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## Reimagining ADDIE for the AI Era: The AIIT-Embedded Framework

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### Abstract

The ADDIE model has long provided systematic rigor in instructional design, but its limited integration of emerging technologies restricts its relevance in today's digital era. Artificial intelligence (AI) offers transformative potential for personalization, adaptive learning, real-time analytics, and automation; however, current applications remain fragmented and are seldom embedded into established design models. This study upgrades the Artificial Intelligence–Integrated Instructional and Training Technologies (AIIT) framework by embedding the five phases of ADDIE (Analysis, Design, Development, Implementation, and Evaluation). AIIT is defined through eight interrelated characteristics, such as adaptive learning, real-time feedback, personalized instruction, skill development, workforce performance, interactive engagement, knowledge transfer, and ethically informed instructional practices that collectively redefine instructional design within the contemporary digital paradigm. Using a structured literature synthesis combined with reflective author analysis, this study develops the AIIT embedded ADDIE model, which preserves ADDIE's systematic discipline while infusing it with adaptability, intelligence, and ethical safeguards. Conceptually, the study advances instructional design theory by bridging definitional gaps and updating a classical model for the AI era; practically, it provides instructional designers and organizations with a criterion-based framework for adopting AI responsibly. Although conceptual in scope, the AIIT embedded ADDIE model establishes a foundation for future empirical research and offers a coherent roadmap for designing adaptive, ethical, and performance-driven learning environments.

**Keywords:** Instructional Design, ADDIE model, Artificial Intelligence, AI-Integrated Instructional and Training Technologies (AIIT), Instructional Design Models, Training and Development

### Introduction

The rise of artificial intelligence (AI) “marks a paradigm shift in how knowledge is imparted and acquired, showcasing the transformative potential of emerging technologies” (Siddiqui et al., 2025, p. 2526). The use of AI offers advanced personalization, automation, and adaptability that were previously inaccessible through traditional technologies (Lo & Hew, 2017). Therefore, the inclusion of AI within instructional design (ID) has become vital for improving efficiency, interactivity, and relevance in contemporary learning environments (Dogan, 2025). ID has been defined as “the science and art of creating detailed specifications for the development, evaluation, and maintenance of situations which facilitate learning and performance” (Richey et al., 2010, p. 3). ID plays a



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major role in structuring the sequential steps, phases, and events that design a training program (Rehman, 2015). Whereas 17 published instructional design models can be found in the literature (Rehman, 2015); however, more than 100 are now in practice (Crompton et al., 2023). Among all the ID models, ADDIE serves as a conceptual and organizational framework for systematic instructional development (Ni & Branch, 2008). The ADDIE model remains superior because of its iterative characteristic. This allows the training or instructional designer to revisit the phases (analysis, design, development, implementation and evaluation) refine for continuous improvement (Chyung, 2008; Crompton et al., 2023; Myers et al., 2008).

In an era of AI-driven learning and continuous digital transformation, the field of instructional design (ID) faces increasing pressure to evolve in response to emerging technologies. Thus, modern research increasingly emphasizes the integration of instructional strategies along with digital tools within the ID models to enhance and transform trainings into more coordinated, efficient and effective (Abuhassna & Alnawajha, 2023). Therefore, since ADDIE's inception, training designers have integrated a variety of digital tools and technological strategies into the ADDIE model to improve instructional effectiveness and learner engagement (Abuhassna et al., 2024; Crompton et al., 2023). While these integrations demonstrate the framework's adaptability, they also reveal a conceptual limitation: there are no defined characteristics that guide the selection of technologies for each phase of ADDIE. As a result, technology integration remains inconsistent and largely tool driven, depending on situational needs rather than systematic criteria. This lack of structure causes instructional efforts to become fragmented and short lived, as technological relevance shifts rapidly with the emergence of new innovations (Reiser & Dempsey, 2017; Lee & Jang, 2014). Additionally, the traditional training models have become obsolete; therefore, AI-driven tools should be applied to the training process because they bring shift in all the phases of a training program (Chen, 2023).

Therefore, there is a need for an updated ADDIE model that should highlight a set of characteristics to select AI-driven technologies. This paper argues that the absence of defined technological characteristics is the primary challenge that limits the adaptability of ADDIE in training and learning environments. The updated research has tried to incorporate different AI technologies within the ADDIE model (Abuhassna et al., 2024); however, none have addressed the need to update ADDIE with a pre-defined set of characteristics to select these AI-technologies. Therefore, this study proposes the integration of the AI Integrated Instructional and Training (AIIT) framework (Rehman & Gul, 2025) with the ADDIE model to establish an updated model. This AIIT embedded ADDIE model supports the systematic integration of AI-driven technologies. And supports the selection of technologies with the aid of eight characteristics across all phases.

### 1.2. Statement of the Study

This study addresses the limitations of the traditional ADDIE model by embedding the eight defining characteristics of the AIIT framework (Rehman & Gul, 2025) into each of its five phases. These characteristics include adaptive learning, real time feedback, personalized instruction, skill development,



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workforce performance, interactive engagement, knowledge transfer, and ethically informed instructional practices. The study seeks to generate an updated instructional design (ID) model by integrating these characteristics within ADDIE. Academically, this updated ID model fills the theoretical gap by incorporating AI-driven technologies according to their characteristics. Practically, this model can be applied by training or instructional designers to design a training program.

### 1.3. Objectives of the Study

The following objectives guide the present study:

- To critically evaluate the limitations of the traditional ADDIE model in integrating modern learning technologies.
- To assess the potential of the AIIT framework, represented by eight characteristics (adaptive learning, real time feedback, personalized instruction, skill development, workforce performance alignment, interactive engagement, knowledge transfer, and ethically informed instructional practices), to address these limitations.
- To systematically embed these eight AIIT characteristics into the five phases of ADDIE to propose an updated instructional design model.

## 2. Critical-Integrative Review of Literature

This literature review has examined the role of ADDIE as an instructional design model. It has elaborated the limitations and challenges that ADDIE faces in terms of technology integration. The review also argued about the importance of AI technologies within instructional design models. Therefore, this review focuses on the integration of AIIT framework within the ADDIE model. Following Ridley (2012) this study adopts a narrative and integrative review approach to synthesize diverse theoretical and practical perspectives. Selected elements of the PRISMA 2020 checklist are employed solely to enhance transparency and reporting clarity; such as rationale, objectives, and information source disclosure rather than to conduct a full systematic or exhaustive (Page et al., 2021). Sources were chosen based on conceptual relevance to ADDIE, AI integration, and instructional design theory, ensuring that the review aligns with the study's theoretical and model-development objectives. Relevant sources were identified through a narrative review of academic databases, including Google Scholar, Emerald Insight, JSTOR, Wiley Online Library, Taylor & Francis Online, ResearchGate, and Scopus. The review article draws on evidence from peer-reviewed journal articles, scholarly monographs, and institutional reports between 2003 to 2025. Since there are different dates mentioned in the literature about the origin of ADDIE. For instance, Chyung (2008) mentioned that ADDIE was first introduced by the practitioners during the 1970s. However, the actual acronym was mentioned in the literature around 1980s. Whereas it is unclear how and who came up with the acronym of ADDIE. On the other hand, literature identified that the year 1996 marks the point at which ADDIE was first discussed (Molenda, 2003, as cited in Mayfield, 2011).

Therefore, ADDIE has become consolidated and “is being used by many instructors, trainers, universities, and even the American Society for Training and Development. This widespread acceptance shows the model's utility as a



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development and learning framework” (Mayfield, 2011, p. 19). This period provides both historical depth and contemporary relevance. This body of literature provided the foundation for examining the convergence of ADDIE and AIIT, leading toward the development of an updated, integrated instructional design framework. Different search words and keywords were used because the researchers were concerned with technological integration within ADDIE and the role of ADDIE within the training programs etc. The search terms include AI in training and development, AI-driven learning, ADDIE model, Technology within ADDIE, instructional design models, Traditional ID models, AI enabled ID models etc. These keywords were used to search for both foundational and contemporary data. The review proceeds with the following subsections:

- Section 1: Instructional Design and the ADDIE model
- Section 2: Artificial Intelligence in Training and Instructional Design
- Section 3: The AIIT Framework and Its Relevance
- Section 4: Toward Integration of AIIT and ADDIE
- Section 5: Synthesis and Gap Analysis

### **2.1. Section-1: Instructional Design and the ADDIE model**

#### a. The Role of ADDIE in Instructional Design

The ADDIE model serves as a foundational model for instructional design (Molenda, 2003). ADDIE ensures that training is both practical and aligned with organizational goals (Branch, 2009). The first phase of Analysis ensures that all the learner's needs, training objectives, and learning conditions are met (Mayfield, 2011; Myers et al., 2008; Ni & Branch, 2008). Whereas the structure of the training program, content, and delivery methods are planned in the Design phase (Myers et al., 2008), the Development phase then takes this blueprint and brings it to life, creating the actual materials and resources that will be used in the training. This could include a range of formats, from digital e-learning modules to traditional classroom materials, depending on the needs identified earlier in the process (Mayfield, 2011). Implementation is where the training program is rolled out to the learners. The phase involves the implementation of developed plans. It also involves preparations on behalf of trainers and instructors to deliver the training modules (Myers et al., 2008). Following the delivery of the training, the Evaluation phase assesses the effectiveness of the training program. This involves gathering feedback, measuring learning outcomes, and identifying areas for improvement in future iterations of the training (Mayfield, 2011; Myers et al., 2008; Ni & Branch, 2008).

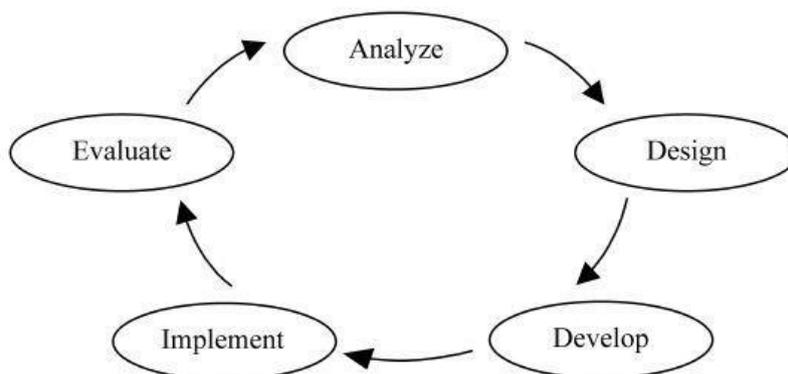
Furthermore, the flexibility of ADDIE is one of the characteristics that is highly recognized (Branch, 2009; Crompton et al., 2023). Although ADDIE is illustrated as a linear process, in practice it often involves iterative cycles. That allows instructional or training designers to revisit and revise the previous phases based on the information gained from the evaluation phase (Mayfield, 2011; Rehman, 2015). Eventually, this characteristic of ADDIE enables the instructional or training designers to achieve the learning or training objectives and to align the learning experiences with the learners or trainees needs (Branch, 2009; Ni & Branch, 2008). Additionally, the current research indicates that



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technological integration within ADDIE is widespread worldwide because it is beneficial and supports training programs (Crompton et al., 2023). Whereas the ADDIE model highlights remarkable adaptation and potential when integrated with technologies (Abuhassna et al., 2024).

b. Linear, Cyclic and Non-Linear Perspectives

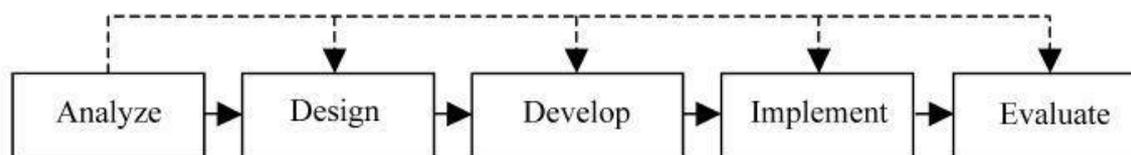


Throughout the years, different illustrations of ADDIE came into being to describe a systematic approach towards instructional development. Three of such illustrations are identified, such as linear, linear-cyclical, and non-linear-cyclical ADDIE models (Chyung, 2008). These are mentioned below:

**Figure 2.1: Linear ADDIE Phases**

**Figure-1: Adopted from: (Chyung, 2008, p. 82)**

The above figure represents a systematic linear structure of the ADDIE model. Each phase is followed step-by-step; however, the information/data obtained from the analysis phase is sent back to each of the systematic steps. Besides linear, the ADDIE model can also be cyclic and non-linear.



**Figure 2.2: Cyclic ADDIE Phases**

**Figure-2: Adopted from: (Chyung, 2008, p.83)**



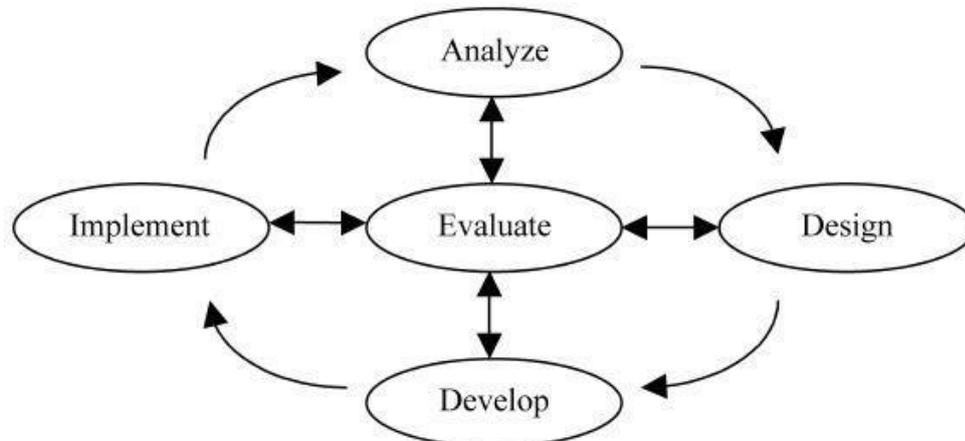
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The above figure shows the cyclical flow of the ADDIE model, where the five phases Analyze, Design, Develop, Implement, and Evaluate are connected in sequence. The arrows indicate that the process is iterative, meaning evaluation feeds back into analysis, allowing continuous refinement and improvement of instructional design.

### Figure 2.3: Non-Linear ADDIE model

#### Figure-3: Adopted from: (Chyung, 2008, p.83)

The figure above shows a non-linear version of the ADDIE model, where 'evaluation' is placed at the center and directly linked to all other phases Analyze, Design, Develop, and Implement. The arrows indicate that evaluation is continuous and informs every stage of the instructional design process, making the model more flexible and iterative rather than strictly sequential. The above illustrations show that, over the years, ADDIE has been proposed in different ways for instructional development. According to Chyung (2008), although ADDIE provides a systematic approach, it does not tell exactly what to do at each step. Thus, it is the responsibility of the instructional or training designer to



decide tasks for each step. At the same time, integrating technologies into the ADDIE model improves usability, learning approaches, learner experiences, and the financial outcomes of training programs (Crompton et al., 2023). Whereas the use of modern, updated technologies, such as AI, can improve training effectiveness (Chen, 2023; Dixit & Jatav, 2024; Maity, 2019; Suravi, 2024).

#### c. Significance of ADDIE in Contemporary Training

According to Mabina (2025, p. 83), “The ADDIE model offers a systematic framework for designing, developing, and evaluating AI-supported learning strategies, ensuring continuous refinement”. The ADDIE model's significance in instructional design lies in its structured, systematic approach that ensures the development of effective, efficient, and learner-centered instructional materials. Its adaptability, emphasis on evaluation, and theoretical underpinnings make it a valuable framework for instructional designers aiming to meet the dynamic needs of trainees in various training and educational contexts (Branch, 2009; Crompton et al., 2023; Ni & Branch, 2008). Moreover, its significance is underscored by its widespread adoption across various industry sectors, demonstrating its adaptability to diverse learning environments and its capacity



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to integrate modern technologies to enrich learning experiences (Crompton et al., 2023).

The question is that why Addie Limitations matter today: Because to fulfill the current demands of the contemporary learning environment, it is necessary to upgrade the ADDIE model. For example, during the days of Covid pandemic reliance on e-learning increased. Although AI techniques were present; however, it was necessary to update the educational design and thus ADDIE was used as a basic model to integrate AI within the educational design (Mostafa et al., 2024).

Furthermore, Researchers have identified that professionals can use instructional design frameworks such as ADDIE to define and achieve individual learning goals, and that incorporating technology enhances these outcomes (Van Petegem, 2021). However, technology adoption follows several progressive stages as outlined in the Technology Adoption Cycle by Craig Chelius (Van Petegem, 2021), and progression between these stages is influenced by personal and contextual differences. This means that trainees do not share equal levels of technological readiness or literacy, which directly affects their ability to engage with and benefit from digital training environments. Consequently, adopting or integrating technology into training programs requires careful alignment with the trainees' needs and the nature of the training content (Rehman & Gul, 2025), since the effectiveness of a program ultimately depends on the learner's capacity to use the technology effectively (Kaizer et al., 2020).

### **2.2. Section-2: Limitation/Challenges of ADDIE in Technology Integration**

#### a. Rigidity and Sequential Structure

The ADDIE model, while a foundation in instructional design, faces several challenges in adapting to modern technology. One significant challenge is the pace of development; the ADDIE model is often criticized for being too slow to meet the rapid development needs of today's technology-driven environments. This slow pace is at odds with business needs that frequently demand quicker responses, leading to a call for the inclusion of rapid development topics to augment the ADDIE approach (Ni & Branch, 2008). Additionally, the process-based nature of ADDIE, which emphasizes documentation and sequential phases, can lead to inefficiencies and misinterpretations when requirements shift during the development process. This can result in rework, budgetary issues, and dissatisfaction with the final product (Reiser & Dempsey, 2017).

#### b. Limited Personalization and Adaptability

The traditional ADDIE model does not place enough emphasis on the learner's experience, which is increasingly important in the design of modern educational technology. A process based on rapid prototyping, which focuses on engaging learners and adapting content dynamically, is suggested as more appropriate for today's instructional design challenges. Furthermore, ADDIE's failure to involve stakeholders effectively throughout the design process can hinder the achievement of support and alignment with the needs of learners and other stakeholders such as trainees (Reiser & Dempsey, 2017).

#### c. Phase-Specific Challenges



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Each phase of the ADDIE model faces unique challenges in the integration of modern technology, from the initial analysis of learning needs to the final evaluation of training effectiveness.

- **Analysis Phase:** In the Analysis phase, the primary challenge lies in the underutilization of technology to collect and analyze data. Despite the availability of advanced tools for gathering diverse information types, there's a notable gap in leveraging these technologies to their full potential, particularly in identifying the needs and scope within various occupational contexts such as healthcare and education (Crompton et al., 2023). It can be argued that there is a significant opportunity for future research to explore how technology can be more effectively employed in this initial phase of ADDIE to enhance the precision and depth of needs analysis.
- **Design Phase:** The technological challenges in the Design phase of ADDIE primarily revolve around the integration and effective use of modern training technologies. Despite the potential of these technologies to facilitate interactive, engaging, and personalized learning experiences, the ADDIE model does not explicitly guide their incorporation at this stage (Chyung, 2008). Eventually, this oversight can limit the framework's ability to fully leverage the capabilities of digital tools and platforms, which are increasingly crucial in enhancing learning experiences. This misalignment suggests a need for the framework to evolve and incorporate more flexible approaches to instructional design to ensure that training programs are not only well-designed in terms of content and structure but also aligned with the technological expectations and preferences of modern learners (Molenda, 2003; Zierer & Seel, 2012).
- **Development Phase:** The Development phase faces several challenges due to technological integration, primarily revolving around the rapid pace of technological change and the need for instructional materials to remain current and relevant. As technology evolves, there's a continuous need to update and adapt instructional materials to incorporate the latest tools and platforms. This can be resource-intensive, requiring ongoing investment in both time and finances to ensure that learning resources do not become obsolete (Crompton et al., 2023).
- **Implementation Phase:** The challenges related to integrating emerging technologies during the implementation phase of ADDIE include ensuring that new technologies function effectively in real-world settings, overcoming technical difficulties during deployment, and providing adequate training for trainers to operate these technologies successfully. Additionally, there may be issues with compatibility, technical support, and maintaining system stability as new tools are introduced (Ni & Branch, 2008).
- **Evaluation Phase:** Lastly, the Evaluation phase, when integrated with technology, encounters several challenges that can impact its effectiveness and efficiency. One significant challenge is the rapid pace of technological advancements, which



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can render evaluation tools and methods obsolete if they do not evolve at a similar speed. This necessitates a continuous review and update of evaluation criteria and tools to ensure they remain relevant and capable of accurately assessing the effectiveness of technology-enhanced learning interventions (Reiser & Dempsey, 2017). Another challenge is the complexity of measuring the impact of technology on learning outcomes. The multifaceted nature of technology integration means that evaluators must discern the specific contributions of technological tools to the learning process, which requires sophisticated, multifaceted evaluation strategies. This complexity is compounded by the need to ensure that evaluation methods themselves are not biased by the technology being used, ensuring a fair and accurate assessment of learning outcomes (Spariosu, 2006). On the other hand, data privacy and security also emerge as critical concerns in the Evaluation phase. With the increasing use of digital platforms and tools for both delivering instruction and conducting evaluations, safeguarding the privacy and security of learner data becomes paramount. Evaluators must navigate these concerns carefully, implementing vigorous data protection measures to maintain the integrity of the evaluation process and the trust of participants (Evans, 2011; Reiser & Dempsey, 2017). Finally, the technical skills of evaluators are put to the test in the Evaluation phase. Evaluators must be proficient in the latest technologies used in education to effectively assess their integration and impact. This may require ongoing professional development and a commitment to staying abreast of technological advancements in the field of instructional design (Branch, 2009; Reiser & Dempsey, 2017).

### **2.3. Section-3: Artificial Intelligence in Training and Instructional Design**

#### **a. A Paradigm Shift**

The use of AI in training programs signifies a paradigm shift by introducing a level of personalization and efficiency previously unattainable with traditional training methods. This shift is underpinned by AI's ability to adapt learning content to the individual needs and learning styles of each participant, thereby enhancing the effectiveness and engagement of training programs (Lo & Hew, 2017). Moreover, AI's capacity for real-time analytics allows for the continuous refinement of training content based on immediate feedback and performance metrics, ensuring that learning experiences remain relevant and impactful (Kaizer et al., 2020). This evolution from a one-size-fits-all approach to a more tailored and dynamic learning environment marks a significant departure from traditional training methodologies, highlighting the transformative potential of AI in the realm of learning and development (Evans, 2011).

#### **b. The Role of AI in Training Programs**

Artificial Intelligence (AI) plays a transformative role in training programs, significantly enhancing the way organizations deliver, personalize, and evaluate



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learning experiences. By leveraging AI, training programs can become more intuitive and engaging, moving beyond traditional classroom settings to on-screen and mobile platforms where learning is tailored to individual preferences and needs (Chen, 2023; Maity, 2019). Whereas AI facilitates this by offering human-like interactions and intelligent user interfaces, making the learning experience more natural and closer to the learner's expectations (Chen, 2023). Through intelligent data analysis and interactive technologies, AI supports the creation of learning experiences that are tailored to individual needs and preferences, thereby improving the engagement, efficiency, and outcomes of training initiatives (Kambur & Yildirim, 2023). This shift not only makes training more accessible but also more relevant to the modern workforce, which increasingly values flexibility and personalization in learning (Maity, 2019). Moreover, AI's capability to design training content based on individual learner habits and preferences allows for a more personalized learning journey. This approach moves away from the one-size-fits-all model, instead providing content that is directly relevant to each learner's role, skills, and learning pace (Chen, 2023). The integration of AI with virtual reality (VR) further enriches this experience by offering live visual simulations, thereby enhancing the practical understanding of job tasks through virtual training experiences (Maity, 2019).

In the realm of human resources, AI's impact extends to improving decision-making processes, aiding in recruitment, and identifying the most suitable training modules for employees (Kambur & Akar, 2022; Kambur & Yildirim, 2023; Qamar et al., 2021). AI algorithms help eliminate biases, ensuring that training opportunities are equitable and based on objective criteria. This not only streamlines the selection process for training participants but also ensures that the training content is aligned with the learner's preferences and organizational goals (Maity, 2019). Additionally, AI-driven training programs also stand to benefit organizations by making training modules more interactive and engaging (Maity, 2019). This not only boosts employee motivation to participate but also enhances the overall effectiveness of the training. By automating the scheduling of appointments and providing real-time feedback, AI makes the learning process more efficient and responsive to the learner's progress and needs (Chen, 2023; Maity, 2019).

Furthermore, AI technologies facilitate a shift from instructor-centric to learner-centric training models (Chen, 2023). This approach prioritizes the learner's experience and outcomes, focusing on delivering training that is not only efficient but also impactful in terms of performance improvement and return on investment (ROI). AI's ability to analyze data and provide insights can help organizations develop a learning culture that supports continuous improvement and adaptation to changing business needs (Chen, 2023; Suravi, 2024).

### c. Personalize Learning Experiences

AI can personalize learning experiences in several ways, leveraging its capabilities to tailor training content and delivery to meet the unique needs of each learner. By analyzing past completion rates, interactions with various types of learning content, present skill demands, and future career development goals, AI can intelligently recommend and assign learning content that is most relevant to an individual's learning journey (Chen, 2023; Debroy, 2023; Dixit & Jatav,



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2024; McNeill et al., 2025; Yıldızhan Bora & Şahin Kölemen, 2025). This personalized approach is further enhanced by AI's ability to build a knowledge base that transforms corporate knowledge into a structured format that can be easily accessed and utilized for training purposes, ensuring that the training process is not only personalized but also effective (Chen, 2023). Moreover, AI facilitates the creation of engaging and effective learning experiences by integrating functionality-based AI Chatbots, which enhance the personalized learning experience of individual learners (Ch'ng, 2023). This is complemented by AI's capability to design training programs that are intuitive and engaging, using individual learner habits and preferences to create smarter platforms for the transfer of training content. Such platforms can include human-like conversations and smarter user interfaces for on-screen communication, making the learning experience more interactive and tailored to the learner's needs (Maity, 2019). In addition, AI's potential to identify learner characteristics and design training and development modules and programs based on these characteristics ensures that the training content is not only personalized but also aligned with the learner's progress and organizational goals. This approach is supported by limited memory AI systems, which can design a training program that includes the mode of delivery and scheduling, further personalizing the learning experience (Kaizer et al., 2020).

### **d.** Automate Content Delivery

AI can significantly automate content delivery by leveraging various technologies and methodologies. Initially, AI can collaborate with creators to generate content, utilizing tools like ChatGPT, Hypotenuse, and Jasper for content creation, and Grammarly and Quillbot for content assistance, ensuring the material is both engaging and error-free (Ch'ng, 2023). This automation extends to the delivery of learning systems through immersive environments, where AI, combined with the Waikato Environment for Knowledge Analysis (WEKA), facilitates natural language processing and user interaction, allowing for the delivery and access of learning systems via mobile methods and the deployment of fully simulated experiences, such as robotic surgery technology (Crompton et al., 2023). Moreover, AI plays a crucial role in making training materials and data sectors easily accessible to employees, tailoring learning modules to individual learning habits and preferences. This approach not only makes training programs more intuitive but also bridges the gap in the absence of an instructor, offering a more natural and engaging learning experience (Chen, 2023). The collaboration between humans and AI in the content supply chain further enhances the efficiency and accuracy of content delivery. This synergy maximizes the strengths of both, with AI processing massive quantities of data and humans adding creativity and critical thinking (Ch'ng, 2023).

Additionally, AI applications in automated factories and intelligent job performance aids demonstrate the potential for AI to facilitate informed problem-solving and reflective reasoning, altering the type of training received in high-technology occupational roles (Dede, 1987). The integration of AI and edge computing in long-distance education breaks geographical boundaries and improves the ability of students to solve complex engineering problems, showcasing AI's role in enhancing online education (Gao et al., 2021). Lastly, robust knowledge management practices enabled by AI ensure that knowledge,



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whether tacit or codified, is easily accessible across an organization. This seamless and intuitive access to information, combined with personalized training and development practices, illustrates how AI can identify learner characteristics and design tailored modules, significantly automating and personalizing the content delivery process (Maity, 2019).

### e. Provide Real-Time Analytics

AI can revolutionize the way training programs are analyzed and optimized in real-time by leveraging its capacity to process and analyze vast amounts of data swiftly. One of the primary ways AI achieves this is by automatically recording training data, which allows for evaluating trainees' performance during the training process. This capability not only facilitates immediate feedback to trainees but also enables the identification of areas where the training content may need adjustments to better meet the learners' needs (Chen, 2023). Furthermore, AI-supported learning systems have made it possible for HR employees to access training that is tailored to their needs more efficiently. This self-service approach to training, supported by AI, ensures that employees receive relevant, high-quality learning experiences without being overwhelmed by unnecessary information (Kambur & Yildirim, 2023).

Additionally, AI tools can be applied across various stages of the training process, including knowledge management, needs analysis, training organization, and results feedback. By transforming organizations into knowledge organizations, AI-based training ensures that the demands of personalized training are met, thereby improving the overall quality of learning. This approach not only benefits the individual learner by providing tailored learning experiences but also enhances the organization's ability to develop a skilled workforce (Chen, 2023). Moreover, the use of AI in training programs can significantly reduce the effort required to analyze surveys and feedback from employees and trainers. This not only helps in identifying training needs and understanding individual learner characteristics but also ensures that the right set of learners is selected for each training program, thereby eliminating favoritism and enhancing the effectiveness of the training (Maity, 2019).

### f. Enhancing the Learning Experiences

AI can significantly enhance the learning experiences of trainees in a training program through several key interventions. Firstly, AI can personalize the learning experience by intelligently recommending and assigning content based on past interactions, skill demands, and future career development needs of each trainee, thereby making the training more relevant and effective (Chen, 2023). Additionally, AI can design training programs that are more intuitive and engaging, using human-like conversations and smarter user interfaces for on-screen communication, which can lead to a more immersive learning experience (Chen, 2023; Maity, 2019). AI also enables the creation of realistic virtual simulations through the combination of virtual reality (VR) and AI, allowing trainees to undergo live visual simulations of job tasks. This not only makes the learning process more interactive but also helps in applying learned skills in practical scenarios, enhancing the retention and applicability of knowledge (Kaizer et al., 2020; Maity, 2019). Furthermore, AI-driven platforms can observe and analyze the learning performance of trainees in real-time, adjusting the pace



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and content of the training based on immediate feedback, which ensures that the learning process is optimized for each individual's needs (Chen, 2023).

### 2.4. Section-4: Relevance of AI-Integrated Learning Framework (AIIT) in ADDIE

The AIIT framework incorporates eight key characteristics adaptive learning, real-time analytics, interactive engagement, ethical decision-making, skill development, knowledge transfer, instructional adaptability, and workforce performance forming a radial structure that enhances training programs. These characteristics serve to modernize the traditional ADDIE model by embedding AI into each phase Analysis, Design, Development, Implementation, and Evaluation making the process more dynamic, personalized, and data-driven (Rehman & Gul, 2025).

- Towards the Integration of AIIT and ADDIE

AIIT's eight defining characteristics as per the definition and radial framework, can be systematically integrated into the five phases of ADDIE, enhancing each phase with modern AI-driven solutions that foster adaptive learning, personalized instruction, and ethical decision-making.

- a. Analysis Phase:** During the analysis phase, the focus is on identifying the learning needs, goals, and objectives (Mayfield, 2011). The learners are assessed based on their educational background, prior knowledge, and skill sets. This stage often involves asking step-by-step questions to determine learning styles, motivations, and physical or cognitive characteristics (Myers et al., 2008). Since this phase is already focused on needs assessment and learner profiling, the integration of AI-driven technologies can make the process more efficient. Specifically, incorporating adaptive learning characteristics and personalized instruction characteristics enables training objectives to be tailored more accurately to individual learner profiles, thereby enhancing the effectiveness of the Analysis phase.
- b. Design Phase:** The Design phase of ADDIE serves a multi-functional purpose (Crompton et al., 2023). At this stage, instructional designers analyze the data gathered during the analysis phase and brainstorm to plan learning experiences. They decide upon the best instructional strategies, learning activities and multimedia elements to make the learning engaging and effective (Berends, 2023). Moreover, in this phase the designers establish learning objectives that are aligned with the learner's current skill level and desired outcomes, ensuring that instructional strategies support the achievement of learning goals (Mayfield, 2011). By integrating AIIT's skill development and interactive engagement characteristics technology can be leveraged more precisely to align objectives with learner needs, ensuring that the instructional design process directly supports the acquisition of targeted skills and competencies. AI facilitates the design of interactive content, such as simulations or chatbots, to make learning experiences more engaging (Maity, 2019).
- c. Development Phase:** This phase requires the development of actual learning materials, including e-learning modules, instructional videos, handouts, and interactive activities. At this stage, instructional designers also incorporate strategies to ensure that learning is effectively retained and transferred by



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learners into practice (Berends, 2023). By embedding AIIT characteristics such as real-time feedback and automation, the development process can become more efficient and adaptive because AI tools provide instant feedback during content creation, enabling continuous improvements by identifying errors, suggesting enhancements, and personalizing guidance in real-time (Debroy, 2023). Furthermore, integrating the workforce performance characteristic ensures that AI-enhanced tools support the creation of performance-based assessments that monitor skill acquisition and workplace readiness, thereby improving both the effectiveness and applicability of the training.

- d. Implementation Phase:** During this phase, the learning materials are delivered to learners through various modalities, including in-person training sessions, online classrooms, or blended approaches. The Implementation phase also involves monitoring the delivery process to identify elements that require adjustment and those that are working effectively (Berends, 2023). However, this phase is also significant in identifying discrepancies, such as gaps between desired knowledge development and actual learner performance, which provides valuable insights for future improvements (Mayfield, 2011). By embedding AIIT characteristics such as adaptive learning and interactive engagement, this phase will become more dynamic, and learner centered. Adaptive learning technologies enable training delivery to adjust in real time to learner progress and performance, while interactive engagement tools such as chatbots, simulations, or gamified platforms foster active participation, making the implementation process more effective and immersive (Crompton et al., 2023).
- e. Evaluation Phase:** Learning is a continuous process, and it is important to evaluate its effectiveness (Berends, 2023). In the Evaluation phase of ADDIE, feedback from learners is collected and analyzed to determine whether the learning objectives have been achieved. A continuous evaluation process allows instructional designers to gather data, identify gaps, and make immediate improvements to enhance training outcomes (Berends, 2023; Branch, 2009). By embedding AIIT characteristics such as knowledge transfer and ethical decision-making, this phase will become more rigorous and transparent. Knowledge transfer ensures that evaluation extends beyond measuring recall to assessing how effectively learners apply knowledge in real-world contexts, while ethically informed practices safeguard fairness, accuracy, and transparency in assessments, thereby strengthening both accountability and learner trust.

### 2.5. Synthesis and Gap Analysis of Reviewed Literature

Despite the extensive body of literature on instructional design, training models, and AI-driven learning systems, significant gaps remain, justifying the need for embedding AIIT within the ADDIE model.

- a. Limited Integration of Emerging Technologies in ADDIE:** While the ADDIE model provides systematic rigor in instructional design, it has been criticized for limited adaptability to emerging technologies (Maity, 2019). Although AI applications have demonstrated potential in enhancing personalization, automation, and analytics (Lo & Hew, 2017; Kaizer et al., 2020), the literature shows little evidence of these capabilities being formally embedded



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within ADDIE. This lack of integration leaves a conceptual and operational gap between traditional instructional design and contemporary technological innovations.

- b. Fragmented Application of AI in Training Programs:** Existing studies frequently examine AI in training and education through isolated lenses such as adaptive learning systems, real-time analytics, or gamification without consolidating these contributions into a unified instructional model (Chen, 2023; Kambur & Yildirim, 2023). This fragmentation has resulted in a scattered body of evidence, limiting both the scalability of AI-enhanced systems and their systematic adoption across sectors.
- c. Absence of a Comprehensive AIIT embedded Framework:** Although AIIT has been conceptually introduced as a response to technological convergence, current literature does not provide a clear framework for mapping AIIT's eight characteristics adaptive learning, real-time feedback, personalized instruction, skill development, workforce performance, interactive engagement, knowledge transfer, and ethically informed instructional practices onto existing instructional models like ADDIE. This absence of a comprehensive blueprint constrains both theoretical development and practical application.
- d. Underexplored Ethical and Decision-Making Dimensions:** Scholarly discussions on AI in instructional design highlight benefits such as efficiency and personalization but often overlook the ethical implications of its use, including fairness, transparency, and bias in algorithm-driven recommendations (Hershock, 2020; Nyathani, 2023). The absence of an ethical decision-making component within ADDIE or its AI extensions raises concerns about equity and responsible implementation in diverse learning environments.
- e. Lack of Longitudinal Evidence on Integrated Effectiveness:** Most research highlights short-term improvements in learner engagement or performance when AI is used in isolated contexts (Evans, 2011; Chen, 2023). However, little empirical evidence exists on the long-term effectiveness of embedding AI across all phases of instructional design. The absence of longitudinal studies evaluating sustained learning outcomes, workforce performance, and organizational impact highlights a critical research gap, underscoring the need for integrated models such as AIIT embedded ADDIE. The five interrelated gaps limited integration of technology in ADDIE, fragmented AI applications, lack of a comprehensive AIIT embedded framework, insufficient ethical discourse, and absence of long-term evidence underscore the necessity of developing an updated instructional design framework. By addressing these gaps, this study directly responds to its objectives outlined in Section 1.3: it examines ADDIE's significance and limitations, evaluates the potential of AIIT characteristics, and proposes a practical integrated model. The AIITembedded ADDIE model therefore serves not only as a theoretical contribution but also as a foundation for future research and practice in designing adaptive, ethical, and performance-driven learning environments.

### 3. Updated Framework: AIIT embedded ADDIE

Building on the critical review, the AIIT embedded ADDIE model integrates the eight defining characteristics of AIIT into the five phases of ADDIE. The

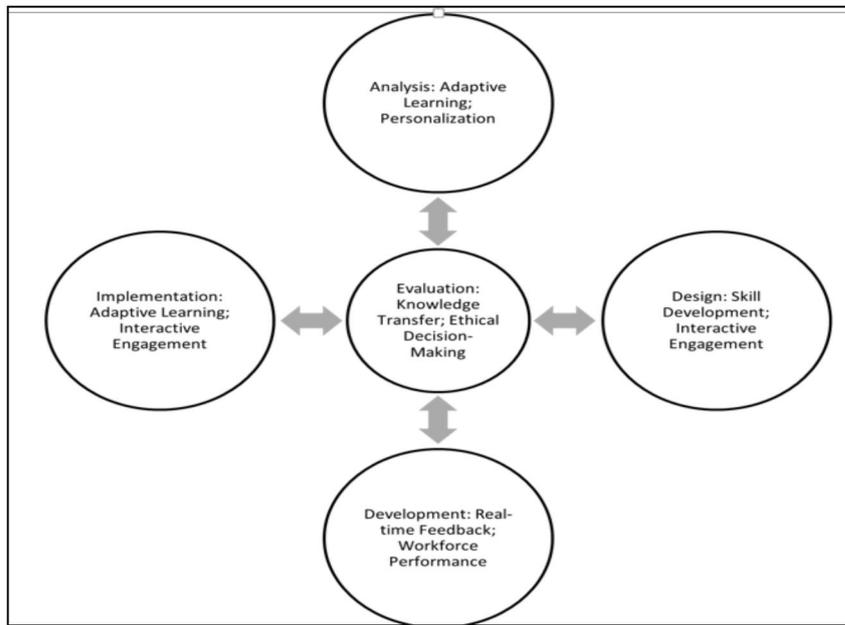


following table summarizes the synthesis.

**Table-1: Integration of AIIT Characteristics within ADDIE Phases**

| ADDIE Phase           | AIIT Characteristics                                  | Integration / Application   |
|-----------------------|---|---|
| <b>Analysis</b>       | Adaptive learning, Personalized instruction           | AI-driven learner profiling and needs assessment align training objectives with individual learner profiles.  |
| <b>Design</b>         | Skill development, Interactive engagement             | Learning paths are aligned with targeted competencies and enriched through experiential tools such as simulations and gamification.                       |
| <b>Development</b>    | Real-time feedback, Automation, Workforce performance | AI tools automate content creation, provide immediate feedback for refinement, and embed performance-based assessments to strengthen workforce readiness. |
| <b>Implementation</b> | Adaptive learning, Interactive engagement             | AI-powered platforms adjust pacing and content delivery in real time, while interactive tools (e.g., chatbots, VR) enhance engagement.                    |
| <b>Evaluation</b>     | Knowledge transfer, Ethical decision-making           | Evaluation expands beyond recall measuring real-world application, while ethical safeguards ensure fairness, transparency, and accountability.            |

While some AIIT characteristics may conceptually overlap, each is defined with a distinct operational focus for integration into ADDIE phases. For instance, adaptive learning pertains to adjusting content pacing to learner progress, whereas personalized instruction focuses on aligning content with learner-specific goals and preferences. Real-time feedback emphasizes immediate guidance during learning activities, and interactive engagement refers to active participation through simulations, chatbots, or gamified tools. This delineation ensures clarity when mapping AIIT characteristics to ADDIE phases.



**Figure-4: AIIT-ADDIE Integration Matrix**

The figure illustrates the integration of the eight defining characteristics mentioned in the radial framework of AIIT (Rehman & Gul, 2025) within the five phases of the ADDIE instructional design model. Inspired by the cyclic structure of ADDIE (Chyung, 2008), the framework emphasizes iteration, with double arrows representing the continuous feedback loops between Evaluation and the other phases. Evaluation is positioned at the center, reflecting its ongoing role in informing and refining all stages of instructional design. The Analysis phase incorporates adaptive learning and personalization through AI-driven learner profiling. The Design phase embeds skill development and interactive engagement, aligning objectives with competencies and experiential tools. The Development phase integrates real-time feedback, automation, and workforce performance to accelerate material creation and strengthen applied skill assessment. The Implementation phase emphasizes adaptive learning and interactive engagement, ensuring delivery remains responsive to learner needs. Finally, the Evaluation phase is expanded to include knowledge transfer and ethical decision-making, thereby promoting both accountability and real-world applicability.

By presenting the AIIT-ADDIE integration framework, this study translates the conceptual synthesis of the literature into a practical model. The framework not only demonstrates how AIIT characteristics can be systematically embedded across ADDIE's phases but also highlights the iterative, learner-centered, and ethically informed nature of instructional design in the digital era. In doing so, it directly addresses the theoretical and operational gaps identified in the review and provides a structured foundation for applying AI-driven instructional design in real-world contexts. The subsequent discussion section examines the broader implications of this integration, focusing on its potential to reshape instructional practice, enhance workforce performance, and safeguard ethical standards in



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technology-enhanced learning environments.

### 4. Discussion

The AIIT embedded ADDIE model developed in this study directly addresses the primary objective of bridging the gap between classical instructional design and the integration of artificial intelligence. The literature review demonstrated that while the ADDIE model has long served as a systematic and structured foundation for instructional design, it has been criticized for rigidity and its limited capacity to accommodate emerging technologies (Chyung, 2008; Maity, 2019). Conversely, AI technologies have been shown to enhance personalization, real-time analytics, and adaptive learning (Lo & Hew, 2017; Chen, 2023), but existing research has treated these applications in fragmented and isolated ways. The integration of AIIT characteristics into ADDIE therefore represents a significant step toward reconciling these parallel developments, offering a unified model that maintains systematic rigor while embedding adaptability, intelligence, and ethical safeguards.

This study achieved its objectives by systematically embedding the eight defining characteristics of AIIT adaptive learning, real-time feedback, personalized instruction, skill development, workforce performance, interactive engagement, knowledge transfer, and ethically informed instructional practices into the five phases of ADDIE. This mapping process demonstrated how classical stages such as Analysis, Design, Development, Implementation, and Evaluation can be enhanced with AI-driven insights. For example, adaptive learning and personalization strengthen the Analysis phase through AI-driven learner profiling, while the Evaluation phase is expanded through ethical decision-making and a focus on knowledge transfer to real-world practice. This integration produces a coherent and future-oriented instructional design model that is responsive to both organizational goals and learner need.

From a theoretical perspective, the AIIT embedded ADDIE model advances the field by updating a classical instructional design model for the digital age. Scholars such as Reiser & Dempsey (2017) and Merrill (2014) have emphasized the enduring value of structured instructional design but also noted its limitations in capturing the capabilities of emerging technologies. Embedding AIIT into ADDIE addresses this critique by ensuring that artificial intelligence is not an external add-on but an embedded, structural element informing each phase of the design cycle. The model demonstrates how systematic rigor and technological adaptability can coexist, positioning ADDIE for continued relevance in AI-driven learning environments.

The practical implications of this integration are substantial. Instructional designers and trainers frequently face uncertainty when selecting from the wide range of available AI tools, often lacking a clear framework to guide decision-making. The AIIT embedded ADDIE model reduces this ambiguity by offering criteria-based guidance: technologies can be evaluated based on whether they support adaptive learning, real-time feedback, interactive engagement, or other AIIT characteristics. For organizations, this ensures training programs are not only efficient and scalable but also directly linked to workforce performance and learner engagement. Importantly, the inclusion of ethically informed decision-making addresses organizational concerns about fairness, transparency, and



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responsible adoption, which remain underexplored in current training literature.

This study also has limitations that must be acknowledged. First, the analysis was conceptual and narrative in nature, drawing primarily from secondary sources rather than empirical testing. This constrains generalizability and highlights the need for validation in applied contexts. Second, while the framework incorporates ethical principles, concrete operational guidelines for ensuring fairness, bias reduction, and data privacy are still required. Finally, given the rapid pace of technological innovation, the framework will require ongoing refinement to remain current and practically useful. Despite these limitations, the contributions of this study are significant. It is among the first to explicitly embed AIIT's defining characteristics within the ADDIE model, thereby transforming a traditional framework into a technology-ready design system. It advances conceptual clarity by showing how instructional design, workforce training, and AI can be systematically aligned, rather than treated as fragmented domains. Moreover, it shifts the perspective from AI as a disruptive external force to AI as a structural and ethical component of instructional design.

While the AIIT embedded ADDIE model is conceptually linked to improved learning effectiveness and workforce performance, these outcomes remain to be empirically validated in future research. Future research should focus on empirically testing the AIIT embedded ADDIE model across diverse contexts such as higher education, corporate training, and healthcare, with attention to measuring long-term effectiveness and workforce performance. Longitudinal studies would provide insight into the sustainability and scalability of this integrated model. Additionally, operationalizing the framework into practical tools such as implementation rubrics, decision checklists, and design templates would enhance its usability for practitioners. By pursuing these directions, future work can ensure that instructional design remains adaptive, ethical, and effective in an era of continuous technological transformation.

### 5. Conclusion

This study responds to the limitations of the traditional ADDIE model by embedding the AI-Integrated Instructional and Training Technologies (AIIT) model into its five phases. While ADDIE has long provided systematic rigor and structural discipline in instructional design, it has been criticized for its limited adaptability to emerging technologies. By integrating AIIT's eight defining characteristics adaptive learning, real-time feedback, personalized instruction, skill development, workforce performance, interactive engagement, knowledge transfer, and ethically informed instructional practices this study advances a unified model that retains ADDIE's systematic strengths while addressing the demands of technology-driven learning environments.

The key contribution of this research lies in formalizing the AIIT embedded ADDIE model as a practical and future-ready instructional design model. It not only enhances the adaptability and responsiveness of training programs but also ensures that ethical safeguards and real-world applicability are systematically embedded in the design cycle. Although conceptual in nature, this framework establishes a foundation for future empirical studies to test its effectiveness



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across diverse educational and professional contexts, evaluate its long-term impact on workforce performance, and operationalize its ethical components into concrete practices. In doing so, this study advances the field of instructional design by demonstrating how classical models can be revitalized through AI integration. The AIIT embedded ADDIE model thus provides both theoretical clarity and practical direction, bridging the gap between tradition and innovation, and offering a coherent, adaptive, and ethically responsible roadmap for instructional design in the digital era.

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