บทความเทคนิค (Technical Article)

Journal of Digital Education and Learning Engineering

ดำเนินการวารสารโดย สมาคมการศึกษาดิจิทัลและวิศวกรรมการเรียนรู้

Strategies for Leveraging AI Tools to Enhance Design Thinking Skills for Learners in the Digital Education Era

Phongsak Phakamach[1*], Sasirada Pangthai[2], Pinya Sukwiphat[3], Natchaya Sommartdejsakul[4] & Ritthidech Phomdee[4]

Rattanakosin International College of Creative Entrepreneurship, Rajamangala University of Technology Rattanakosin, Thailand[1*], Faculty of Education, Pitchayabundit College, Thailand[2], Thatphanom College, Nakhon Phanom University, Thailand[3], Advanced Future Talent Academy (AFTA), Thailand[4]

Abstract

This article outlines key strategies for integrating Artificial Intelligence (AI) tools into Design Thinking pedagogy to enhance learners' skills in the digital education era. The core concept positions AI as an "enabling assistant" that expands capabilities in critical thinking, creativity, and problem-solving. AI efficiently manages tasks such as in-depth data analysis for user needs in the Empathize phase, expanding new concepts for diverse ideation in the Ideate phase, accelerating prototyping, and refining solutions with AI feedback mechanisms in the Test phase. This approach aims to reduce learners' cognitive burden, allowing them to focus on deep thinking and complex, human-centered decision-making. A crucial strategy involves cultivating essential human skills alongside AI expertise. This includes teaching prompt engineering to extract valuable insights from AI and fostering the ability to critically evaluate AI outputs for biases, inaccuracies, or limitations. Instilling a deep understanding of ethics is also vital, guiding learners to comprehend the social impacts and responsible use of AI in design. Educators play a central role as facilitators and mentors, guiding learners to use their human-centered judgment in final decisions, ensuring human insight remains core to the innovation process. Implementing these recommendations transforms learners from mere technology consumers into "agile and discerning innovators". They will not only be proficient in using modern AI tools but also practice deep decision-making, critical sharpness, and ethical awareness essential for applying Design Thinking to complex real-world problems. This approach prepares learners to be adaptable, creative, and responsible contributors in an increasingly AI-driven society.

Keywords: Strategies for Leveraging, AI tools, design thinking skill, digital education

---

*Corresponding author

Email address: phongsak.pha@rmutr.ac.th

■ Introduction

The digital education era is profoundly changing how we learn, teach, and prepare future generations. In this evolving landscape, traditional rote learning is no longer sufficient. There is a growing need to cultivate crucial "21st century skills" such as critical thinking, creativity, collaboration, communication, and problem-solving. Among these skills, Design Thinking stands out as a powerful, human-centered, iterative, and collaborative approach to solving complex problems (Phakamach, 2023; Marengo et al., 2024). It is a methodology for creative problem-solving centered on empathy for the end-user, and it typically involves five interconnected phases: Empathize, Define, Ideate, Prototype, and Test (Elsbach & Stigliani, 2018). This process guides users from understanding a problem to generating and validating solutions. For learners, this methodology fosters curiosity, resilience, and a deep commitment to user-centricity, teaching them to identify needs, brainstorm possibilities, and refine their creations based on feedback. These skills are crucial for future careers that demand adaptability, ingenuity, and innovation (Nakata & Hwang, 2020; Rösch et al., 2023). Concurrently, Artificial Intelligence (AI) has become a pervasive force, reshaping industries from healthcare to education. AI's capabilities, including data analysis, pattern recognition, natural language processing, predictive modeling, and generative content creation, are transforming information processing and decision-making (Li & Wong, 2023). In education, AI promises personalized learning and enhanced access to analytical power. Its true potential lies in augmenting human intelligence and creativity, enabling insights and innovations previously out of reach. When viewed as an intelligence amplifier, AI opens new frontiers for learning and problem-solving (Mariyono & Nur Alif Hd, 2025).

The synergy between Design Thinking and AI offers a significant opportunity for modern education. Historically, aspects of Design Thinking, such as data synthesis, ideation, and rapid prototyping, could be time-consuming or limited by human bias. AI tools can accelerate and enable these processes. By automating analytical tasks, AI frees learners to focus on higher-order thinking: empathy, critical judgment, creative leaps, and strategic decision-making (Dell'Era et al., 2025). For example, AI can swiftly analyze user feedback, generate diverse ideas, assist in digital prototype development, or help categorize test results. This streamlines Design Thinking, enriches outcomes, and enables faster iteration. AI also democratizes Design Thinking, making sophisticated capabilities accessible to more learners. The partnership between human ingenuity and AI's computational power is key to cultivating a new generation of innovators adept at using technology to solve human-centered problems (Alsobeh, & Woodward, 2024). However, integrating AI into Design Thinking education requires careful consideration of nuances and ethics. Learners must develop both technical proficiency in using AI tools and the critical acumen to evaluate their outputs. Issues like algorithmic bias, data privacy, and responsible use of generative AI demand a balanced pedagogical approach (Payadnya et al., 2025). Educators must guide learners to understand the limitations of AI, recognize potential inaccuracies, and ultimately use human judgment as the final decision-maker for solutions. The goal is to create a symbiotic relationship where human creativity and critical thinking are enhanced by AI's capabilities, not overshadowed by them. This requires a deliberate teaching strategy that

emphasizes thoughtful integration, ethical awareness, and the skills needed for learners to work effectively with AI (Aad, & Hardey, 2025; Chen et al., 2025).

This article explores how AI tools can be strategically used to enhance learners' Design Thinking skills, preparing them to not only adapt to but also actively shape the digital era. Educational institutions should strategically integrate AI tools into the Design Thinking curriculum. This document provides a framework of specific strategies for incorporating AI into each stage of the Design Thinking process, from understanding user needs to testing solutions. Our goal is to cultivate learners who are empowered creators, innovative problem-solvers, and empathetic contributors. These learners will be ready to tackle tomorrow's multifaceted challenges with a combination of human ingenuity and technological prowess. The following sections will offer practical guidance for educators who wish to harness the transformative power of AI to foster excellence in Design Thinking.

■ Literature Review

The growing recognition of Design Thinking as a key methodology for innovation and problem-solving has coincided with the widespread advancement of AI in various sectors, including education. Recent academic literature increasingly explores the symbiotic relationship between these two areas, suggesting that AI tools can significantly enhance the human-centered, iterative processes of Design Thinking, thereby improving learners' skills in the digital education era (Alsobeh, & Woodward, 2024). Researchers emphasize that AI should serve as an intelligence amplifier, not a replacement for human cognition, enabling learners to tackle "wicked problems" with greater efficiency and insight. This integration aims to cultivate 21st century skills, including critical thinking, creativity, collaboration, and problem-solving, which are essential for navigating complex future landscapes (Routray & Khandelwal, 2024; Payadnya et al., 2025; Aad & Hardey, 2025).

Studies highlight specific applications of AI across the Design Thinking phases. In the Empathize phase, AI-powered tools, such as sentiment analysis and natural language processing (NLP), are shown to efficiently process large volumes of qualitative data, revealing deeper insights into user needs and behaviors that might otherwise be missed by human analysis alone. This data-driven understanding allows for more precise problem framing in the Define stage, with AI assisting in identifying patterns and generating diverse "How Might We" questions. For Ideation, generative AI and large language models (LLMs) act as brainstorming partners, expanding creative horizons by suggesting unconventional solutions and overcoming cognitive biases, leading to a broader spectrum of innovative ideas. During Prototyping, AI-assisted UI/UX design tools and low-code/no-code platforms enable rapid development of digital and even physical prototypes, streamlining the creation process and reducing time and resource demands (Sposato, 2025). Finally, in the Test phase, AI-powered analytics can synthesize user feedback, analyze user interactions, and even predict user behavior, providing rapid, data-informed insights for iterative refinement of solutions (Arslan et al., 2025). Research consistently points to these applications as key to accelerating the Design Thinking cycle and enhancing its outcomes.

While the benefits are clear, the literature also highlights significant challenges and ethical considerations in integrating AI into Design Thinking education. A major concern is the potential for over-reliance on AI, which could diminish human critical thinking, creativity, and independent problem-solving skills if not managed carefully (Omran Zailuddin et al., 2024). Scholars emphasize that learners must develop both technical proficiency in using AI tools and the critical ability to evaluate their outputs, recognizing potential biases or inaccuracies. Ethical considerations, such as data privacy, algorithmic bias, and accountability, are paramount. This requires a balanced teaching approach that prioritizes human-centered design and continuous human judgment (Hardaker & Glenn, 2025). Therefore, while AI offers transformative potential for enhancing Design Thinking skills, successful implementation requires educators to act as facilitators and mentors, guiding learners to use AI responsibly and to maintain human insight at the core of the innovation process (Mudkanna Gavhane & Pagare, 2024; Payadnya et al., 2025).

Before outlining the strategies for using AI tools to enhance Design Thinking skills for learners in the digital education era, which is the objective of this article's content, the following section will first discuss the importance of Design Thinking principles for learners in the digital education era, with other related sections presented subsequently.

■ The Importance of Design Thinking Principles for Learners in the Digital Education Era

In the digital education era, where technology evolves rapidly and information is abundant, Design Thinking has become an exceptionally crucial skill for learners. Knight et al. (2020), Rösch et al. (2023), and Magistretti et al. (2023) pointed that it's not just about creating products or services; it's a thought process that helps students deeply understand problems, create sustainable solutions, and effectively adapt to change. Robbins and Fu (2022) explored and presented the key reasons for the importance of Design Thinking for learners in this era:

1. Focuses on Real Problems and User-Centricity

Design Thinking begins with a deep understanding and empathy for the user. This teaches learners to look beyond their own assumptions and genuinely comprehend people's needs, problems, and contexts. This skill is vital in a digital age where information can be overwhelming. A thorough understanding of the problem leads to the development of precise and truly valuable solutions.

2. Fosters Creativity and Innovation

In an era where everything can be replicated, creating new things is paramount. Design Thinking encourages learners to generate ideas (Ideate) freely, without limitations, and without fear of failure. This process helps students think outside the box and develop novel solutions, which is essential for fostering innovation in a technology-driven world (Dell'Era et al., 2025).

3. Develops Collaboration and Communication Skills

Design Thinking is a process that emphasizes teamwork. Learners will acquire skills in brainstorming, presenting ideas, actively listening to feedback, and collaborating with others from diverse backgrounds and

expertise. These skills are necessary for working in digital environments that prioritize cross-functional collaboration.

4. Builds Adaptability and Learning from Failure

The principles of Design Thinking involve repeated prototyping and testing. This process teaches learners not to cling to initial ideas but to learn from mistakes and continuously iterate and improve. Students will realize that failure is not an end but an opportunity for learning and growth. This skill of adaptability and resilience is highly important in a rapidly changing digital world.

5. Prepares for the Future of Work

The future job market demands individuals with skills in Complex Problem Solving, Creativity, and Critical Thinking, all of which are core to Design Thinking. Having these skills enables learners not only to use digital tools but also to become creators, innovators, and individuals who can apply technology to solve real-world problems.

In summary, Design Thinking is more than just a methodology; it's a mindset that cultivates learners become creative problem-solvers, empathetic individuals, effective collaborators, and lifelong learners. These qualities are crucial for success in the digital education era and the future. After discussing the importance of Design Thinking, the next section will cover AI tools that could be used to enhance these skills and inform the development of effective application strategies.

■ Using AI Tools to Enhance Design Thinking Skills for Learners in the Digital Education Era

Using AI tools to enhance Design Thinking skills for learners in the digital education era is crucial. This prepares students for a rapidly changing world of work and strengthens their ability to solve complex problems effectively. Magistretti et al. (2023), Bilal et al. (2025), Payadnya et al. (2025), and Dell'Era et al. (2025) mentioned the key reasons of using AI tools to enhance Design Thinking skill learners in the digital education era as follows:

1. Increased Efficiency and Speed

1) Reduces Repetitive Tasks: AI can reduce repetitive tasks by handling time-consuming work like collecting and analyzing large amounts of data, summarizing information from interviews, or creating initial prototypes. This gives students more time to focus on strategic thinking and creative processes that require human intellect.

2) Rapid Prototyping: AI tools significantly accelerate the creation of wireframes, mockups, or even complex prototypes. This enables learners to test ideas multiple times within a short period.

2. Enhanced Analysis and Empathy

1) Deeper Data Insights: AI can analyze in-depth data from user behavior, feedback, and various trends more accurately and quickly than humans. This allows learners to gain a much deeper understanding of users' "Pain Points" and "Gain Points" during the Empathize stage.

2) Reduced Analytical Bias: AI can help minimize personal biases that might arise during data interpretation, leading to more accurate and neutral problem definition.

3. Fostering Creativity and Innovation

1) Sparks New Ideas: Generative AI can produce diverse and novel concepts, images, or text based on input data. This expands learners' thinking horizons and encourages out-of-the-box thinking during the Ideate stage.

2) Overcoming Mental Blocks: AI can offer ideas that may not be limited by learners' existing experiences or knowledge, leading to more distinct and creative solutions.

4. Increased Learning and Experimentation Opportunities

1) Easier Iterative Testing: With AI, creating and refining prototypes for testing is quick and simple. This allows learners to repeat the iteration cycle multiple times, which is a core principle of Design Thinking.

2) Learning from Results: AI can analyze test results and provide suggestions for improvement, helping learners understand the strengths and weaknesses of their concepts and how to refine them.

5. Future-Proofing Skills

1) Essential Digital-Era Skills: Design Thinking combined with AI usage is a highly sought-after skill by employers in the digital age, as organizations increasingly adopt AI in their operations and innovation processes.

2) Complex Problem-Solving Capability: The modern world is filled with complex and rapidly changing problems. Integrating Design Thinking with AI provides learners with robust tools and processes to tackle these challenges.

In summary, using AI tools to enhance Design Thinking skills not only boosts efficiency and effectiveness at each stage but also strengthens creativity, in-depth analysis, and most importantly, prepares learners with the necessary skills to become creators and problem-solvers in a future driven by technology.

■ Strategies for Leveraging AI Tools to Enhance Design Thinking Skills for Learners in the Digital Education Era

The effective integration of AI into Design Thinking education can significantly amplify learners' capabilities, streamline the innovation process, and foster deeper insights. Mudkanna Gavhane and Pagare (2024), Bilal et al. (2025), Ellikkal and Rajamohan (2025), and Dell'Era et al. (2025) presented the following strategies outline how AI tools can be strategically applied across each phase of Design Thinking as follows:

1. Empathize: Deepening User Understanding with AI

In the Empathize phase, the goal is to gain profound insights into users' needs, behaviors, and contexts. AI tools can revolutionize data collection and synthesis as follows:

1) AI-Powered Sentiment and Trend Analysis: Learners can utilize AI-driven sentiment analysis tools to process vast amounts of qualitative data from interviews, social media, and open-ended surveys. This allows for rapid identification of emotional nuances, pain points, and emerging trends among user groups, enabling a more comprehensive understanding of their underlying needs. For instance, an AI tool can quickly

highlight recurring frustrations expressed in hundreds of customer reviews, directing learners to specific areas for deeper investigation (Marengo et al., 2024).

2）Natural Language Processing (NLP) for Data Synthesis: NLP tools can assist in organizing, categorizing, and summarizing large textual datasets gathered during user research. This helps learners synthesize complex information efficiently, identify key themes, and uncover implicit needs that might be overlooked in manual analysis, thereby freeing up cognitive load for empathetic reflection.

2. Define: Sharpening Problem Statements with AI

The Define phase involves synthesizing research findings into a clear, actionable problem statement. AI can help refine this critical step as follows:

1) AI-Assisted Problem Framing: By feeding AI the synthesized data, learners can prompt generative AI models to suggest diverse "How Might We" (HMW) questions. This broadens the scope of potential problem definitions, encouraging learners to think beyond obvious solutions and critically evaluate various angles of the core challenge (Marengo et al., 2024).

2）AI for Causal Analysis and Visualization: AI tools can help identify causal relationships within complex datasets to pinpoint root causes of user problems. Subsequently, visualization AI can generate intricate diagrams or mind maps, visually representing these interdependencies, allowing learners to articulate a more precise and well-supported problem statement (Marengo et al., 2024).

3. Ideate: Expanding Creative Horizons with AI

In the Ideate phase, the aim is to generate a wide array of potential solutions. AI serves as a powerful brainstorming partner as follows:

1）Generative AI for Idea Generation: Learners can use LLMs to prompt for novel ideas based on specific problem statements, user personas, or desired features. AI can offer diverse concepts, combine seemingly unrelated ideas, and even generate variations of existing ideas, helping overcome creative blocks and fostering a more expansive ideation process (Omran Zailuddin et al., 2024).

2) AI-Powered Concept Expansion and Diversification: Beyond initial generation, AI can help expand on promising ideas by suggesting different angles, target audiences, or implementation methods. This encourages learners to explore niche applications or unconventional approaches, significantly increasing the diversity and originality of proposed solutions (Omran Zailuddin et al., 2024).

4. Prototype: Accelerating Solution Development with AI

The Prototype phase involves creating tangible representations of solutions for testing. AI tools facilitate rapid and efficient prototyping as follows:

1) AI-Assisted UI/UX Design and Code Generation: For digital solutions, AI-powered design tools can generate initial wireframes, mockups, or even functional code snippets from textual descriptions or sketches. This dramatically reduces the time and technical barrier to creating usable prototypes, allowing learners to quickly translate abstract ideas into interactive models.

2）AI for Component Generation and Integration: In more complex systems, AI can assist in generating specific components or suggest how different modules can be integrated, speeding up the assembly of prototypes for various functionalities, whether for hardware or software.

5. Test: Optimizing Solutions Through AI-Driven Feedback

The Test phase involves gathering user feedback on prototypes to refine solutions. AI enhances the analysis and iteration process as follows:

1）AI-Powered User Testing Analysis: AI can analyze qualitative data from user testing sessions (e.g., transcribed interviews, video recordings of user interactions, eye-tracking data) to identify patterns in user behavior, common usability issues, and areas of confusion. This enables learners to quickly pinpoint critical feedback points (Cook & Cook, 2024; Mudkanna Gavhane & Pagare, 2024).

2) AI for Feedback Synthesis and Prioritization: When faced with large volumes of feedback, AI can summarize key themes, categorize comments, and even help prioritize areas for improvement based on frequency or sentiment. This allows learners to efficiently identify the most impactful changes needed for their prototypes, leading to more focused and effective iterations (Cook & Cook, 2024).

By strategically integrating these AI tools, learners are not just using technology; they are actively developing advanced Design Thinking skills. They become more empathetic, innovative, and efficient problem-solvers in the dynamic digital landscape. This augmentation allows them to focus on higher-order cognitive tasks, making them adept at leveraging technological advancements for human-centered innovation. The next section will provide guidelines for implementing strategies for using AI tools to enhance Design Thinking skills for learners in the digital education era.

■ Guidelines for Effective Implementation of AI Strategies to Enhance Design Thinking Skills for Learners in the Digital Education Era

Bellis et al. (2023), Alsobeh and Woodward (2024), Bilal et al. (2025), Mariyono and Nur Alif Hd (2025), Payadnya et al. (2025), and Sposato (2025) gave a perspective to effectively implement strategies for leveraging AI tools to enhance Design Thinking skills within the digital education context, clear and comprehensive guidelines are essential as follows:

1. Build Foundational Understanding of AI and Design Thinking

1）For Educators: Intensive practical training is crucial for educators to gain a deep understanding of both the principles and stages of Design Thinking, as well as the capabilities, limitations, and practical applications of various AI tools (e.g., Generative AI, Sentiment Analysis tools, or AI-powered visualization tools). The training should focus on enabling educators to effectively guide learners in using AI to enhance the design thinking process correctly, ethically, and with maximum efficiency (Alsobeh & Woodward, 2024; Arslan et al., 2025).

2) For Learners: Engaging and informal foundational activities should be organized to introduce the core concepts of Design Thinking and the basic capabilities of AI. It's essential to emphasize AI's role as an "intelligent assistant" that augments learners' thinking and creativity, rather than replacing human deliberation. These activities might include demonstrating basic AI usage in simulated scenarios to help learners visualize and understand its benefits (Mudkanna Gavhane & Pagare, 2024; Bilal et al., 2025; Payadnya et al., 2025).

2. Systematically Integrate AI into the Curriculum

1）Identify Strategic Connection Points: Curriculum developers, in collaboration with educators, should clearly identify which Design Thinking stages AI tools can most effectively augment. For instance, in the Empathize stage, AI can assist in analyzing large volumes of user data, while in the Ideate stage, it can rapidly generate diverse ideas. Once these connection points are identified, teaching plans, projects, and learning activities should be adjusted to naturally and sequentially incorporate the use of AI tools into each stage (Salinas-Navarro et al., 2024).

2）Provide Appropriate Tools and Platforms: Selecting AI tools that are accessible, user-friendly, and align with the learning objectives of each stage is vital. Consideration should be given to tools that support collaborative work to foster group learning. Furthermore, a digital environment conducive to AI usage, such as access to necessary platforms and information on technical requirements, should be prepared (Omran Zailuddin et al., 2024).

3. Emphasize Experiential and Critical Learning

1）Challenging and Authentic Projects: Design projects or case studies that provide learners with opportunities to use AI tools in real-world complex problem-solving scenarios, or problems based on authentic user contexts. These projects should foster innovative thinking and the comprehensive application of Design Thinking from beginning to end (Rösch et al., 2023).

2）Promote Critical Thinking and Ethics: Encourage learners to consistently question the results obtained from AI, such as "Is the data analyzed by AI reliable?", "Are there hidden biases in AI's output?", or "What are the ethical implications of the solutions proposed by AI?" Emphasizing human judgment for final decisions and considering the ethical impact of AI usage is critically important (Chen et al., K., 2025).

4. Develop Essential Skills Concurrently with AI Use

1）Prompt Engineering and Deep Questioning: Teach learners the art and science of crafting effective prompts to obtain AI results that are precise, high-quality, and expandable. Additionally, foster deep questioning skills, both towards AI and the problem being solved, to extract truly insightful information (Hardaker & Glenn, 2025).

2）Collaboration and Communication: While AI can alleviate some workload, Design Thinking still relies on teamwork, idea exchange, effective communication, and consensus-building among individuals. Promoting these skills alongside AI usage is absolutely necessary (Hardaker & Glenn, 2025).

5. Continuously Evaluate and Improve

1）Holistic Assessment of Design Thinking Skills: Assessment should cover not only the final project outcomes but also the learners' design thinking process at each stage, including their ability to select and apply AI tools to enhance those skills (Verganti et al., 2021; Salinas-Navarro et al., 2024).

2）Collect Data and Refine Strategies: Gather feedback from both educators and learners regarding the use of AI tools in the learning process. Regularly reviewing and refining teaching strategies, tools used, and curriculum content will help ensure the long-term effectiveness of AI integration for enhancing Design Thinking (Verganti et al., 2021; Rösch et al., 2023).

Implementing these guidelines will enable learners to not only gain a deep understanding of Design Thinking but also to develop smart, discerning, and creative AI usage skills, which are essential for becoming successful citizens and innovators in the digital education era. The previous section discussed strategies for leveraging AI tools to enhance Design Thinking skills and their effective applications. The following section will introduce suitable AI tools for elevating Design Thinking and its practical application for learners in the digital education era.

■ Suitable AI Tools for Enhancing Design Thinking and Its Application for Learners in the Digital Education Era

Elevating Design Thinking skills and their practical application for learners in the digital education era can be achieved more effectively by using appropriate AI tools. Fan et al. (2025), Patel and Lim (2025), and Bilal et al. (2025) mentioned in each stage of Design Thinking, AI tools can enhance students' capabilities as follows:

1. Empathize Stage

Goal: To deeply understand the users, target audience, problems, and context.

1) AI-powered Sentiment Analysis & Text Analysis Tools (e.g., IBM Watson Natural Language Understanding, Google Cloud Natural Language API, or tools within CX/UX Research platforms):

Application: Analyze data from interviews, open-ended surveys, social media comments, or product/service reviews to identify sentiments (positive/negative/neutral), emotions, trends, and key issues raised by users. This helps students systematically and quickly understand users' "Pain Points" and "Gain Points."

2) AI-driven Data Visualization Tools (e.g., Tableau, Power BI with AI features for data analysis):

Application: Help organize and present large amounts of collected data in an easily understandable format, such as graphs, charts, or dashboards. This enables students to visualize data relationships and uncover hidden insights.

3) AI for Persona Generation (e.g., Userforge):

Application: Create User Personas based on collected data, giving students a clearer picture of their users, which is crucial for building empathy and understanding.

2. Define Stage

Goal: Synthesize the gathered information to formulate the true core problem (Problem Statement).

1) AI-powered Summarization Tools (e.g., ChatGPT, Google Gemini, Anthropic Claude):

Application: Help condense large amounts of information from the Empathize stage into concise key points. This allows students to filter out irrelevant information and focus on the main problem.

2) AI for "How Might We" (HMW) Questions Generation:

Application: Students can input a discovered problem, and the AI can help generate a variety of interesting "How Might We" questions to open up different perspectives for finding solutions.

3) AI-powered Mind Mapping & Collaboration Tools (e.g., Miro, Xmind AI):

Application: Assist in organizing information, synthesizing insights, and systematically connecting ideas, making the formulation of the Problem Statement clearer and more comprehensive.

3. Ideate Stage

Goal: Generate diverse and novel ideas or solutions to the problem.

1) Generative AI (Text-to-Text, Text-to-Image) (e.g., ChatGPT, Google Gemini, Midjourney, DALL-E, Adobe Firefly):

(1) Text-to-Text Application: Input a problem or challenge, and let the AI generate numerous potential solution concepts. This expands students' thought horizons and suggests ideas they might not have considered.

(2) Text-to-Image Application: Use to quickly create visual mock-ups or conceptual images, helping abstract ideas become tangible. This clarifies the communication of ideas.

2) AI-powered Brainstorming & Idea Management Tools (e.g., Stormz, Ideaflip, Miro, Xmind AI):

Application: Help manage digital brainstorming sessions, group ideas, vote on them, and prioritize concepts, making the Ideation process structured and efficient.

4. Prototype Stage

Goal: Create a prototype of the chosen concept for testing.

1) AI-assisted Prototyping Tools (e.g., Uizard, Figma (with AI plugins), Adobe XD (with AI features)):

(1) Sketch-to-UI Application: Quickly convert hand-drawn sketches into wireframes or UI mockups.

(2) Text-to-UI Application: Generate basic UI/UX designs from text commands. This allows students to create prototypes rapidly, reducing time spent on technical details, and focusing on concept testing.

(3) AI Component Creator (e.g., UXPin Merge): Helps automatically generate UI/UX components.

2) AI for Rapid Prototyping (e.g., Adobe Firefly for images, AI-powered video creation tools):

Application: Helps create supplementary prototype media (e.g., illustrations, explanatory videos) quickly, making prototypes more engaging and communicative.

5. Test Stage

Goal: Test the prototype with real users to gather feedback and make improvements.

1) AI-powered User Testing Platforms (e.g., UserTesting.com, Maze):

Application: Record and analyze user behavior, analyze comments, and identify common problem patterns. This provides students with accurate and rapid insights from testing results.

2) AI for Feedback Analysis (e.g., NLP tools, AI-powered survey tools):

Application: Analyze text feedback from users (e.g., from surveys, interviews) to identify key issues, trends, and user sentiments. This ensures that the summary of testing results and improvement decisions are data-driven.

3) AI for Iteration Suggestions:

Application: Some platforms may have AI features that suggest ways to improve prototypes based on user feedback data.

Implementation and Integration in Digital Education Contexts

The implementation and integration of AI in digital education contexts include the following points:

1) Project-Based Learning (PBL): Utilize AI as a supportive tool throughout all stages of Design Thinking projects.

2) Digital Collaboration: Employ AI-powered Collaboration Tools (e.g., Miro, Mural) with AI features for idea management, data organization, and summarizing collaborative work.

3) Personalized Learning: AI-powered learning platforms (e.g., LearnWorlds, Thinkific with AI-powered course builders/feedback) can help adapt content and exercises to each student's progress and needs in developing Design Thinking skills.

4) Scenario Simulation: Use AI to create simulated scenarios for testing concepts or practicing empathy with complex problems.

5) Ethics and Responsible Use: It's crucial to teach students to understand the limitations of AI, potential biases from the data AI learns from, and how to use AI ethically and responsibly in their creative work.

Integrating AI tools into the teaching and learning of Design Thinking will increase efficiency, reduce time and resource limitations, and, most importantly, foster learners' critical thinking and creativity skills to an advanced level in the digital education era.

■ Conclusion and Discussion

The digital education era represents a pivotal moment, presenting both unprecedented challenges and remarkable opportunities for cultivating a generation of future-ready learners. As meticulously detailed in the "Guidelines for Effective Implementation of AI Strategies to Enhance Design Thinking Skills for Learners in the Digital Education Era" document, a strategic and thoughtful approach to integrating Artificial Intelligence (AI) tools into Design Thinking pedagogy is not merely advantageous, but fundamentally essential. By systematically addressing foundational understanding, meticulous curriculum integration, robust experiential learning, targeted skill development, and continuous evaluation, educational institutions are uniquely positioned to effectively leverage AI's capabilities. This integration serves to significantly amplify learners' critical thinking, creativity, collaborative prowess, and sophisticated problem-solving abilities, preparing them for a world defined by dynamic complexity and constant technological evolution (Cook & Cook, 2024). The synergy between human ingenuity and AI's computational power promises to unlock new frontiers for innovation and learning, transforming the very essence of educational engagement.

The preceding discussion underscored a crucial paradigm: AI should unequivocally function as an intelligent assistant, purposefully augmenting human capabilities rather than attempting to replace them. This principle dictates a pedagogical approach that strategically empowers learners to utilize AI for enhanced efficiency and deeper insights across every phase of the Design Thinking process. For instance, AI

can revolutionize data analysis in the Empathize phase, allowing for quicker identification of user needs and underlying sentiments from vast datasets. In the Ideate phase, generative AI tools can dramatically expand the breadth and originality of ideas, helping learners overcome creative blocks and explore unconventional solutions (Aad & Hardey, 2025). Furthermore, AI can significantly accelerate prototyping, transforming abstract concepts into tangible models with unprecedented speed, and critically, refine solutions through sophisticated AI-driven feedback mechanisms during the Test phase. However, this powerful integration must be intrinsically accompanied by a strong and deliberate focus on developing essential human skills. These include the nuanced art of prompt engineering, the indispensable capacity for critical evaluation of AI outputs to discern bias or inaccuracy, and a profound commitment to ethical considerations in all AI applications. The ultimate effectiveness of this educational framework hinges on educators fully embracing their evolving roles as facilitators and astute mentors, guiding learners to not only skillfully interact with AI's results but also to exercise their own informed, human-centric judgment as the ultimate arbiter of solutions (Bilal et al., 2025).

Ultimately, the successful implementation of these comprehensive strategies promises to move learners far beyond the passive consumption of technology, a common pitfall in many digital learning environments. Instead, it will proactively transform them into agile and discerning innovators who are not only fluent in operating cutting-edge AI tools but also possess the profound discerning judgment, critical acumen, and ethical awareness indispensable for applying Design Thinking effectively to the multifaceted and complex problems of the real world. This holistic approach prepares them to be exceptionally adaptable, profoundly creative, and unequivocally responsible contributors in an increasingly AI-driven global society. By cultivating a symbiotic relationship between human cognition and artificial intelligence, we are equipping learners with the tools and mindset required to confidently navigate and actively shape the challenges and opportunities of the 21st century.

◼ Recommendations

From the comprehensive data discussed, a holistic picture emerges regarding the importance, utility, and practical application of AI tools for learners in the digital education era. Specifically, the strategic approach for leveraging AI tools to enhance Design Thinking is a crucial consideration for educational institutions, leading to several key recommendations for effectively integrating AI tools into Design Thinking pedagogy as follows:

Firstly, prioritize AI as an augmentative assistant, not a replacement for human intellect. Educational frameworks should explicitly position AI tools as powerful amplifiers for critical thinking, creativity, and problem-solving, rather than as substitutes for human cognitive processes. This means designing learning activities where AI efficiently handles data analysis (e.g., sentiment analysis for user needs in the Empathize phase), expands ideation (e.g., generative AI for diverse concept generation in the Ideate phase), accelerates prototyping, and refines solutions through advanced feedback mechanisms. The core objective should

always be to free up learners' cognitive load for higher-order thinking, empathetic understanding, and complex decision-making.

Secondly, cultivate essential human skills concurrently with AI proficiency. It is crucial to develop specific competencies that enable learners to effectively collaborate with AI. This includes teaching the "art" of prompt engineering, ensuring learners can craft precise and effective queries to extract valuable insights from AI tools. Equally important is fostering the indispensable capacity for critical evaluation of AI outputs, equipping learners to discern biases, inaccuracies, or limitations inherent in algorithmic results. A strong commitment to ethical considerations must also be embedded, guiding learners to understand the societal impacts and responsible use of AI in design. Educators must actively embrace their roles as facilitators and astute mentors, guiding learners to exercise their own informed, human-centric judgment as the ultimate arbiters of solutions, ensuring that human insight remains at the core of the innovation process.

Ultimately, by implementing these recommendations, educational institutions can move learners beyond passive technology consumption. This strategic approach will proactively transform them into agile and discerning innovators who are not only fluent in operating cutting-edge AI tools but also possess the profound judgment, critical acumen, and ethical awareness necessary for applying Design Thinking effectively to complex real-world problems.

■ *References*

Aad, S., & Hardey, M. (2025). Generative AI: hopes, controversies and the future of faculty roles in education. *Quality Assurance in Education, 33*(2), 267-282.

Alsobeh, A., & Woodward, B. (2024). An Integrative Review of AI-Powered STEM Education. International *Journal of AI in Education and Applied Research, 7*(1), 1-15.

Arslan, N., Haj Youssef, M., & Ghandour, R. (2025). AI and learning experiences of international students studying in the UK: an exploratory case study. *Artificial Intelligence in Education, 1*(1), 1-23.

Bellis, P., Magnanini, S., & Verganti, R. (2023). Dialogue for strategy implementation: how framing processes enable the evolution of new opportunities. *Journal of Knowledge Management, 28*(11), 1-32.

Bilal, D., He, J., & Liu, J. (2025). Guest editorial: AI in education: transforming teaching and learning. *Information and Learning Sciences, 126*(1/2), 1-7.

Chen, K., Tallant, A.C., & Selig, I. (2025). Exploring generative AI literacy in higher education: student adoption, interaction, evaluation and ethical perceptions. *Information and Learning Sciences, 126*(1/2), 132-148.

Cook, J.S., & Cook, J. (2024). Artificial intelligence in management education: transformative potential and challenges. *SAM Advanced Management Journal, 89*(4), 340-355.

Dell'Era, C., Magistretti, S., Candi, M., Bianchi, M., Calabretta, G., Stigliani, I., & Verganti, R. (2025). Design thinking in action: a quantitative study of design thinking practices in innovation projects. *Journal of Knowledge Management, 29*(11), 32-58.

Ellikkal, A., & Rajamohan, S. (2025). AI-enabled personalized learning: empowering management students for improving engagement and academic performance. *Vilakshan - XIMB Journal of Management, 22*(1), 28-44.

Elsbach, K.D., & Stigliani, I. (2018). Design thinking and organizational culture: a review and framework for future research. *Journal of Management, 44*(6), 2274-2306.

Fan, Y., Tang, L., Le, H., Shen, K., Tan, S., Zhao, Y., Shen, Y., Li, X., & Gašević, D. (2025). Beware of metacognitive laziness: effects of generative artificial intelligence on learning motivation, processes, and performance. *British Journal of Educational Technology, 56*(2), 489-530

Hardaker, G., & Glenn, L.E. (2025). Artificial intelligence for personalized learning: a systematic literature review. *International Journal of Information and Learning Technology, 42*(1), 1-14.

Knight, E., Daymond, J., & Paroutis, S. (2020). Design-led strategy: how to bring design thinking into the art of strategic management. *California Management Review, 62*(2), 30-52.

Li, K.C., & Wong, B.T.-M. (2023). Artificial intelligence in personalised learning: a bibliometric analysis. *Interactive Technology and Smart Education, 20*(3), 422-445.

Magistretti, S., Dell'Era, C., Cautela, C., & Kotlar, J. (2023). Design thinking for organizational innovation at PepsiCo. *California Management Review, 65*(3), 5-26.

Marengo, A., Pagano, A., Pange, J., & Soomro, K.A. (2024). The educational value of artificial intelligence in higher education: a 10-year systematic literature review. *Interactive Technology and Smart Education, 21*(4), 625-644.

Mariyono, D., & Nur Alif Hd, A. (2025). AI's role in transforming learning environments: a review of collaborative approaches and innovations. *Quality Education for All, 2*(1), 265-288.

Mudkanna Gavhane, J., & Pagare, R. (2024). Artificial intelligence for education and its emphasis on assessment and adversity quotient: a review. *Education + Training, 66*(6), 609-645.

Nakata, C., & Hwang, J. (2020). Design thinking for innovation: composition, consequence, and contingency. *Journal of Business Research, 118*, 117-128.

Omran Zailuddin, M.F.N., Nik Harun, N.A., Abdul Rahim, H.A., Kamaruzaman, A.F., Berahim, M.H., Harun, M.H., & Ibrahim, Y. (2024). Redefining creative education: a case study analysis of AI in design courses. *Journal of Research in Innovative Teaching & Learning, 17*(2), 282-296.

Patel, N.S., & Lim, J.T.-h. (2025). Critical design futures thinking and GenerativeAI: A Foresight 3.0 approach in higher education to design preferred futures for the industry. *Foresight, 27*(2), 380-402.

Payadnya, I.P.A.A., Putri, G.A.M.A., Suwija, I.K., Saelee, S., & Jayantika, I.G.A.N.T. (2025). Cultural integration in AI-enhanced mathematics education: Insights from Southeast Asian educators. *Journal for Multicultural Education, 19*(1), 58-72.

Phakamach, P. (2023). Educational innovation: elements and mechanisms for the development of Thai educational institutions towards internationalization. *Journal of Education and Innovative Learning, 3*(2), 161-179.

Robbins, P., & Fu, N. (2022). Blind faith or hard evidence? Exploring the indirect performance impact of design thinking practices in R&D. *R&D Management, 52*(4), 704-719.

Rösch, N., Tiberius, V., & Kraus, S. (2023). Design thinking for innovation: context factors, process, and outcomes. *European Journal of Innovation Management, 26*(7), 160-176.

Routray, R., & Khandelwal, K. (2024). Artificial intelligence (AI) adoption: do Generation Z students feel technostress in deploying AI for completing courses of study at universities?. *Asian Education and Development Studies, 13*(5), 534-545.

Salinas-Navarro, D.E., Vilalta-Perdomo, E., Michel-Villarreal, R., & Montesinos, L. (2024). Designing experiential learning activities with generative artificial intelligence tools for authentic assessment. *Interactive Technology and Smart Education, 21*(4), 708-734.

Sposato, M. (2025). A call for caution and evidence–based research on the impact of artificial intelligence in education. *Quality Education for All, 2*(1), 158-170.

Verganti, R., Dell'Era, C., & Swan, S. (2021). Design thinking: critical analysis and future evolution. *Journal of Product Innovation Management, 38*(6), 603-622.