-service teachers. This approach allowed us to maintain a close alignment between the qualitative analysis and the research questions driving the study.

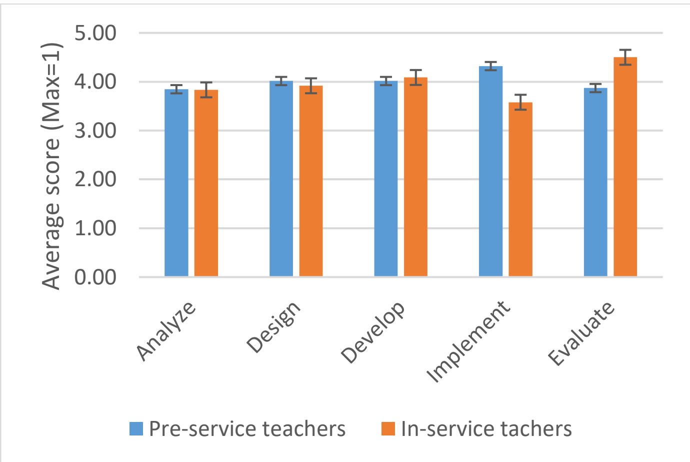
RESULTS

Analyses of Likert-type Items

Figure 1 presents the average scores reported by pre-service and in-service teachers on the perceived necessity of AI integration at each stage of the ADDIE design model. The vertical axis represents the average score on a Likert-type scale ranging from 1 to 5.

Figure 1.

Necessity of AI Integration Across the ADDIE Model Stages



As illustrated in Figure 1, both groups rated AI as useful across all stages of the ADDIE model, though their priorities differed. Pre-service teachers gave the highest rating to the Implement stage (4.32), reflecting strong interest in AI's role in real-time instructional delivery.

They assigned relatively similar scores to Design, Develop, and Evaluate (around 4.01), with a slightly lower rating for Analyze (3.85). In contrast, in-service teachers rated Evaluate the highest (4.50), followed by Develop (4.09) and Implement (4.08), while Design and Analyze received slightly lower scores (3.92 and 3.83, respectively). These results suggest that in-service teachers particularly value AI's contribution to evaluating instructional outcomes, whereas pre-service teachers emphasize its operational benefits in implementing instruction. To test whether the differences in responses between the two groups were statistically significant, a Mann-Whitney U test was conducted (Table 1), and effect sizes were reported using rank biserial correlation.

Table 1.

Mann Whitney U t-test

	Statistic	p		Effect Size
Analyze	1619	0.903	Rank biserial correlation	-0.02
Design	1554.5	0.436	Rank biserial correlation	0.09
Develop	1589	0.828	Rank biserial correlation	-0.03
Implement	1218	0.014	Rank biserial correlation	0.29
Evaluate	1207.5	0.017	Rank biserial correlation	-0.29

As presented in Table 1, the results show that the Analyze ($p = .903$), Design ($p = .436$), and Develop ($p = .828$) stages did not differ significantly between the two groups, suggesting similar perceptions of AI integration across these phases. The effect sizes for these stages were also very small ($r < 0.10$). However, significant differences emerged in the Implement ($U = 1218$, $p = .014$, $r = 0.29$) and Evaluate ($U = 1207.5$, $p = .017$, $r = -0.29$) stages. The positive effect size for Implement shows that pre-service teachers rated this stage significantly higher than in-service teachers, while the negative effect size for Evaluate indicates that in-service teachers rated this stage significantly higher than pre-service teachers. These results align with the patterns shown in Figure 1: pre-service teachers emphasized AI's role in instructional delivery, whereas in-service teachers valued its application in assessment and feedback. The effect sizes for both significant results ($|r| = 0.29$) reflect small-to-moderate practical differences.

Thematics Analyses of Four Open Ended Questions

This section was structured around the four open-ended questions. Responses from pre-service teachers were analyzed first, followed by those from in-service teachers. Participant numbers (e.g., 2, 76, 103) are used to reference individual perspectives.

Pre-service Teachers Responses

Which stage(s) of the ADDIE model do you believe would benefit the most from AI integration? Why?

Several pre-service teachers identified the Analysis phase as the stage that would benefit most from AI integration. For instance, Participant 44 remarked, "The most beneficial stages of AI integration are analysis and design," emphasizing AI's role in foundational planning. Similarly, Participant 2 stated, "The Analysis and Development stages of AI integration are the most beneficial," highlighting how AI's data-handling capabilities enhance early design accuracy. Participant 29 noted, "AI is particularly beneficial in the Analysis stage, as it can collect and evaluate student data to identify learning needs," illustrating AI's diagnostic potential. Participant 31 reinforced this view, saying, "Analysis: AI can quickly analyze data and help identify performance gaps," pointing to efficiency. Likewise, Participant 44 added, "In the analysis phase, AI analyzes the needs, identifies the target audience, and problems."

Many pre-service teachers highlighted the Design phase as an essential stage where AI can provide substantial value. For example, Participant 80 stated, "The most beneficial stages of AI integration are analysis and design," emphasizing AI's dual role in understanding learner needs and structuring instructional plans. Similarly, Participant 1 remarked, "The most beneficial stages of AI integration are design and development," pointing to AI's effectiveness in crafting instructional content. Participant 29 noted that AI's benefits extend into the design process following analysis, while Participant 33 gave a more focused perspective: "Design: AI can adapt learning materials to individual learning styles," underscoring AI's potential for personalization. Participant 38 concluded, "The Design and Development phases benefit most from AI integration due to content creation and alignment with objectives."

Pre-service teachers also pointed to the Development phase as a critical stage where AI can enhance the creation of educational materials. Participant 51 wrote, "The most beneficial stages of AI integration are design and development," stressing AI's utility in shaping content. Similarly, Participant 102 stated, "The Analysis and Development stages of AI integration are the most beneficial," highlighting AI's role in producing instructional materials based on prior assessments. Reinforcing this perspective, Participant 38 observed, "The Design and Development phases benefit most from AI integration due to content creation and alignment with objectives." Participant 46 added, "The phases where AI is most beneficial are Analysis and Development," supporting AI's value in constructing instructional tools. Finally, Participant 128 explained, "Design and Development phases. Because AI can help create instructional materials quickly and efficiently."

Many pre-service teachers consistently recognized the Implementation phase as a valuable point where AI can make a considerable contribution. Participant 15 noted, "AI plays a crucial role during the implementation of lessons. It helps make the classroom more interactive and supports in-service teachers in delivering content effectively." Participant 58 added, "*For* example, I find AI tools helpful while teaching, as they adjust explanations based on pre-service teachers' responses." Similarly, Participant 83 explained, "The Design and Development stages benefit the most, but implementation is where AI makes learning more interactive," highlighting AI's role in enhancing engagement and personalization during instruction. In contrast, Participant 120 stated, *"I think the 'Analysis' and 'Evaluation' phases will benefit,"* while Participant 108 remarked, "The 'Design' and 'Evaluation' phases will benefit most from AI," reflecting appreciation for AI's role in supporting both assessment and design strategies.

Several pre-service teachers also indicated the Evaluate phase as the most significant within the ADDIE model. Participants 102 and 132 stated, “Through evaluation, it accurately analyzes results,” emphasizing AI’s ability to process outcome data efficiently. Likewise, Participant 107 wrote, “Evaluation phase: This phase evaluates the effectiveness of the instructional process,” suggesting that AI tools enhance feedback mechanisms and strengthen learning analytics.

What are potential risks or limitations of using AI in instructional design, particularly in your teaching context?

The most frequently mentioned concern among pre-service teachers was data privacy. Many expressed unease about how AI systems handle sensitive information, especially in educational contexts where the protection of student data is paramount. For example, Participant 10 remarked, “Risks of using AI: data privacy, algorithmic bias,” reflecting a broad anxiety about data access and potential misuse. Similarly, Participant 72 stated, “Risks of using AI: misinformation, disregard for privacy,” underscoring the need for secure systems that do not compromise confidentiality. Another widely noted issue was ethics, particularly regarding the responsible and transparent use of AI. Pre-service teachers raised questions about whether AI systems can remain accountable while supporting instruction. Participant 19 summarized this view: “Ethical concerns. AI should not replace human decision-making,” emphasizing that while AI can assist, ultimate authority must remain with educators. Likewise, Participant 86 cautioned, “Ethical issues such as manipulation and lack of consent might arise,” stressing the importance of safeguarding user autonomy and ensuring informed, ethical use of AI in instructional settings.

Pre-service teachers also expressed concerns that AI might generate incorrect information or misguide learners, reflecting doubts about the reliability of AI-generated content. Participant 22 linked this directly with privacy concerns, while Participant 49 elaborated, “AI sometimes gives wrong information, and pre-service teachers may not verify it,” illustrating the risk of passive reliance on AI outputs. Another recurring theme was algorithmic bias, with several participants warning that AI could produce unfair or skewed outcomes. For example, Participant 61 mentioned “algorithmic bias” alongside privacy issues, highlighting how these concerns often co-occur. Participant 23 further explained, “Biases in AI can lead to inequality in learning,” pointing to the danger of disadvantaging certain groups of learners. Finally, many pre-service teachers feared a loss of human creativity due to over-reliance on AI. Several responses (Participants 8, 16, 91, and 119) suggested that AI could constrain both pre-service and in-service teachers’ original thinking. Participant 16 cautioned, *“Pre*-service teachers may become too dependent and lose creative thinking skills,” warning against intellectual passivity. Similarly, Participant 91 noted, *“*AI could limit in-service *teachers’* ability to design creative, personalized activities.”

Can you share a specific example where AI-supported instructional design enhanced your teaching or learning outcomes?

Many pre-service teachers (e.g., Participants 3, 43, 48, 81) referred specifically to ChatGPT as a key example of AI enhancing their learning. They explained that the tool was used to clarify concepts, draft content, and support communication. Participant 3 simply noted, “Yes, ChatGPT helps,” indicating consistent, straightforward use. Others elaborated on applying ChatGPT for brainstorming ideas, clarifying instructions, or simulating dialogue. AI was also frequently reported as useful for assessment-related tasks, such as generating quizzes, evaluating responses, or automating grading. Participant 47 stated, “I used AI to create multiple-choice quizzes for my lessons,” showing how in-service teachers employ AI to streamline evaluation. Similarly, Participants 25, 29, 94, and 142 described using AI to identify learning gaps or suggest follow-up activities tailored to student needs. Several responses emphasized AI’s role in personalized learning experiences, particularly through adaptive tools and recommendation systems. Participant 21 explained, “AI created personalized content for different student levels,” while others (Participants 6, 57, 111, and 128) described using AI to adjust the difficulty of tasks to match learner readiness.

Another common theme was feedback and evaluation. Pre-service teachers (e.g., Participants 69, 77, 100) appreciated how AI tools provided immediate, targeted feedback on written or spoken work. For example, Participant 100 stated, “AI gave feedback on my writing instantly,” highlighting how rapid responses reduced turnaround time and supported iterative improvement. Several pre-service teachers (e.g., Participants 1, 29, 140) also emphasized the use of AI for creating instructional materials, such as worksheets, slides, or lesson plans. Participant 41 explained, “I used AI to generate lesson content based on the textbook,” illustrating how AI supports in-service teachers in aligning resources with curricular goals.

What kind of training or support would you need to effectively use AI in instructional design?

The most commonly requested support was training and workshops. Pre-service teachers stressed the need for structured learning opportunities to understand how to implement AI effectively in education. Participant 70 stated, “To use AI effectively, I need training in data and tool usage,” pointing to a desire for hands-on, practical knowledge. Participant 1 repeated this by saying, “I need practical training in how to use AI tools for teaching.” A significant number of pre-service teachers (e.g., 3, 4, 35, 54, 108, 122, 128) also identified technical support as essential for successful AI integration. This includes troubleshooting help, onboarding guidance, and access to experienced mentors. Participant 3 noted, “To use AI effectively, I need practical training and support,” indicating that mere access to tools is insufficient without ongoing help. Participant 4 simply stated, “Artificial intelligence support,” showing the expectation that institutions should provide dedicated assistance for navigating AI tools. Although less common, a few pre-service teachers (e.g., 17, 67, 105) pointed to the need for instructional resources, such as manuals, guides, or curated libraries of AI-based lesson materials. These could help educators apply what they learn in training to actual classroom settings. A small number of responses (e.g., 6, 42, 83) also reflected the need for basic AI knowledge, especially for those unfamiliar with the technology. Participant 83 suggested that training should start with fundamental concepts and terminology to ensure broader accessibility.

In-Service Teachers' Responses

Which stage(s) of the ADDIE model would benefit the most from AI integration?

In the Analysis phase, in-service teachers valued AI's capacity to process learner data and identify instructional needs. Participant 11 pointed out, "The stages that benefit the most are analysis and development, because AI can support needs analysis and content generation." Participant 9 emphasized, "The analysis and design stages are the most beneficial because AI can identify gaps in learners' performance and adapt instruction accordingly." The Design phase was frequently mentioned as the stage where AI can bring the most benefit. In-service teachers highlighted AI's utility in shaping instructional objectives and methods. Participant 7 stated, "The design stage is more beneficial because AI can support decision-making by providing pedagogical suggestions based on learning data." Participant 8 also noted, "The stages where AI will benefit the most are design and development, because it can help create personalized materials."

The Development phase was identified as a stage where AI's creative and productive capabilities could streamline content creation. Participant 2 noted, "I believe that the stages that benefit the most are design and development, because AI can help in preparing tasks, materials, and presentations." Participant 10 echoed this, saying, "The Design and Development stages are where AI tools can automate content generation and lesson delivery tools." While mentioned less frequently than the Design or Evaluation phases, several in-service teachers also pointed to Implementation as the stage where AI tools directly assist in delivering instruction and managing classroom dynamics. Participant 3 implied this by including implementation among the stages that benefit most from AI, highlighting its role in making instruction more dynamic and adaptive. Participant 18 added that AI supports learning "during the actual teaching process," indicating its value in real-time classroom application.

In-service teachers' responses reveal that many view the Evaluate phase as a critical point for AI integration in instructional design. Several explicitly linked AI to its capacity to enhance feedback, assessment, and instructional review. Participant 1 stated, "I believe that the stages that benefit the most... include evaluation," suggesting that AI's analytical capabilities can strengthen outcome measurement. Participant 8 emphasized, "The stages where AI will benefit the most are development and evaluation," highlighting AI's role in closing the learning loop through performance review. Similarly, Participant 12 described AI tools as beneficial for "providing feedback," reinforcing the idea that evaluation can become timelier and targeted through AI.

What are potential risks or limitations of using AI in instructional design, particularly in your teaching context?

The most frequently mentioned concern was data privacy. In-service teachers emphasized the risks associated with AI accessing and processing sensitive student information. Participant 23 expressed this clearly: “I believe that there are several important risks, such as data privacy and content security.” Participant 22 added, “Risks: data privacy, content quality, lack of contextual understanding,” pointing to broader concerns about the integrity and protection of educational data. Another major theme was ethical concerns, including fairness, consent, and accountability of AI systems. Participant 15 warned of “unintended consequences and ethical issues related to biased data,” showing apprehension about AI’s neutrality. Similarly, Participant 20 stated, “Ethical issues arise when AI decisions are based on flawed or opaque algorithms,” reflecting unease over the lack of human oversight. Some in-service teachers also expressed fears about overdependence on AI, cautioning that excessive reliance could erode teacher judgment or reduce learners’ autonomy. Participant 4 observed, “Relying too much on AI might reduce teacher-student interaction and weaken pedagogical insight.” Likewise, Participant 9 commented, “Risks: data security, unfair decisions, over-reliance on machine recommendations,” raising concerns about the reduction of human involvement in critical decisions.

A subtler but recurring concern was the loss of human creativity in teaching. Participant 16 remarked that “standardization through AI may suppress the creativity of both in-service teachers and learners,” while Participant 3 added, “AI recommendations may not always be consistent with innovative teaching practices.”

Can you share a specific example where AI-supported instructional design enhanced your teaching or learning outcomes?

A prominent theme among in-service teachers (e.g., 5, 11, 17, 21, 24) was the use of AI for lesson material creation. Many described how AI tools assisted them in generating content such as worksheets, explanations, or visual aids. Participant 5 shared, “Yes, I can give a concrete example from my own practice: I used AI to generate slide presentations and structure lesson content.” Participant 11 added, “I used ChatGPT to create different lesson explanations based on student levels.” In-service teachers frequently cited ChatGPT as a particularly valuable AI tool (e.g., 3, 8, 17, 22), applying it to tasks ranging from drafting content to enhancing student engagement. Participant 3 explained, “Using ChatGPT helped optimize learning objectives and generate engaging discussion prompts.” Similarly, Participant 8 noted, “ChatGPT helped me explain complex topics more clearly to my pre-service teachers.”

Several in-service teachers (e.g., 2, 13, 23) described AI’s role in assessment support, particularly in automating or generating quizzes and tests. Participant 2 reported, “I created tests using AI, it saved me a lot of time and ensured good coverage of topics.” Participant 23 also mentioned using AI to build assessment rubrics and align them with learning goals. A few in-service teachers (e.g., 4, 10, 13) highlighted the value of AI in feedback and evaluation, especially for delivering fast, personalized responses. Participant 4 stated, “AI helped me provide instant feedback to pre-service teachers on their writing tasks,” while Participant 13 reflected, “I used AI tools to analyze student progress and adjust my instruction accordingly.”

What kind of training or support would you need to effectively use AI in instructional design?
The most frequently requested support was training and workshops. In-service teachers emphasized the need for structured, hands-on learning experiences to build their confidence and competence in using AI tools. Participant 7 remarked, "To effectively use AI in ID, I need step-by-step training sessions tailored to my teaching context." Participant 13 echoed this, saying, "It is essential to have targeted workshops that demonstrate practical classroom applications." Many in-service teachers (e.g., 6, 10, 11, 20) also highlighted the importance of technical support for navigating AI tools and addressing implementation challenges. Participant 6 noted the need for "ongoing support and guidance as I explore new AI systems," while Participant 11 stressed the value of "access to someone who can help when I encounter technical issues." Some in-service teachers (e.g., 2, 7, 19) also indicated that ready-made instructional resources, such as guides, templates, or curated content, would help them integrate AI more effectively into their practice. Participant 19 shared, "Real-world training on using AI tools and guidelines for safe, pedagogically sound use would be really helpful."

Comparisons of Student and Teacher Responses to Open Ended Items

Both pre-service and in-service teachers identified the Design and Development phases as highly beneficial for AI integration. These stages were consistently linked to AI's ability to support instructional planning and the creation of educational content. Pre-service teachers emphasized how AI can efficiently generate instructional materials and personalize learning paths, while in-service teachers highlighted its role in aligning pedagogy with learner data and automating content creation. However, differences emerged in how other stages were prioritized. Pre-service teachers rated the Implement phase the highest, reflecting their focus on instructional delivery. In their open-ended responses, they pointed to AI's potential to enhance classroom interaction, adapt explanations in real time, and support learning through tools such as chatbots or intelligent tutoring systems. By contrast, in-service teachers prioritized the Evaluate phase, frequently describing AI as a valuable tool for tracking student progress, analyzing outcomes, and strengthening instructional effectiveness. They particularly noted AI's capacity to generate timely feedback and support data-informed refinement of lessons. The Analyze phase was mentioned with similar frequency by both groups, who recognized AI's usefulness in processing learner data and identifying instructional needs.

Pre-service and in-service teachers expressed several common concerns regarding the potential risks of using AI in instructional design. Data privacy was the most frequently cited issue by both groups, with respondents warning of the risks associated with storing, analyzing, and potentially misusing personal and academic data through AI platforms. Ethical concerns also appeared prominently across responses. In-service teachers were more likely to highlight worries about algorithmic bias, the lack of transparency in AI decision-making, and the risk of unfair or unverified outcomes. Pre-service teachers referenced these issues as well but tended to frame them more generally, often pairing them with fears about misinformation. Differences between the groups emerged in emphasis: pre-service teachers more often mentioned the danger of misinformation and AI’s potential to generate inaccurate or misleading content, reflecting their role as learners who depend on reliable information. In contrast, in-service teachers were more concerned with overdependence on AI, cautioning that excessive reliance might reduce human agency in teaching and decision-making. A further theme present in both groups, though described differently, was the loss of human creativity. Pre-service teachers warned that AI could stifle their own thinking skills, while in-service teachers expressed concern that it might diminish innovation in instructional practices.

Pre-service and in-service teachers shared similar examples of how AI has supported instructional design, though their perspectives reflected their distinct roles in the educational process. Both groups frequently cited the use of ChatGPT, either by name or function, as a key tool for improving learning and teaching. Pre-service teachers described how ChatGPT helped explain complex topics, improve their writing, or provide practice problems. In-service teachers likewise reported using ChatGPT or other AI tools to generate lesson materials, plan instruction, or adapt content for diverse learners. Another recurring theme in both groups’ responses was assessment support. Pre-service teachers valued AI-generated quizzes, automated scoring, and instant feedback for monitoring their progress, while in-service teachers reported using AI to design quizzes, create rubrics, or analyze student responses. Feedback and evaluation were also highlighted by both groups, though with role-specific focus: pre-service teachers emphasized receiving timely feedback from AI systems, whereas in-service teachers noted how AI analytics helped track learning trends and adjust instruction. Additionally, pre-service teachers more often stressed the benefits of personalized learning, where AI adapts content to individual needs, while in-service teachers focused more on instructional efficiency and planning.

Pre-service and in-service teachers demonstrated strong convergence in their responses regarding the training and support required to effectively integrate AI into instructional design. Both groups overwhelmingly emphasized the importance of structured training and workshops, reflecting a shared need to better understand AI tools and their applications in education. Pre-service teachers frequently requested basic or introductory training, highlighting a desire to grasp how AI functions and how it can be applied within their learning contexts. In-service teachers similarly called for practical, classroom-focused training, though their emphasis leaned more toward pedagogical integration and instructional strategies. Technical support also emerged as a recurring theme. While pre-service teachers sought guidance in navigating tools and troubleshooting usage issues, in-service teachers stressed the need for ongoing assistance as they experimented with AI in their practice. Participants from both groups additionally requested ready-made instructional resources, such as user guides, AI-integrated lesson examples, and prebuilt content templates. A key difference lay in the emphasis on time: in-service teachers more frequently noted that meaningful AI integration requires dedicated time and institutional support, whereas pre-service teachers focused more on acquiring foundational knowledge and practical skills for immediate application.

DISCUSSIONS

The results of this study provide strong evidence that the integration of AI into the ADDIE instructional design model is perceived positively by both pre-service and in-service mathematics teachers. Participants recognized AI's potential to enhance the effectiveness, adaptability, and personalization of instruction across all five phases of the model. A key finding was the variation in emphasis placed on specific phases depending on teaching experience. Pre-service teachers most strongly endorsed the Implement phase, highlighting AI's ability to support real-time instructional delivery through tools such as intelligent tutoring systems and chatbots, reflecting their immediate interest in improving classroom engagement and instructional support. In contrast, in-service teachers prioritized the Evaluate phase, emphasizing the value of AI-driven analytics, feedback mechanisms, and data-informed reflection for continuous instructional improvement. These distinctions suggest that perceptions of AI integration are shaped by educators' professional roles and needs (Domínguez-González, 2023). Both groups expressed strong agreement regarding the benefits of AI in the Design and Develop phases, frequently noting its ability to streamline lesson planning, facilitate content generation, and support differentiated instruction.

These findings align with the broader literature on AI's role in instructional personalization and content automation, affirming that these phases represent high-impact areas for AI adoption. Although the Analyze phase received slightly lower average scores, it was still acknowledged for its diagnostic value. Participants recognized AI's capacity to process learner data and identify instructional needs early in the design process, reinforcing the model's emphasis on data-informed planning and learner-centered design from the outset. Despite their support, both pre-service and in-service teachers raised important concerns about AI integration, particularly regarding data privacy, algorithmic bias, and the risk of over-reliance on automated systems. Teachers also cautioned against the erosion of human creativity and pedagogical judgment, underscoring the importance of thoughtful and ethical implementation of AI tools in education. Finally, both groups reported frequent use of generative AI tools, particularly ChatGPT, for tasks such as developing instructional materials, generating quizzes, providing feedback, and explaining complex topics.

The differing emphases placed by pre-service and in-service teachers on specific ADDIE phases highlight the influence of their professional roles and teaching experience. Pre-service teachers, who are still developing their instructional identity, expressed greater interest in the Implement phase, where AI can support engagement, delivery, and classroom responsiveness. This aligns with their immediate need for tools that enhance active teaching and student interaction (Ray & Sikdar, 2024). In contrast, in-service teachers prioritized the Evaluate phase, reflecting their focus on measuring learning outcomes, refining instruction, and improving effectiveness—responsibilities that are more central to their professional practice (Perrault et al., 2002).

These findings support existing research showing AI's potential to enhance instructional design through personalized, adaptive, and data-driven approaches. For example, Lin et al. (2023) and Holmes et al. (2019) describe how intelligent tutoring systems and real-time analytics can transform both teaching and learning by adapting content to individual needs and providing instant feedback. The consistent endorsement of the Design and Development phases by both groups of teachers aligns with the broader literature on AI-enabled instructional planning and content automation (Ndjama, 2025). Zawacki-Richter et al. (2019) emphasized that AI tools are particularly effective in helping educators create diverse, accessible, and learner-centered materials, findings that are echoed in this study.

Furthermore, the strong support for the Evaluate phase among in-service teachers highlights the growing recognition of AI's role in educational assessment. AI-driven learning analytics and predictive modeling enable more continuous and relevant evaluation of student progress, which is increasingly essential in data-informed instructional environments. These findings support Skvorchevsky and Dyatlova's (2024) argument that intelligent, adaptive systems are central to the future of instructional design and educational effectiveness. The results of this study present several practical implications for educators, instructional designers, and institutions aiming to integrate AI into ID processes. First, the differing priorities between pre-service and in-service teachers underscore the importance of differentiated professional development. Training programs should be tailored to address the distinct needs of novice and experienced educators: for pre-service teachers, the focus should be on practical applications of AI in classroom delivery and engagement, while in-service teachers would benefit more from advanced strategies in data analytics, evaluation, and instructional refinement. Second, the widespread concerns over data privacy, algorithmic bias, and ethical use indicate a pressing need for institutions to establish clear policies and guidelines for AI deployment in education. Schools and universities must ensure transparency, strong data protection protocols, and accountability measures to safeguard both educators and learners. Third, since both groups consistently valued AI's contributions to the Design and Development phases, institutions should prioritize investment in AI tools that support these areas. AI-powered lesson planners, content generators, multimedia creators, and accessibility tools can considerably reduce teachers' workload while enhancing instructional quality. Similarly, AI applications in the Evaluate phase, such as analytics dashboards and automated feedback systems, should be promoted among in-service teachers to strengthen data-informed teaching practices. Finally, the frequent use of tools like ChatGPT shows that many educators are already engaging with AI independently (García-Carreño, 2025). Institutions could build on this adoption trend by providing structured support, including curated resource libraries, user guides, and communities of practice.

Several limitations should be acknowledged in this study. First, the relatively small sample of in-service teachers limits the generalizability of the findings to broader teaching populations. While their responses were rich and informative, they may not fully represent the diversity of perspectives across different educational settings or disciplines. Second, the study focused exclusively on mathematics education. Because instructional needs and practices can vary significantly across subject areas, the applicability of the AI-integrated ADDIE model may differ in fields such as language arts, science, or social studies. Future research should therefore examine how AI functions within instructional design models in these varied contexts to assess its broader relevance. Finally, the study primarily referenced currently available AI tools, such as ChatGPT, which continue to evolve rapidly. As new technologies emerge and existing tools are refined, their capabilities, limitations, and educational implications may shift considerably. Thus, the findings of this study represent a snapshot in time and may not capture the long-term effects of AI integration in ID.

Based on the study findings, several areas for future research are recommended. First, expanding the scope to include a wider range of subject areas, such as science, language arts, and social studies, would help determine whether the perceived benefits and challenges of AI integration into the ADDIE model are consistent across disciplines. Second, future research should analyze the effects of specific AI tools (e.g., adaptive learning platforms, generative content systems, learning analytics dashboards) within each phase of the ADDIE framework in real classroom environments. Such studies could identify which technologies are most effective and under what conditions they provide the greatest benefits. Finally, future studies should examine the phase-specific influence of AI tools in authentic classroom settings. Exploring how tools such as adaptive learning platforms, AI-driven assessment generators, and intelligent tutoring systems support each stage of the ADDIE model can provide practical recommendations for tool selection and implementation strategies.

CONCLUSION

This study has demonstrated that embedding artificial intelligence within the ADDIE model holds considerable potential for enhancing the design, development, implementation, and evaluation of mathematics instruction. Both pre-service and in-service teachers acknowledged AI’s ability to personalize learning pathways, streamline content creation, and provide real-time feedback, with pre-service teachers especially valuing AI’s support during classroom implementation and in-service teachers emphasizing its role in data-driven evaluation. At the same time, shared concerns about data privacy, algorithmic bias, and the possible erosion of human creativity highlight the need for ethical safeguards and transparent practices when integrating AI tools into instructional design.

By presenting a clear framework for AI integration at each ADDIE phase and validating it through mixed-methods inquiry, this research provides a practical guide for researchers, educators, and institutions aiming to harness AI responsibly. To fully realize the potential of AI-enhanced ID, stakeholders should invest in targeted professional development, establish strong ethical and privacy protocols, and continuously evaluate the impact of emerging technologies across diverse disciplines and contexts. Ultimately, when applied thoughtfully, AI can make ID more adaptive, efficient, and learner-centered, transforming educational practice in the digital age.

REFERENCES

AlAfnan, M. A., & Al, M. (2024). Taxonomy of educational objectives: Teaching, learning, and assessing in the information and artificial intelligence era. *Journal of Curriculum and Teaching*, *13*(4), 173-191.

Alshammari, A. & Al-Enezi, S. (2024). Role of Artificial Intelligence in Enhancing Learning Outcomes of Pre-Service Social Studies Teachers *Journal of Social Studies Education Research, 15*(4), 163-196. https://jsser.org/index.php/jsser/article/view/5787/699

Balta, N. (2025). Artificial intelligence pedagogical content knowledge. *The European Educational Researcher,* 8(1),1-3. https://doi.org/10.31757/euer.811

Balta, N. (2015). A systematic planning for science laboratory instruction: Research-based evidence. *Eurasia Journal of Mathematics, Science and Technology Education*, *11*(5), 957-969. https://doi.org/10.12973/eurasia.2015.1366a

Baytak, A. (2024). The Content Analysis of the Lesson Plans Created by ChatGPT and Google Gemini. *Research in Social Sciences and Technology, 9*(1), 329-350. https://doi.org/10.46303/ressat.2024.19

Branch, R. M. (2009). *Instructional design: The ADDIE approach*. Springer. https://doi.org/10.1007/978-0-387-09506-6

Chen, L., Chen, P., & Lin, Z. (2020). AI in education: A review. *IEEE Access, 8*, 75264–75278. https://doi.org/10.1109/ACCESS.2020.2988510

Chauke, T., Mkhize, T., Methi, L., & Dlamini, N. (2024). Postgraduate Students' Perceptions on the Benefits Associated with Artificial Intelligence Tools on Academic Success: In Case of ChatGPT AI tool. *Journal of Curriculum Studies Research, 6*(1), 44-59. https://doi.org/10.46303/jcsr.2024.4

Creswell, J. W., & Clark, V. L. P. (2017). *Designing and conducting mixed methods research*. Sage publications.

Domínguez-González, M. A., Hervás-Gómez, C., Díaz-Noguera, M. D. & Reina-Parrado, M. (2023). Attention to diversity from artificial intelligence. *The European Educational Researcher,* 6(3), 101-115. DOI: https://doi.org/10.31757/euer.633

Digital Learning Institute. (2025). *Leveraging AI in accessible design to transform digital learning*. https://www.digitallearninginstitute.com/blog/leveraging-ai-in-accessible-design

Edutopia. (2023). *7 AI tools that help teachers work more efficiently*. https://www.edutopia.org/article/7-ai-tools-that-help-teachers-work-more-efficiently/

El-Sabagh, H. A. (2021). Adaptive e-learning environment based on learning styles and its impact on development students' engagement. *International Journal of Educational Technology in Higher Education, 18*(53). https://doi.org/10.1186/s41239-021-00281-0

Essa, S. G., Celik, T., & Human-Hendricks, N. E. (2023). Personalized adaptive learning technologies based on machine learning techniques to identify learning styles: A systematic literature review. *IEEE Access, 11*, 48392–48409. https://doi.org/10.1109/ACCESS.2023.3284635

García-Carreño, IV. (2025). ChatGPT's impact on social sciences: A bibliometric analysis and future perspectives. *The European Educational Researcher,* 8(1), 5-28. DOI: https://doi.org/10.31757/euer.812

Gibson, R. (2024). *The impact of AI in advancing accessibility for learners with disabilities*. *EDUCAUSE Review*. https://er.educause.edu/articles/2024/9/the-impact-of-ai-in-advancing-accessibility-for-learners-with-disabilities

Guvercin, S. (2025). The urgent case for AI literacy in the 21st century. *International Educational Review, 3*(1), 41-44. DOI: https://doi.org/10.58693/ier.313

Holmes, W., Bialik, M., & Fadel, C. (2019). *AI in education: Promises and implications for teaching and learning*. Center for Curriculum Redesign.

Holmes, W., & Tuomi, I. (2022). State of the art and practice in AI in education. *European journal of education*, *57*(4), 542-570.

Hongli, Z., & Leong, W. Y. (2024). AI solutions for accessible education in underserved communities. *Journal of Innovation and Technology, 2024*.

Johnson, R. B., & Christensen, L. B. (2024). *Educational research: Quantitative, qualitative, and mixed approaches*. Sage publications.

Kabudi, T., Pappas, I., & Olsen, D. H. (2021). AI-enabled adaptive learning systems: A systematic mapping of the literature. *Computers and Education: AI, 2*, 100017. https://doi.org/10.1016/j.caeai.2021.100017

Lin, C. C., Huang, A. Y., & Lu, O. H. (2023). AI in intelligent tutoring systems toward sustainable education: A systematic review. *Smart Learning Environments, 10*(1), 41. https://doi.org/10.1186/s40561-023-00260-y

Ma, S. (2024, May 22). *How generative AI tools assist with lesson planning*. Edutopia. https://www.edutopia.org/article/ai-tools-lesson-planning/

Makeleni, S., Mutongoza, B., & Linake, M. (2023). Language Education and Artificial Intelligence: An Exploration of Challenges Confronting Academics in Global South Universities. *Journal of Culture and Values in Education, 6*(2), 158-171. https://doi.org/10.46303/jcve.2023.14

Molenda, M. (2003). In search of the elusive ADDIE model. *Performance Improvement*, 42(5), 34–36.

Ndjama, J. D. N. (2025). The use of artificial intelligence in lesson delivery and evaluation in large-scale teaching environments. *Interdisciplinary Journal of Education Research*, *7*(s1), a08-a08.

Ogurlu, U., & Mossholder, J. (2023). The Perception of ChatGPT among Educators: Preliminary Findings. *Research in Social Sciences and Technology, 8*(4), 196-215. https://doi.org/10.46303/ressat.2023.39

Patton, M. Q. (2015). *Qualitative research and evaluation methods* (4th ed.). Sage.

Perrault, A. H., Gregory, V. L., & Carey, J. O. (2002). The integration of assessment of student learning outcomes with teaching effectiveness. *Journal of Education for Library and Information Science*, 270-282.

Ray, S., & Sikdar, D. P. (2024). AI-Driven flipped classroom: Revolutionizing education through digital pedagogy. *Psychology*, *7*(2), 169-179.

Roll, I., & Wylie, R. (2016). Evolution and revolution in AI in education. *International Journal of AI in Education, 26*(2), 582–599. https://doi.org/10.1007/s40593-016-0110-3

Skvorchevsky, K. A., & Dyatlova, O. V. (2024). Modern adaptive and intelligent digital learning systems: Mechanisms and potential. *Voprosy obrazovaniya / Educational Studies Moscow, 1*, 190–211.

Tereshenok, A. (2025). *How AI helps to create an accessible learning environment*. Retrieved from https://aristeksystems.com/blog/how-ai-helps-to-create-an-accessible-learning-environment/

University of Cincinnati Online. (2023). *How instructional designers use AI to optimize workflow and the student experience*. https://online.uc.edu/blog/how-instructional-designers-use-ai/

Xie, H., Chu, H. C., Hwang, G. J., & Wang, C. C. (2019). Trends and development in technology-enhanced adaptive/personalized learning: A systematic review of journal publications from 2007 to 2017. *Computers & Education, 140*, 103599. https://doi.org/10.1016/j.compedu.2019.103599

Weng, X., Ye, H., Dai, Y., & Ng, O. L. (2024). Integrating artificial intelligence and computational thinking in educational contexts: A systematic review of instructional design and student learning outcomes. *Journal of Educational Computing Research*, *62*(6), 1640-1670.

Yang, S., Tian, H., Sun, L., & Yu, X. (2019, June). From one-size-fits-all teaching to adaptive learning: the crisis and solution of education in the era of AI. In *Journal of Physics: Conference Series* (Vol. 1237, No. 4, p. 042039). IOP Publishing.

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on AI applications in higher education – where are the educators? *International Journal of Educational Technology in Higher Education, 16*(1), 1–27. https://doi.org/10.1186/s41239-019-0171-0

Zhai, X., Chu, X., Chai, C. S., Jong, M. S. Y., Istenic, A., Spector, M., ... & Li, Y. (2021). A Review of Artificial Intelligence (AI) in Education from 2010 to 2020. *Complexity*, *2021*(1), 8812542.