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Generative Artificial Intelligence as an Innovation in Educational Technology: Implications for Digital Learning and Twenty-First-Century Competencies

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ABSTRACT

Purpose – This paper aims to analyze Generative Artificial Intelligence (GenAI) as an innovation in educational technology and examine its implications for digital learning and twenty-first-century competencies, particularly within the Indonesian context.

Methodology – The study employs an integrative literature review method with a conceptual analysis approach. The literature sample comprises relevant international journal articles, official institutional reports, and theoretical frameworks (TPACK, SAMR, TAM, UTAUT, and ADDIE) published between 2020 and 2026. Data analysis followed a systematic four-stage procedure: identifying key concepts, grouping findings by thematic focus, analyzing through educational technology theories, and synthesizing the results into a critical narrative and tabular mapping.

Findings – Results indicate that while GenAI accelerates learning resource production, enriches feedback, and supports adaptive learning, its pedagogical value is realized only when embedded within deliberate instructional design. Unregulated use presents significant risks, including information hallucination, algorithmic bias, data privacy violations, academic dishonesty, and unequal digital access.

Contribution – This study contributes a comprehensive, theory-grounded GenAI integration model. It provides actionable frameworks for positioning educators as pedagogical guides, students as critical learning agents, and institutions as managers of responsible AI governance, offering vital policy and practical guidelines for advancing equitable, ethical, and effective digital education in Indonesia.

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INTRODUCTION

Educational technology examines how learning processes and resources are designed, developed, utilized, managed, and evaluated. From this perspective, GenAI should not be understood merely as a digital conversation application. GenAI is a system that can generate new representations of knowledge based on the data patterns it has learned. In education, this capability creates opportunities to produce teaching materials, practice variations, feedback, discussion scenarios, case simulations, and learning media in a shorter time (Kasneci et al., 2023; Tlili et al., 2023).

However, GenAI does not possess conceptual understanding in the same way humans do. This system predicts the most probable output based on linguistic or data patterns. As a result, GenAI outputs may appear convincing but remain inaccurate. In education, this condition requires educators and students to verify information, compare sources, and assess the appropriateness of content. Educational technology provides a framework to ensure that GenAI use remains grounded in learning objectives, learning principles, student characteristics, and content validity (Akgun & Greenhow, 2022; Miao, 2023).

Digital transformation in education has entered a new phase with the emergence of Generative Artificial Intelligence (GenAI). This technology does not merely provide information. It can also generate text, images, code, audio, video, simulations, and design ideas based on user prompts. In the context of educational technology, this development is important because GenAI has shifted from an administrative support role to a pedagogical one. GenAI can help educators design learning scenarios, create sample questions, develop media, provide initial feedback, and offer more responsive learning support. However, these capabilities do not automatically improve the quality of learning. Their impact depends strongly on the quality of instructional design, digital literacy, ethical use, and the readiness of educational institutions (Kasneci et al., 2023; Miao, 2023).

GenAI changes the role of educators, but it does not eliminate the need for educators. Teachers and lecturers continue to serve as designers of learning experiences, guardians of scientific quality, facilitators of dialogue, ethical guides, and assessors of thinking processes. Educators need to shift from being the sole transmitters of content to becoming curators, mentors, and learning guides. This shift requires new competencies, including the ability to design prompts, evaluate AI outputs, integrate AI into learning activities, and explain the limits of AI use to students (Celik et al., 2022; Miao & Cukurova, 2024).

Students also face a changing role. They are no longer only recipients of learning materials. They need to become critical users of technology. Students must be able to ask precise questions, evaluate answers, trace sources, compare perspectives, and state their personal contributions. (Chan & Hu, 2023) found that students perceived GenAI as useful for learning, writing, and idea exploration. However, they also expressed concerns about accuracy, privacy, ethics, and its impact on self-development. This finding confirms that AI literacy needs to be integrated into the learning process, not treated as an additional topic separate from it.

Twenty-first-century learning requires students to master critical thinking, creativity, communication, collaboration, digital literacy, and problem-solving skills. GenAI can strengthen these competencies when it is used to encourage exploration, reflection, dialogue, and creative production. In contrast, GenAI can weaken the learning process when students simply copy answers without understanding the reasoning, process, and evidence behind them. At this point, the main issue does not lie in the technology itself. It lies in how education regulates the relationship among humans, machines, knowledge, and academic responsibility. (Farrokhnia et al., 2024; Weng et al., 2024).

The Indonesian context provides a strong reason to discuss GenAI seriously. Internet access among the Indonesian population continues to increase. Statistics Indonesia reported that 72.78 percent of the Indonesian population accessed the internet in 2024, while APJII reported that internet penetration reached 79.5 percent in the same year (APJII, 2024; BPS, 2025). These figures indicate a major opportunity to expand digital learning services. However, access does not always mean readiness for digital learning. Infrastructure, connection quality, teacher competence, school policy, student literacy, and data protection still determine the quality of technology adoption. Therefore, GenAI should not be understood as an instant solution to educational

problems in Indonesia.

Challenges related to education quality also remain visible in international achievement data. The PISA 2022 report shows that Indonesia still needs to strengthen literacy, numeracy, and higher-order thinking skills. In creative thinking, Indonesia also remains below the OECD average (OECD, 2023, 2024). This fact is important because GenAI is often associated with creativity and productivity. However, creativity supported by GenAI differs from creativity that grows through conceptual understanding, practice, questioning, and self-evaluation. Education must ensure that students do not merely produce outputs that appear good. Students must also understand the thinking process that produces those outputs.

In educational technology studies, innovation is not assessed solely by a tool's sophistication. Innovation is assessed from its ability to improve the learning process in a planned, measurable, ethical, and contextually appropriate way. GenAI can be an innovation when it is integrated into instructional design that integrates objectives, content, strategies, media, learning activities, assessment, and reflection. Without design, GenAI risks becoming a shortcut tool that accelerates tasks without deepening understanding. Therefore, the discussion on GenAI needs to move beyond the question of whether to use this technology. It must address how, when, for what purpose, by whom, within what limits, and how its impact should be evaluated (Celik et al., 2022; Holmes & Tuomi, 2022).

Previous studies have discussed the opportunities and risks of GenAI in education. Several studies have highlighted the benefits of GenAI for personalization, writing support, idea generation, teaching efficiency, and learning resource development (Chan & Hu, 2023; Tlili et al., 2023). Other studies emphasize academic risks, such as plagiarism, fabricated references, bias, inaccuracy, and the weaknesses of AI-generated text detection (Cotton et al., 2024; Liang et al., 2023; Perkins, 2023). Nevertheless, a synthesis is still needed to connect GenAI with instructional design from an educational technology perspective, especially in the Indonesian context, which is marked by diverse access, learning cultures, and institutional capacities.

Based on this background, this article aims to analyze GenAI as an innovation in educational technology and examine its implications for digital learning and twenty-first-century competencies. This article develops its discussion by integrating empirical evidence, policy reports, and theoretical frameworks, including TPACK, SAMR, TAM, UTAUT, and ADDIE. The contribution of this article lies in its critical synthesis, which positions GenAI not as a replacement for educators but as part of a learning ecosystem that must be managed through design, literacy, ethics, and institutional policy.

TPACK emphasizes the integration of content knowledge, pedagogical knowledge, and technological knowledge. When using GenAI, educators need to understand the subject matter they teach, appropriate learning strategies, and the technology's capabilities and limitations. GenAI has value when it helps educators transform abstract concepts into meaningful learning activities. For example, in science education, GenAI can help create phenomenon-based simulations, investigative questions, and experiment rubrics. However, decisions about conceptual accuracy, depth of content, and age appropriateness remain the responsibility of educators (Celik et al., 2022; Mishra & Koehler, 2006).

SAMR helps explain the level of technology integration through substitution, augmentation, modification, and redefinition. At the substitution level, GenAI merely replaces older tools, such as replacing manual searching with automated summaries. At the augmentation level, GenAI improves task quality through varied examples and rapid feedback. At the level of modification, learning tasks can be redesigned. For instance, students may be asked to compare GenAI responses with scientific literature and write evidence-based critiques. At the redefinition level, GenAI enables new forms of learning tasks, such as cross-class collaborative projects that produce multimodal media and document the learning process (Chiu, 2024; Puentedura, 2006).

TAM and UTAUT are relevant for understanding the acceptance of GenAI among teachers, lecturers, students, and institutional managers. Users tend to accept technology when they perceive it as useful, easy to use, supported by the environment, and aligned with their work or learning needs. In the context of GenAI, trust is also an important factor, as users must assess whether AI outputs are reliable, safe, and ethical.

Therefore, GenAI adoption cannot rely only on technical training. Institutions need to build perceived usefulness, a sense of safety, technical support, academic guidelines, and a culture of verification (Choung et al., 2023; Davis, 1989; Venkatesh et al., 2003).

ADDIE provides an operational sequence for integrating GenAI. In the analysis stage, educators assess learning needs, student profiles, risks, and technological readiness. In the design stage, educators determine objectives, activities, assessments, and rules for using GenAI. In the development stage, GenAI can help prepare media, modules, questions, or simulations, which must then be validated. In the implementation stage, educators guide the use of GenAI transparently. In the evaluation stage, educators assess learning outcomes, thinking processes, the quality of interactions, and ethical impacts. This sequence helps prevent impulsive and unmeasured use of GenAI (Branch, 2009; Miao, 2023).

Learning Personalization

Personalization is one of the main reasons GenAI is attractive to education. GenAI can adjust the level of explanation, provide additional examples, help students improve their writing, and answer questions quickly. In large classes, this feature can help educators provide initial support to students who need further explanation. However, personalization should not mean handing over the learning process to machines. Effective personalization still requires learning objectives, needs diagnosis, educator guidance, and monitoring of student progress (Bond et al., 2024; Ouyang et al., 2022).

The risk of personalization arises when students receive only comfortable answers and are not challenged to think more deeply. GenAI can also provide responses that are too general, biased, or unsuitable for local contexts. In Indonesian education, personalization needs to take into account language, culture, literacy levels, access to devices, and regional diversity. Therefore, GenAI-based personalization needs to be integrated with differentiated instruction, formative assessment, and self-reflection so that it does not become digital dependency (Holmes & Tuomi, 2022; Miao, 2023).

Digital Media and Learning Resources

GenAI accelerates the development of digital learning media. Educators can ask GenAI to create video scripts, storyboards, case simulations, reading summaries, tiered exercises, infographics, prompting questions, and a variety of examples. This advantage is important because many teachers and lecturers face time constraints in preparing diverse media. GenAI can also help simplify academic texts into more accessible language without removing the core concepts. However, every generated material must undergo curation, source validation, and contextual adjustment (Farrokhnia et al., 2024; Kasneci et al., 2023).

Media development with GenAI also requires awareness of copyright, licensing, and cultural representation. Media that appear attractive are not always accurate, inclusive, or free from bias. Educators need to examine whether the images, narratives, examples, or illustrations generated by AI align with educational values, avoid stereotyping certain groups, and do not use students' personal data. In the framework of educational technology, media quality is assessed not only through aesthetics but also through alignment with objectives, content accuracy, accessibility, interactivity, and its impact on learning engagement (Akgun & Greenhow, 2022; Miao, 2023).

Learning Assessment and Academic Integrity

GenAI challenges traditional assessment practices, especially for essays, summaries, reports, and open-book tests, which can be completed easily by machines. Therefore, responses that rely only on prohibition are often inadequate. Educators need to design assessments that evaluate process, argumentation, evidence, reflection, and the ability to apply concepts to real contexts. Assessments may require students to include process logs, revision notes, reflections on GenAI use, an oral defense, or source verification. In this way, GenAI is not viewed merely as a threat, but as a reason to improve assessment quality (Cotton et al., 2024; Rudolph et al., 2023; Weng et al., 2024).

AI detectors cannot serve as the sole decision-making tool in academic judgment. (Liang et al., 2023)

showed that AI text detectors may be biased against non-native English writers. In the Indonesian context, this risk is important because many students write in a second language or use limited language styles. Allegations of academic misconduct must rely on strong evidence, fair procedures, and dialogue with students. Academic integrity policies need to distinguish among permitted, restricted, and prohibited uses of GenAI based on the purpose of each assignment (Perkins, 2023; Sullivan et al., 2023).

METHODOLOGY

Research Design

This research uses an integrative literature review method with a conceptual analysis approach. This method was selected because the article's purpose is not to test statistical hypotheses but to synthesize evidence, theories, and policy issues related to GenAI in educational technology. An integrative literature review allows researchers to combine empirical findings, systematic reviews, policy reports, and instructional design theories to produce a more comprehensive understanding (Bond et al., 2024; Torraco, 2016).

Data Collection

The literature sources were selected from international journal articles, official institutional reports, and policy documents relevant to GenAI, AI in education, digital learning, assessment, AI literacy, and educational technology. The main literature was prioritized based on publications from 2020 to 2026. A systematic search was conducted in the Scopus academic database to ensure comprehensive coverage of peer-reviewed, high-impact publications in this field. Classical sources were used selectively to explain foundational theories, such as TAM, UTAUT, TPACK, SAMR, and ADDIE. Official sources included UNESCO, OECD, BPS, APJII, and the World Economic Forum because these institutions provide data and guidelines relevant to digital education policy.

The inclusion criteria were as follows: (1) the source discusses GenAI or AI in education; (2) the source is related to instructional design, the role of educators, personalization, digital media, assessment, AI literacy, ethics, or institutional readiness; (3) the source was published in a journal, reputable proceeding, or official report; and (4) the source has an active DOI or URL. The exclusion criteria included popular articles without a data basis, articles not relevant to education, and sources that promoted only specific products without academic analysis.

The literature selection process in this study follows a systematic pathway, as illustrated by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) diagram in Figure 1.

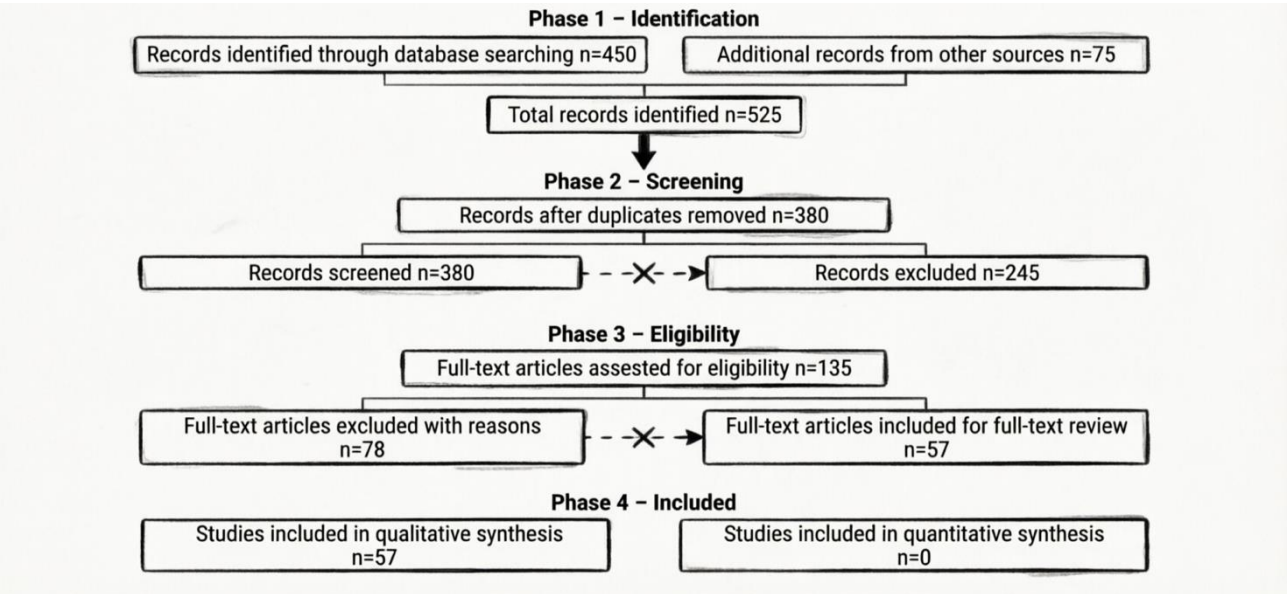

Figure 1. Prisma flow diagram

Data Analysis

The analysis was conducted in four stages. First, the literature was read to identify key concepts and main findings. Second, the findings were grouped by article focus: instructional design, the roles of educational actors, personalization, media, assessment, AI literacy, institutional readiness, ethical risks, integration models, and the Indonesian context. Third, each group was analyzed using educational technology theories. Fourth, the results of the analysis were synthesized into a critical narrative and table form.

FINDINGS

Before presenting the thematic synthesis, it is essential to describe the systematic literature selection process that underpins the findings. Following the PRISMA guidelines outlined in the methodology, the initial literature search was conducted through database searches (Scopus and OpenAlex) and supplemented with records from other relevant sources. As illustrated in Figure 1, the identification phase yielded a total of 525 records, comprising 450 from database searches and 75 from additional sources. After removing duplicates, 380 records remained for screening. During the screening phase, 245 records were excluded based on title and abstract assessment due to irrelevance to educational technology, lack of focus on GenAI pedagogy, or publication outside the 2020–2026 timeframe. This left 135 full-text articles for eligibility assessment. Of these, 78 were excluded for reasons such as insufficient attention to instructional design frameworks, assessment reforms, AI literacy, or the specific Indonesian educational context. Consequently, 57 full-text articles met the inclusion criteria and were included in the qualitative synthesis. No quantitative synthesis (meta-analysis) was performed because the study used an integrative literature review with conceptual analysis. Table 1 summarizes this selection flow. This systematic sifting ensures that the subsequent discussion is grounded in credible, relevant, and current evidence drawn from a rigorously filtered corpus.

Table 1. PRISMA-Based Literature Selection Flow for the Integrative Review

Phase	Stage	Number of Records
Identification	Records identified through database searching	450
	Additional records from other sources	75
	Total records identified	525
Screening	Records after duplicates removed	380
	Records screened	380
	Records excluded (title/abstract screening)	245
Eligibility	Full-text articles assessed for eligibility	135
	Full-text articles excluded with reasons	78
	Full-text articles included for full-text review	57
Included	Studies included in the qualitative synthesis	57
	Studies included in quantitative synthesis (meta-analysis)	0

GenAI and Instructional Design from the Perspective of Educational Technology

The review shows that GenAI is most productive when used at the instructional design stage, not only during implementation. At the planning stage, GenAI can help educators formulate learning objectives, create varied activities, develop prompting questions, design rubrics, and prepare learning materials in different formats. However, educators must still examine the alignment of GenAI outputs with the curriculum, learning outcomes, student characteristics, and scientific standards. Without such examination, GenAI may produce materials that are fluent in language but weak in conceptual accuracy (Kasneci et al., 2023; Miao, 2023).

From an educational technology perspective, GenAI needs to be positioned as a cognitive partner, not as a single source of truth. This means that GenAI can help generate alternatives, but pedagogical decisions must remain in human hands. Educators can use GenAI to develop several learning activity designs, then select and revise the most appropriate ones. This process encourages educators to think more reflectively. Educators do not merely accept technological suggestions. They assess, reject, combine, and improve them. This is where

innovation lies. GenAI accelerates design exploration, but the final quality depends on educators' pedagogical competence (Celik et al., 2022; Chiu, 2024).

GenAI-based instructional design also needs to avoid an excessive focus on final products. Many learning tasks have traditionally assessed final written products or final answers. GenAI makes these products easier to generate. Therefore, instructional design needs to place greater emphasis on process. Students can be asked to show their initial questions, the sources they used, the reasons for choosing a strategy, revisions based on feedback, and their personal reflection. In this way, GenAI does not damage learning. Instead, it encourages learning to move toward a more transparent thinking process (Weng et al., 2024).

The Impact of GenAI on the Roles of Teachers, Lecturers, and Students

GenAI shifts educators' workload from producing basic materials toward curation and guidance. Educators can save time when preparing initial drafts of modules, questions, case studies, or rubrics. The remaining time can be used to support students, examine their thinking processes, and provide more meaningful feedback. However, this time efficiency can occur only when educators have sufficient AI literacy. Otherwise, educators may spend more time correcting inaccurate outputs or dealing with academic problems caused by unclear AI use (Celik et al., 2022; Sullivan et al., 2023).

For teachers and lecturers, the main challenge is not only technical but also professional identity. Some educators may perceive GenAI as a threat to their academic authority. This concern is understandable, but it needs to be transformed into professional reflection. GenAI can answer many factual questions, but it cannot replace pedagogical relationships, contextual understanding in the classroom, sensitivity to students' emotions, moral values, or professional judgment. In other words, educators need to strengthen the most human aspects of education, namely guidance, dialogue, role modeling, and ethical reasoning (Holmes & Tuomi, 2022; Miao & Cukurova, 2024).

For students, GenAI opens opportunities for independent learning. Students can ask for repeated explanations, additional exercises, or different examples according to their needs. However, independent learning is not the same as learning without direction. Students need to be trained to recognize when they use GenAI as a thinking aid and when they begin to surrender their thinking process to machines. At this point, the roles of teachers and lecturers become essential. They need to teach questioning strategies, verification, evaluation, and reflection on the use of AI (Chan & Hu, 2023; Long & Magerko, 2020).

The Contribution of GenAI to Learning Personalization

GenAI offers opportunities to expand personalized learning through rapid responses and varied explanations. In heterogeneous classrooms, students have different backgrounds, learning speeds, and ways of understanding. GenAI can help by providing additional examples for students who have not yet understood the material or offering advanced challenges for more prepared students. Educators can also use GenAI to create different versions of learning materials with varied difficulty levels without starting from scratch (Bond et al., 2024; Ouyang et al., 2022).

However, GenAI-based personalization does not always produce equitable learning. Students with better access to devices, stronger language skills, and higher digital literacy will gain greater benefits. Students with limited access may fall behind. This condition is relevant to Indonesia because internet access is increasing, but the quality of access, devices, and support remains uneven. Therefore, personalization policies must be accompanied by strategies for infrastructure equity, teacher training, open learning resources, and support for schools in underserved areas (BPS, 2025; Miao, 2023).

Personalization also needs to preserve cognitive challenge. GenAI often provides neat and rapid answers. If students receive ready-made answers too often, they may lose the opportunity to practice questioning, reading, constructing arguments, and dealing with learning difficulties. A good personalization design requires students to explain concepts in their own words, compare AI answers with other sources, and show

their reasoning. In this way, personalization does not become a form of comfort that weakens the ability to think (Farrokhnia et al., 2024; Weng et al., 2024).

GenAI in the Development of Digital Media and Learning Resources

One of the most visible contributions of GenAI is accelerating the development of digital media and learning resources. Educators can create material summaries, video scripts, illustrations, case studies, conversation simulations, adaptive quizzes, and assessment rubrics. This capability supports educators who face limited time and resources. In digital learning, media variation is important because students need learning experiences that are not limited to long texts (Kasneci et al., 2023; Tlili et al., 2023).

However, the quality of GenAI-generated media depends strongly on the quality of prompts, training data, and educator curation. GenAI can produce examples that appear relevant, but they may be biased toward certain contexts or inconsistent with local values. In Indonesian education, learning media must take into account the Indonesian language, local languages, cultural diversity, social context, and accessibility for students with special needs. Therefore, GenAI should be used as a tool for developing initial drafts. Final validation must be conducted by educators or material development teams (Akgun & Greenhow, 2022; Miao, 2023).

The development of digital learning resources also needs to consider copyright and source integrity. GenAI can generate texts with unclear sources or combine information from multiple data patterns. Educators need to teach students that AI use does not remove the obligation to cite scholarly sources. At the higher education level, students must continue to use journal articles, books, official data, and policy documents as references. GenAI can help organize structure, but academic evidence must come from verifiable sources (Perkins, 2023).

DISCUSSION

The Influence of GenAI on Learning Assessment

Assessment is one of the areas most rapidly affected by GenAI. Tasks that assess information reproduction can easily be completed with machine assistance. This does not mean that assessment must return fully to closed formats. Education needs to design more authentic assessments. Tasks can be linked to local contexts, field data, practical experiences, interviews, portfolios, oral defense, and process reflection. Such tasks may still involve GenAI, but students must demonstrate their own thinking contributions (Cotton et al., 2024; Rudolph et al., 2023).

GenAI can also support formative assessment. Educators can use GenAI to generate initial feedback on writing drafts, variations of practice questions, or simulated exam questions. Students can use GenAI to check their understanding before discussing the material with teachers or lecturers. However, this use needs to be limited so that it does not replace professional judgment. GenAI does not fully understand students' learning histories, has no moral responsibility, and may provide suggestions that do not align with the rubric (Sullivan et al., 2023; Weng et al., 2024).

Assessment policies need to state clearly whether GenAI may be used, in which parts of the task it may be used, and how its use should be reported. For example, in a research assignment, students may use GenAI for brainstorming and language improvement, but they may not use it to create data, citations, or analysis without verification. In a design assignment, students may use GenAI to create prototypes, but they must explain their design decisions. This clarity is important so that academic integrity is not understood as a total prohibition, but as a process of honesty and scholarly responsibility (Miao, 2023).

AI Literacy as a Twenty-First-Century Competency

AI literacy needs to be positioned as a new competency in twenty-first-century education. This competency includes basic understanding of how AI works, the ability to use AI productively, the ability to evaluate outputs, data awareness, ethics, and social impact. In classroom practice, AI literacy can be taught

through simple activities. Students can compare GenAI answers with textbooks, identify factual errors, improve prompts, evaluate bias, and write reflections on the limits of AI use (Long & Magerko, 2020; Ng et al., 2021).

AI literacy is also connected to work readiness. The World Economic Forum emphasizes changing skill needs due to technological development, including AI, big data, and automation (World Economic Forum, 2025). Education does not need to turn every student into an AI expert. However, every student needs to understand how AI affects work, information, communication, creativity, and decision-making. Schools and higher education institutions need to prepare students to work with AI without losing critical reasoning and social responsibility.

For educators, AI literacy needs to be integrated into continuous professional development. One-time training is not enough because technology changes rapidly. Educators need communities of practice, sample assignments, prompt banks, ethical guidelines, and forums for sharing experiences. Institutions also need to provide space for educators to experiment safely. Without such support, AI literacy will develop unevenly and depend only on individual initiative (Celik et al., 2022; Miao & Cukurova, 2024).

Institutional Readiness in Adopting GenAI

Institutional readiness includes infrastructure, policy, human resources, data governance, academic culture, and impact evaluation. Many institutions tend to respond to GenAI reactively, for example, by prohibiting it or using detection tools. Such responses are not sufficient. Institutions need policies that explain the purposes of GenAI use, data security standards, academic integrity principles, educator support, and mechanisms for handling misconduct. Policies also need to be developed through dialogue with teachers, lecturers, students, parents, and technology managers (Bearman et al., 2023).

Institutional readiness is also related to technology procurement. Not all educational problems require GenAI. Institutions need to assess real needs before purchasing or developing AI systems. Key questions include the following: what learning problem will be addressed, what data will be used, who will be responsible, how privacy risks will be prevented, and how effectiveness will be evaluated. Without these questions, GenAI adoption may become a symbolic and costly project that does not improve learning quality (Holmes & Tuomi, 2022; Miao, 2023).

In the Indonesian context, institutional readiness needs to consider regional disparities. Schools and universities in urban areas may access GenAI more quickly, while areas with limited connectivity require different approaches. Training materials also need to consider language and local context. The government, higher education institutions, schools, industry, and communities need to build an ecosystem of open learning resources so that the benefits of GenAI are not enjoyed only by institutions with strong resources (BPS, 2025; Miao & Cukurova, 2024).

Ethical, Academic, and Pedagogical Risks

The ethical risks of GenAI include data privacy, bias, transparency, copyright, and accountability. Students may enter personal data into AI systems without understanding the consequences. Educators may use classroom data for analysis without clear permission. AI systems can also generate biased outputs because their training data are not neutral. Therefore, education needs to teach the principles of data minimization, informed consent, transparency of use, and protection of vulnerable groups (Akgun & Greenhow, 2022).

Academic risks relate to plagiarism, fabricated references, data manipulation, and dishonesty in the learning process. GenAI can produce writing that appears academic but contains false references or unsupported arguments. In scholarly writing, this is dangerous because it damages trust in knowledge. To reduce this risk, institutions need to implement AI use declarations, citation training, source verification, and assessments that evaluate process. A punishment-based approach alone is not sufficient if students have never been taught how to use AI ethically (Cotton et al., 2024; Perkins, 2023).

Pedagogical risks emerge when GenAI weakens thinking ability. Students may feel that they understand the material because they receive good answers, even though they have not mastered the concepts. Educators may also depend too heavily on GenAI when preparing materials, which can reduce their sensitivity to classroom needs. These risks need to be addressed through instructional design that requires explanation of reasoning, discussion, verification, direct practice, and reflection. GenAI must function as a learning aid, not as a substitute for learning experiences that develop understanding (Farrokhnia et al., 2024; Weng et al., 2024). To synthetically capture these multifaceted risks, benefits, and corresponding mitigation strategies across the core educational domains, Table 2 provides a structured thematic mapping of the key issues discussed above.

Table 2. Synthesis of Key Issues of GenAI in Educational Technology

Focus Area	Critical Synthesis	Practical Implications	Risks and Mitigation
Instructional design	GenAI has value when it is integrated into objectives, activities, media, and assessment. Technology should not stand outside pedagogical design.	Use ADDIE to analyze needs, design activities, develop media, implement learning, and evaluate impact.	Risk of shallow design. Mitigation: content validation, process rubrics, and peer review.
Roles of teachers and lecturers	Educators shift into curators, facilitators, ethical guides, and evaluators of thinking processes.	Train educators to design prompts, check outputs, create AI-permitted tasks, and provide reflective feedback.	Risk of educator dependency. Mitigation: communities of practice and material quality standards.
Roles of students	Students need to become critical AI users, not answer copiers.	Teach source verification, process reflection, and AI use declaration.	Risk of plagiarism and superficial learning. Mitigation: portfolios, process logs, and oral defense.
Personalization	GenAI can provide explanations and exercises based on learning needs, but it must still challenge students.	Use GenAI for differentiated materials, tiered exercises, and initial learning support.	Risk of unequal access. Mitigation: open resources and infrastructure support.
Digital media	GenAI accelerates the creation of scripts, quizzes, simulations, and multimodal materials.	Use GenAI as an initial drafting tool, followed by pedagogical curation and content validation.	Risk of bias and inaccuracy—mitigation: fact-checking, license-checking, and accessibility testing.
Assessment	GenAI requires an assessment that evaluates process, evidence, argumentation, and reflection.	Design authentic assessments using local contexts, portfolios, process records, and oral defense.	Risk of cheating. Mitigation: clear AI use policies and fair procedures.
AI literacy	AI literacy includes conceptual understanding, use, evaluation, ethics, and social impact.	Integrate AI literacy into the curriculum, professional development, and cross-subject assignments.	Risk of uneven literacy. Mitigation: gradual modules and continuous training.
Institutional readiness	GenAI adoption requires policy,	Develop institutional roadmaps, academic	Risk of symbolic adoption. Mitigation:

Focus Area	Critical Synthesis	Practical Implications	Risks and Mitigation
	infrastructure, data protection, and impact evaluation.	guidelines, and technical support services.	needs audits and achievement indicators.
Ethics and pedagogy	GenAI must protect human agency, fairness, privacy, and academic responsibility.	Apply principles of transparency, minimum data use, consent, and accountability.	Risk of bias, hallucination, and privacy violations—mitigation: governance and human verification.
The future of Indonesia	GenAI can strengthen quality and equity when connected to literacy, assessment, and national policy.	Develop national guidelines, AI literacy curricula, and locally contextualized training.	Risk of widening the digital divide. Mitigation: infrastructure, open learning resources, and regional support.

A GenAI Integration Model Based on TPACK, SAMR, TAM, UTAUT, and ADDIE

An effective GenAI integration model needs to connect pedagogical, technological, social, and institutional dimensions. TPACK helps ensure that educators are not only able to use tools but also to connect them to subject matter and learning strategies. SAMR helps assess whether GenAI merely replaces older practices or truly redesigns learning activities. TAM and UTAUT help explain user acceptance by considering perceived usefulness, ease of use, social support, and facilitating conditions. ADDIE helps transform these principles into a systematic design process.

Integration begins with needs analysis. Educators need to identify real learning problems, such as weak argumentative writing skills, limited adaptive practice exercises, or a lack of visual learning media. After that, educators design activities that use GenAI in a directed way. A good activity does not ask students to generate a full essay with GenAI. Instead, it may ask students to use GenAI to obtain two initial arguments, verify those arguments with the literature, and then write their own critique and synthesis. This activity turns GenAI into a thinking trigger, not a replacement for thinking.

The integration model also needs to include evaluation. Evaluation should not be limited to students' final scores. It should also assess prompt quality, source verification quality, depth of reflection, and honesty in declaring AI use. Institutions can evaluate the impact of GenAI through learning experience surveys, analysis of assignment quality, educator interviews, and policy audits. With this approach, GenAI becomes part of a learning improvement cycle, not merely a technological trend. To operationalize this cyclical approach, Table 3 outlines a concrete integration model that aligns ADDIE's sequential stages with the theoretical lenses of TPACK, SAMR, TAM, and UTAUT, specifying the design focus, GenAI use, and quality indicators at each phase.

Table 3. GenAI Integration Model Based on ADDIE, TPACK, SAMR, TAM, and UTAUT

Stage	Design Focus	GenAI Use	Quality Indicators
Analysis	Identifying needs, student characteristics, risks, and technological readiness.	Helping map misconceptions, prepare lists of material needs, and develop diagnostic questions.	Learning problems are clear, needs data are available, and AI use risks are mapped.
Design	Designing objectives, activities, media, assessment, and rules for AI use.	Generating alternative activities, discussion scenarios, rubrics, and AI use declaration formats.	Objectives, activities, and assessments are aligned with TPACK and the intended SAMR level.
Development	Creating media, learning resources,	Preparing draft modules, video scripts,	Materials are valid, free from fabricated

Stage	Design Focus	GenAI Use	Quality Indicators
	exercises, and learning guides.	quizzes, case studies, simulations, and sample feedback.	references, contextually appropriate, and accessible to students.
Implementation	Implementing learning with guidance, classroom rules, and technical support.	Serving as an initial tutor, brainstorming tool, revision tool, and discussion trigger.	Students use AI transparently, critically, and within the boundaries of the task.
Evaluation	Assessing outcomes, processes, user experiences, and ethical impacts.	Helping analyze reflections, answer variations, and needs for material improvement.	Evaluation covers learning achievement, thinking processes, integrity, and user acceptance.

Implications for the Future of Education in Indonesia

The future of education in Indonesia cannot avoid GenAI. The question is not whether GenAI will enter schools and higher education institutions, but how Indonesian education will guide its use. If GenAI is used without a policy, students will learn informally with high risks. If GenAI is completely prohibited, education may lose the opportunity to develop new competencies. A more realistic option is to build a gradual, adaptive, and human-centered governance system.

First, Indonesia needs to develop AI literacy in the curriculum. This literacy can begin with a simple understanding of how AI works, data ethics, bias, and information verification. At advanced levels, students can learn to create AI-based projects that address local problems. This material needs to be adjusted to school contexts, rather than simply imitating curricula from other countries. The focus should be on developing learners who are critical, creative, and responsible.

Second, teachers and lecturers need continuous training. Training must be practical and subject-based. Language teachers need examples that differ from those needed by mathematics teachers. Health lecturers need guidelines that differ from those needed by law or engineering lecturers. Training must also address ethics, assessment, and the development of classroom policies. Without contextual training, GenAI will be used only by some educators who are already interested in technology.

Third, national and institutional assessments need to adapt. Indonesian education needs to provide space for authentic assessment that evaluates thinking processes, creativity, and problem-solving. PISA shows that creative thinking is an important area that needs strengthening (OECD, 2024). GenAI can help provide practice and feedback, but assessment must continue to evaluate human ability to understand problems, construct arguments, collaborate, and make decisions.

Fourth, educational institutions need to protect equity of access. The digital divide may exacerbate educational inequality. Schools with strong connectivity and trained teachers will be able to use this technology more quickly. Schools with limited infrastructure may fall further behind. Therefore, the government and stakeholders need to strengthen infrastructure, provide open learning resources, and build support centers for teachers in underserved areas. GenAI must become part of the equity agenda, not only a modernization tool for certain groups.

Fifth, Indonesia needs to develop ethical guidelines for GenAI that are tailored to the national context. These guidelines need to cover child data protection, AI use declaration, limits of use in academic tasks, copyright protection, and mechanisms for handling academic disputes. The guidelines should not be too general. Schools and higher education institutions need operational examples, such as AI use declaration formats, examples of AI-permitted tasks, examples of AI-restricted tasks, and verification procedures when alleged misconduct occurs.

Through these steps, GenAI can strengthen Indonesian education. However, its success is not determined by technology alone. Success depends on instructional design, educator competence, student literacy, institutional governance, and the courage to change assessment. GenAI can accelerate innovation, but the

direction of innovation must remain guided by national educational goals, human values, and the needs of Indonesian students.

CONCLUSION

GenAI is an important innovation in educational technology because it can support instructional design, personalization, digital media development, formative assessment, and twenty-first-century literacy. However, GenAI does not automatically produce better learning. Its benefits emerge when the technology is used through clear instructional design, guided by learning objectives, centered on students, and supported by educators who have sufficient AI literacy. From the perspective of educational technology, GenAI is best positioned as a cognitive partner and design tool, not as a replacement for teachers, lecturers, or students' thinking processes.

This review shows that GenAI changes the role of educators into curators, facilitators, ethical guides, and evaluators of learning processes. Students also need to become critical, honest, and reflective AI users. Learning personalization can be strengthened through GenAI, but it must preserve cognitive challenge and equity of access. Media development can be accelerated, but it still requires content validation, ethical consideration, and accessibility. Assessment needs to shift from evaluating final products toward evaluating process, evidence, argumentation, reflection, and contextual application.

The risks of GenAI use must not be ignored. These risks include information hallucination, bias, privacy violations, plagiarism, fabricated references, cognitive dependency, and digital inequality. Educational policy needs to manage these risks through AI literacy, AI use declarations, authentic assessment design, data protection, and educator training. AI detection tools are insufficient and should not serve as the sole basis for academic decisions, as they may produce biased and inaccurate judgments.

The main recommendation for educational institutions is to develop a GenAI integration roadmap based on ADDIE, TPACK, SAMR, TAM, and UTAUT. This roadmap should include needs analysis, educator training, examples of learning practices, ethical guidelines, assessment strategies, infrastructure support, and impact evaluation. The Indonesian government and educational institutions need to ensure that GenAI does not merely become a symbol of modernization. It must genuinely strengthen the quality of learning, equity in access, and twenty-first-century competencies.

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