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DIGITAL TRANSFORMATION IN INDONESIAN EDUCATION AN ANALYSIS OF AR/VR , GAMIFICATION, AND ARTIFICIAL INTELLIGENCE NARRATIVES

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Abstract

The development of educational technology in Indonesia has accelerated alongside the Merdeka Belajar policy and the growing demand for digital learning innovation. Emerging technologies, particularly Augmented Reality (AR/VR), gamification, and Artificial Intelligence (AI) have become increasingly prominent in educational research. However, beyond evaluating technological effectiveness or mapping publication trends, less attention has been given to how Indonesian educational literature frames these technologies in relation to pedagogical practices, policy priorities, and contextual implementation challenges. This study aims to examine the dominant narratives and themes associated with AR/VR gamification, an all Indonesian educational publication. Artickle abstracts published between 2019 and early 2025 were retrived from Crossref, Semantic Scholar, and Google Scholar and analysed using content analysis and thematic coding. The findings indicate differences in emphasis across databases: Crossref foregrounds effectiveness and outcome evaluation, Semantic Scholar connects technological innovation with digital transformation and policy discourse, while Google Scholar emphasizes practical classroom implementation. Three overarching narratives emerged: AR/VR as immersive media for contextual representation and simulation, gamification as a pedagogical strategy for supporting motivation and participation, and AI as an adaptive learning ecosystem associated with personalization and learning governance. The study contributes an interpretive perspective that complements publication-level bibliometric mapping by examining how emerging educational technologies are framed in Indonesian educational discourse. These findings also highlight the importance of aligning technology with instructional design, educator readiness, equitable access, and responsible data governance, particularly in vocational education and other resource-constrained learning contexts..

Keywords:
Learning innovation; *digital transformation*; *AR/VR*; *gamification*; *artificial intelligence*.

Abstrak

Perkembangan teknologi pendidikan di Indonesia dipercepat oleh kebijakan Merdeka Belajar dan tuntutan Revolusi Industri 4.0, yang mendorong adopsi teknologi digital dalam ekosistem pembelajaran. Fenomena ini dapat dilihat dari peningkatan publikasi akademik yang membahas teknologi emergensi seperti *Augmented/Virtual Reality* (AR/VR), gamifikasi, dan Kecerdasan Buatan (AI). Namun, sebagian besar penelitian masih berfokus pada evaluasi kuantitatif efektivitas, sementara analisis naratif tentang bagaimana teknologi-teknologi ini diposisikan dan diinterpretasikan dalam literatur pendidikan Indonesia masih terbatas. Penelitian ini bertujuan untuk mengeksplorasi narasi dan tema utama yang muncul dalam publikasi akademik terkait AR/VR, gamifikasi, dan AI di Indonesia. Data dikumpulkan dalam bentuk abstrak artikel dari tiga basis data utama (Crossref, Semantic Scholar, dan Google Scholar) pada periode 2019 hingga awal 2025. Analisis dilakukan dengan kombinasi analisis konten untuk mengidentifikasi pola istilah dominan dan pengkodean tematik untuk menafsirkan makna laten dan konstruksi naratif dalam abstrak. Hasil menunjukkan perbedaan penekanan antar basis data, dengan Crossref menonjolkan efektivitas dan pengujian hasil, Semantic Scholar mengaitkan inovasi dengan kebijakan dan transformasi digital, serta Google Scholar menekankan implementasi praktis di kelas. Mengenai narasi, AR/VR diposisikan sebagai media imersif untuk representasi kontekstual dan simulasi, gamifikasi sebagai strategi pedagogis untuk meningkatkan motivasi dan partisipasi, dan AI sebagai ekosistem adaptif yang mendukung personalisasi dan tata kelola pembelajaran. Kesimpulannya, transformasi digital pendidikan Indonesia

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berlangsung dalam tiga lapisan utama: media, strategi, dan ekosistem, yang membutuhkan pendekatan berbasis desain, literasi digital guru, dan kebijakan etika data. Studi ini memberikan kontribusi interpretatif yang memperkaya analisis bibliometrik sebelumnya dan menawarkan implikasi praktis bagi peneliti, praktisi, dan pembuat kebijakan

Kata Kunci:
Inovasi pembelajaran; *transformasi digital*; *AR/VR*; *gamifikasi*; *kecerdasan buatan*.

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1. INTRODUCTION

The acceleration of digital transformation in Indonesia's education ecosystem has become more pronounced in the last five years. Policy pushes such as Merdeka Belajar open space for curriculum autonomy, assessment, and more learner-centered teaching practices, emphasizing 21st-century competencies and integrating digital learning resources. Several policy reviews show that Merdeka Belajar implementation increases student engagement, but still leaves logistical problems, capacity gaps, and consistency of implementation in the field (A., Bau., et al., 2025; Apriani, 2016). On the practical side, the national research map on digital education shows a growing volume of publications until early 2025, with the topics of Augmented/Virtual Reality (AR/VR), gamification, and Artificial Intelligence (AI) starting to occupy a strategic position in the learning innovation discourse (A., Bau, et al., 2025 ; Fuadiy et al., 2025).

This phenomenon goes hand in hand with infrastructure dynamics. Connectivity efforts, including low-orbit satellite initiatives targeting islands and remote areas, give hope for more equitable internet access for vital public services, including education(Lafleur, 2025) . However, cross-agency data confirms that the digital divide is still real, tens of thousands of schools are not connected, and around a quarter of Indonesia's population does not use the internet, which directly impacts disparities in digital learning opportunities (Cai et al., 2022; Tang, 2022) . In this context, "emerging" learning technology themes need to be read not solely in terms of effectiveness, but also from the narratives and meanings that Indonesian researchers build when facing the realities of education policy, infrastructure, and human resource readiness (A. et al., 2024;).

Globally, the literature shows AR/VR gaining ground as an immersive medium for science, technovation, and learning contexts that are difficult to replicate in real classrooms; a comprehensive review maps the surge in research over the past decade and emphasizes the diversity of applications and integration challenges (Al-Ansi et al., 2023). Recent studies even review the role of AR specifically for language learning and higher education/Gen-Z contexts, confirming relevant cutting-edge trends that also resonate in Indonesia (A., A., et al., 2025; Christou et al., 2025; Zulfachmi et al., 2025). At the same time, gamification is consistently reported to positively impact academic performance and learning motivation, as evidenced by a recent meta-analysis. Meanwhile, AI in education in Indonesia is positioned as an enabler of personalization, adaptive assessment, and automation of pedagogical tasks, but raises new agendas on ethics, data privacy, and readiness gaps of Education actor(A., A., et al., 2025; Haetami, 2025; Novianti, 2025).

Although research on AR/VR, gamification, and AI in education has expanded, much of the existing literature emphasizes technological effectiveness, learning outcomes, or publication trends. These approaches provide valuable evidence of research development and instructional impact, but they offer less insight into how these technologies are framed within the Indonesian educational context, particularly in relation to policy priorities, educator readiness, infrastructure constraints, and ethical governance. This gap is important because the meaning and feasibility of educational technology depend not only on its technical capabilities but also on the institutional and social conditions in which it is implemented. For vocational education and training, these considerations are especially relevant because technology integration must support practical competencies and remain responsive to industry needs while accounting for differences in institutional resources. Therefore, an interpretive analysis of the narratives in Indonesian educational publications can complement existing effectiveness-oriented and bibliometric studies by examining how emerging technologies are positioned, what challenges are emphasized, and what implications these narratives suggest for educational practice (Al-Ansi et al., 2023; Novianti, 2025).

The first key issue is the readiness of educators. Recent studies have highlighted the challenges of teachers' digital competencies especially in vocational education which affect the effectiveness of technology-based innovation implementation and its relevance to industry needs (Rahmawati et al., 2025; Wiharja et al., 2026). Second, the wide access gap between regions and education units has implications for the inequality of technology-based learning opportunities (Gemiharto, 2024; Gemiharto & CMS, 2024; Imaduddin & Firdaus, 2025; Rahmawati et al., 2025). Third, the ethical framework and personal data protection. Since the transition period of the Personal Data Protection Law (PDP Law) ends on October 17, 2024 (Maspul & Putri, 2025; Prasetyo et al., 2025) , full compliance obligations apply to data controllers/processors with consequences on the design of learning platforms, analytics practices, and the use of AI in schools/universities. Fourth, the policy-practice bridging spirit of Merdeka Belajar encourages innovation. Still, schools and teachers need ongoing support (TPD, infrastructure, teaching materials) so AR/VR, gamification, and AI do not stop as pilot projects (Hunaepi & Suharta, 2024) .

This study examines how AR/VR, gamification, and AI are represented in Indonesian educational publications published between 2019 and early 2025. Specifically, it aims to: (1) identify how these technologies are positioned in the literature as learning media, pedagogical strategies, or components of an adaptive learning ecosystem; (2) examine recurring themes and challenges associated with their implementation, including educator readiness, infrastructure, equitable access, and ethical governance; and (3) interpret how these narratives relate to educational policy and the contextual realities of technology integration in Indonesia. By focusing on the meanings and emphases expressed in article abstracts, this study complements bibliometric mapping and effectiveness-oriented research with an interpretive account of educational technology discourse. It also considers the implications of these narratives for vocational education and training, particularly the alignment of technology with practical learning needs, educator competencies, and locally available resources.

The main contribution of this study is an interpretive framework that distinguishes three recurring positions in the analyzed literature: AR/VR as immersive media for contextual representation and simulation, gamification as a pedagogical strategy for supporting motivation and participation, and AI as an adaptive learning ecosystem associated with personalization and data-informed decision-making. Rather than treating these technologies solely as separate innovations, this framework highlights their different roles in the educational transformation discourse. The analysis also examines how these narratives intersect with Indonesian policy priorities, educator readiness, infrastructure limitations, and ethical considerations. For vocational education and training, this perspective provides a basis for discussing how emerging technologies may be aligned with practical competencies, industry-related learning needs, and local implementation conditions. The contribution is interpretive: it identifies patterns of meaning in the analyzed abstracts rather than establishing the actual effectiveness of the technologies or the prevalence of these patterns across all Indonesian educational research.

Ultimately, the digital transformation of Indonesian education is not simply the adoption of new tools and applications. It is a paradigm shift in how knowledge is represented (AR/VR), how motivation and participation are managed (gamification), and how data is used responsibly to adapt learning (AI). By reading the narratives that Indonesian researchers construct instead of simply counting the effects, this study offers a richer conceptual map for navigating the innovations, risks and opportunities of educational transformation in the digital age.

2. LITERATURE REVIEW

2.1. Digital Transformation in Education

Digital transformation in education is not only related to the use of digital devices and platforms but also encompasses changes in the pedagogical approaches, learning experiences, and the role of technology in supporting the educational process. The development of educational technology shows that various innovations are increasingly being studied based on their potential to support student engagement, material presentation, personalized learning, and information-based decision-making. However, the use of technology does not always result in automatic pedagogical changes because its application is still influenced by learning design, student characteristics, and the context of the educational institution.

In 2024th Wang discover through a systematic review of Artificial Intelligence in Education (AIED), show that AI research in education encompasses a varety of application categories, research topics, methodological approaches, and educational contexts. The findings show that AI in education is not a uniform form of technology, but rather a research field with diverse functions and issues. Meanwhile, Rojas and Sánchez mapped the development of virtual reality (VR) research in education through a systematic

review and bibliometric analysis. The study provides an overview ot the development of research topics, publication sources, and the direction of VR studies in education. Both studies highlight the importance of understanding educational technology through research pattern and its context of use, rather than just the exixtence of the technology itself (Rojas-Sánchez et al., 2022; Wang et al., 2024).

2.2. Augmented Reality and Virtual Reality in Education

Augmented Reality (AR) and Virtual Reality (VR) have become an important part of educational technology research because they allow material to be presented through digital visualization and interactive environments. AR integrates digital objects or information with the real encironment. These characteristics open up opportunities to present abstract concepts, objects that are difficult to observe directly, as well as situations that require simulation. In 2023rd Rojas and Sánchez conducted a systematic review and bibliometric analysis on VR in education to identify key topics, publication sources, highly cited articles, and the contributions of countries in the field. Meanwhile, Marougkas in 2024th reviewed 69 studies on the use of immersive VR for learning, including personalization strategies, benefits, limitations, and development characteristics. Both studies indicated that VR research in education has wide scope, ranging from the utilization of technology to design of learning experiences (Marougkas et al., 2023; Rojas-Sánchez et al., 2022) .

Lampropoulos and Kinshuk specifically examine the relationship between VR and gamification in education through a systematic review. This study is relevant because it shows that immersive technology and game-based approaches can be discussed in an overlapping manner, even though both have different conceptual characteristics. Therefore, AR/VR in this study is not only understood as devices or visual media, but also examined based on how the articles abstractly position them, for example, as immersive learning media, mean of concept visualization, or simulation environment (Lampropoulos & Kinshuk, 2024).

2.3. Gamification as a Pedagogical Strategy

Gamification refers to use the of game design elements in non-game context, including teaching and learning activities. Elements such as point, challenges, feedback, achievements, and competition can be integrated into learning activities to create a more interactive experience. However, gamification shoud not be equated with the general use of games because this approach incorporates game elements as part of the design of activities with the educational objectives. (Zeybek & Saygı, 2024) review gamification research in education and identify several dimensions of the study, including the purpose of implementation, fields of learning, educational levels, and how gamification is integrated into the learning environment. Meanwhile, (L. Li et al., 2024) conducted a meta-analysis and systematic review on the relationship between gamification and intrinsic motivation as well as the psychological needs of learners. The results show that gamification can support intrinsic motivation and perceptions of autonomy and relatedness, but its impact on competence is not always strong. These findings emphasize that the benefits of gamification should not be assumed to be uniform across all learning outcomes.

Besides motivation, learning outcomes are also a focus in gamification research. (Zeng et al., 2024), through a meta-analysis of experimental studies, reported a positive influence of gamification on overall academic performance. However, the results of the experimental-based research do not directly explain how gamification is represented in the Indonesian academic literature. In this study, the focus is not only testing the effectiveness of gamification, but rather on identifying the narratives that emerge in the abstracts, such as gamification as a pedagogical strategy, a means to enchance motivation and participation, or a feedback mechanism.

2.4. Artificial Intelligence in Education

Artificial Intelligence (AI) in education encompasses a variety of computational applications that support the teaching and learning process. Its applications can include adaptive learning systems, personalized content, assessment support, learning analytics, as well as assistance for educators and learners. The development of generative AI also expands the discussion on the use of AI to generate materials, provide feedback, support writing, and assist with various academic activities.(Wang et al., 2024) show that the AIED literature has a variety of application categories and research focuses, so the discussion is not limited to a single function. In a more specific study on generative AI, (Yusuf et al., 2024) mapped 407 publications and identified themes such as applications and technological potential, ethical implications and risks, user experience, adoption at the individual and institutional levels, and technology performance. The results show that the narrative of AI in education encompasses pedagogical opportunities as well as governance issues and the risks of its use.

Thus, AI needs to be examined not only as a tool for personalizing learning but also as part of the educational ecosystem involving teachers, students, institution, and technology usage regulations. In this study, the analysis is directed as how the article abstracts position AI, for example, as means of adaptative learning, assessment support, an assistant for educators, or a technology that raises questions about ethics and governance. These categories are used as a direction for intepretation, not as sesults assumed to emerge before the abstract is analyzed.

2.5. Synthesis of Previous Resesarch and Research Gaps

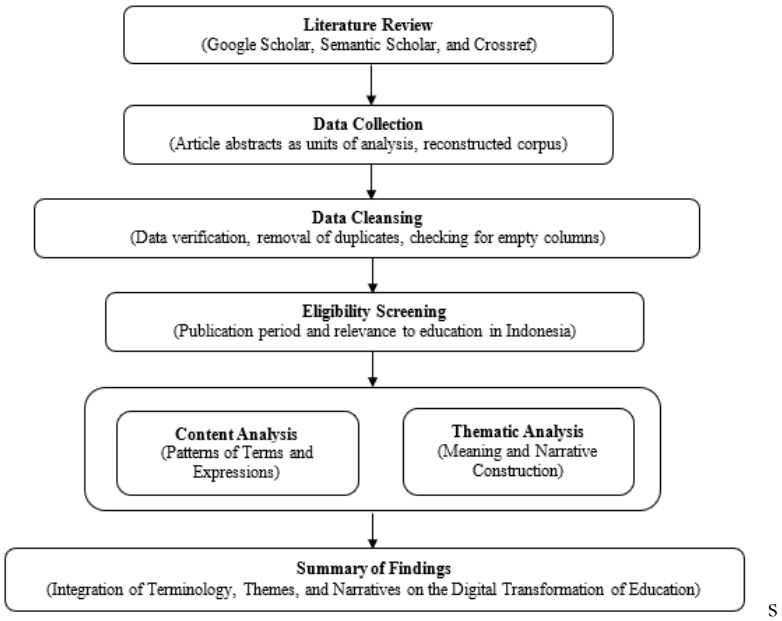
Previous research has shown that AR/VR, gamification, and AI have been studied through various approaches, including systematic reviews, bibliometric analyzes, and meta-analyses. VR studies focus, among other things, on the development of the field, technological characteristics, and the design of learning experiences; gamification studies examine the integration of game elements and their relationship with motivation and learning outcomes; while AI studies discuss the diversity of applications, personalization, as well as ethical implications and implementation challenges (L. Li et al., 2024; Marougkas et al., 2023; Rojas-Sánchez et al., 2022).

Although these studies provide an important foundation, their focus and units of analysis differ. Some examine the effectiveness or learning outcomes, while others map the development of publications and application categories. Based on the literature reviewed for this study, there is still room to comprehensively examine how these three groups of technologies are represented in the abstract narratives of academic articles related to education in Indonesia. This focus allows the research to examine not only what technologies are discussed but also how these technologies are positioned within the discourse of education, for example, as media, pedagogical strategies, or parts of the learning ecosystem.

Therefore, this research complements previous studies through content analysis and thematic analysis of abstracts of articles related to AR/VR, gamification, and AI in education in Indonesia. Its contribution lies in the comparison of the patterns of terms and narratives of the three groups of technologies within a single analytical framework. Since the unit of analysis in this research is the abstract, the results aim to explain the representation and narrative tendencies in the analyzed texts, rather than to directly conclude the effectiveness of the technologies or to represent the entire educational practices in Indonesia.

3. METHOD

This study employs a descriptive qualitative approach to understand how narratives regarding emerging learning technologies, namely, Augmented Reality/Virtual Reality (AR/VR), gamification, and Artificial Intelligence (AI) are constructed in the academic literature on education in Indonesia. This study does not focus on measuring the effectiveness of these technologies or the sheer number of publications, but rather on the patterns of terms and themes, and meaning contained in the abstracts of scientific articles. Therefore, the analysis was conducted by combining content analysis and thematic analysis. Content analysis was used to identify patterns of terms and expressions in the abstracts, while thematic analysis was used to interpret the meanings and narrative constructions related to the use of AR/VR, gamification, and AI in education in Indonesia.



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Figure 1. Flowchart of Literature Review, Data Cleaning, and Thematic Analysis

The research stages were organized as shown in Figure 1. The study began with a literature review using Google Scholar, Semantic Scholar, and Crossref, employing the keywords "augmented reality", "virtual reality", "gamification", "artificial intelligence", and "AI in education" in combination with "Indonesia". The search focused on publications from 2019 through early 2025 related to the educational context in Indonesia, covering elementary, secondary, vocational, and higher education levels. The search results were then collected and organized into research data, with the abstracts of scientific articles serving as the primary source of textual data and units of analysis.

The next stage was data cleansing to prepare a corpus suitable for the research needs. This stage involved checking the structure and completeness of the data, removing columns unnecessary for analysis, identifying and removing duplicate records, and separating records lacking abstract text. After the cleansing process, the data were examined for publication period consistency and relevance to the educational context in Indonesia. Records without abstracts were not used in the thematic interpretation, while available abstracts that met the research criteria were considered for further analysis.

The analysis was conducted using two complementary approaches. First, content analysis was performed by identifying terms and phrases that appeared in the abstracts to gain an understanding of the patterns of discussion regarding learning technologies. Second, thematic analysis was conducted by reading and interpreting the content of the abstracts to identify patterns of meaning and narratives regarding AR/VR, gamification, and AI. The interpretation focused on how these technologies are positioned in the educational literature for example, as learning media, pedagogical strategies, or components of an adaptive learning ecosystem. Initial themes aligned with the research focus, but interpretations were grounded in the available abstract content. A single abstract could encompass more than one technology or theme if the text supported such an interpretation.

The final stage is the synthesis of results, which involves integrating the findings from content analysis and thematic analysis to describe narrative patterns regarding digital transformation in education in Indonesia. This synthesis is used to discuss trends in how AR/VR, gamification, and AI are represented in the analyzed literature, as well as their implications for the development of digital learning. The research findings are interpreted as narrative patterns in the abstracts of scientific articles, not as direct evidence regarding the effectiveness of technology implementation in learning.

1. RESULT AND DISCUSSION

Analysis of abstracts from the three primary databases, Crossref, Semantic Scholar and Google Scholar, provides a mixed picture of how emerging educational technologies are positioned in Indonesian literature. While core terms such as education, learning, technology and innovation appear consistently across the three sources, there are variations in how narratives are constructed. Crossref emphasizes formal evaluation and effectiveness, and Semantic Scholar tends to link innovation to broader policy frameworks and digital

transformation. At the same time, Google Scholar is more practical and contextual, focusing on classroom implementation. To clarify the differences and intersections of these three databases, the following mapping table summarizes the focus of each narrative related to AR/VR, gamification, and AI in Indonesian education.

Table 1. Mapping of Analysis Results based on the journal database

Database	Content Analysis (term pattern)	Thematic Coding (narrative & theme)
Crossref	*results, effectiveness, analysis, testing*	**AR/VR** = immersive media; **Gamification** = outcome-oriented pedagogical strategy; **AI** = personalization & assessment
Semantic Scholar	*digital, society, autonomy, journal*	**AR/VR** = digital modernization; **Gamification** = learning autonomy; **AI** = ecosystem & governance
Google Scholar	*media, apps, innovative, students*	**AR/VR** = classroom media projects; **Gamification** = quiz platform; **AI** = teacher assistant/adaptive assessment

(Source. Primary Research Data, 2025)

3.1. Abstrac Content

The content analysis identified recurring terms related to education, learning, technology, and innovation across the three databases. The reported patterns also suggest differences in emphasis among the sources. Crossref was associated with terms related to results, effectiveness, analysis, and testing, reflecting an evaluative orientation in the analyzed literature. Semantic Scholar was associated with terms such as digital, society, and autonomy, indicating a connection with broader discussions of digital transformation and educational policy. Meanwhile, Google Scholar was associated with terms such as media, applications, innovation, and students, suggesting a stronger emphasis on practical learning contexts and educational media. These patterns provide an interpretive indication of how educational technology is discussed across the retrieved literature. However, because the analysis was based on article abstracts, the patterns should not be interpreted as definitive evidence of the overall research orientation of each database. Further quantitative verification of term frequencies would be necessary to establish the magnitude of these differences (G. Li et al., 2025; Park et al., 2024).

3.2. Thematic

The results of thematic coding analysis are divided into three major narrative patterns: (1) AR/VR as immersive media and abstract representation. (2) Gamification as a pedagogical strategy. (3) AI as an adaptive ecosystem. The three thematic patterns identified through the analysis are summarized in Table 2. The table outlines the interpretive positioning of AR/VR, gamification, and AI together with their reported areas of focus and potential implications for educational practice. This summary provides a conceptual overview of the three themes before their supporting interpretations and contextual implications are discussed in detail.

Table 2. Summary of the Three Thematic Patterns Identified in the Manuscript Analysis.

Technology	Interpretive theme	Main focus reported in the manuscript	Implication
AR/VR	Immersive media and abstract representation	Visualization, simulation, and contextual learning experiences	Align immersive features with learning objectives and available infrastructure
Gamification	Pedagogical strategy	Motivation, participation, feedback, and learning autonomy	Integrate game elements with instructional objectives
AI	Adaptive learning ecosystem	Personalization, assessment, teacher support, and data governance	Combine adaptive support with human oversight and responsible data practices

Articles from crossref often frame AR/VR as a visualization tool to bridge abstract concepts. Semantic Scholar relates it to Society 5.0 and digitalization, and Google Scholar features its use in innovative learning media projects in high schools. Recent literature also confirms that AR/VR is efficacious in improving conceptual understanding and psychomotor skills, but the effect is highly dependent on instructional design

and infrastructure readiness (Arnab et al., 2024; Chapagain & Aryal, 2025; Goi, 2024; Pani et al., 2025) . The second narrative, Gamification as a pedagogical strategy, Crossref highlights gamification as a strategy to improve learning outcomes, Semantic Scholar relates it to learning autonomy and Merdeka Belajar policies. At the same time, Google Scholar presents concrete applications such as Kahoot or Quizizz. Consistent with recent meta-analyses, gamification increases motivation, engagement, and achievement. Still, its success is strongly influenced by the design of the elements (not just points/badges) and integration with learning objectives (Alsawaier, 2018; Carvalho et al., 2023; Rivera & Garden, 2021) . The following narrative on AI places it as a tool and an infrastructure of the learning ecosystem. Crossref emphasizes personalized learning and assessment, Semantic Scholar highlights its links to ChatGPT, machine learning, and governance, while Google Scholar focuses on its use to support teachers. This trend is in line with recent international reviews that emphasize the potential of AI in personalization, adaptive assessment, and efficiency, but also assert ethical risks, privacy, and algorithmic bias (Lata, 2024; Mahmoud & Sørensen, 2024; Yang & Córdova-Esparza, 2025).

A combination of content analysis and thematic coding shows that while standard terms such as education, learning, and technology appear consistently across databases, the narratives constructed differ. Crossref serves as a representation of formal and evaluative research, Semantic Scholar as an arena for policy narratives and global transformation, while Google Scholar captures innovation practices in the classroom. These results confirm that the position of AR/VR, gamification, and AI in Indonesian education is divided into three layers of discourse: immersive media (AR/VR), pedagogical strategies (gamification), and adaptive ecosystems (AI).

3.3. Emerging Issues and Implications

Abstracts from the Crossref database show a research trend emphasizing effectiveness, outcome testing, and academic achievement. This narrative depicts technologies such as AR/VR, gamification, and AI as primarily positioned as tools for measuring learning performance. However, an apparent challenge is the lack of detail on how instructional design is implemented, for example, briefing, scaffolding, and debriefing in VR/AR, gamification elements used (points, badges, leaderboards), and personalization metrics in AI studies. In fact, recent international literature confirms that the success of learning technologies is not only the result of the device, but the fit between technological affordances, task design, and assessment. For example, a meta-analysis of VR in STEM fields emphasized the importance of clarity of instructional design so that the benefits of immersiveness are not lost by cognitive load (Elme et al., 2022). Similarly, a meta-analysis of Kahoot! Shows a positive effect of gamification on achievement, but only if design elements are appropriately explained and implemented (Chang & Hwang, 2024). Therefore, the dominant Indonesian research in Crossref would have a more substantial contribution if it reported the mechanics of instructional design in detail, not just quantitative results.

Abstracts from Semantic Scholar show how emerging technologies are closely linked to policy narratives and macro transformations, such as Society 5.0, learning autonomy, and digitalization. The main issues that arise are the need for AI literacy for educators and the clarity of data governance. AI is often positioned as a potential adaptive learning ecosystem. Still, the details of privacy-by-design mechanisms, bias mitigation, and data auditing strategies are rarely spelled out at the abstract level. In fact, a recent literature review on AI in higher education emphasized that AI integration must go hand in hand with ethical, pedagogical, and technical literacy to avoid dependency without understanding (George, 2023) . Likewise, a recent systematic review on AI-powered personalized learning emphasized the importance of humans-in-the-loop in the instructional adaptation process, to ensure transparency, accountability, and data regulation compliance (Okafor et al., 2025; Shao et al., 2025). Thus, the obvious implication for Indonesia is the need to integrate AI literacy in teacher training programs and develop data governance protocols in schools/universities aligned with the Personal Data Protection Law (PDP Law).

Abstracts from Google Scholar generally feature practical innovations at the classroom level, such as using AR/VR as a learning medium, implementing game-based quizzes (Kahoot, Quizizz), or AI as a teacher assistant in assessment. An emerging issue is the potential novelty effect, where technological novelty drives initial positive effects more than long-term pedagogical effectiveness. This is related to the lack of reports on task-technology alignment (the fit between technology affordances and learning objectives and tasks) and the duration of the intervention. A systematic review of gamification in K-12 shows that the positive effects of gamification on motivation and achievement only persist when the design of gamification elements is aligned with learning objectives, rather than being merely decorative (Mulyani et al., 2025). Similarly, a meta-analysis of AR in higher education confirms that the effects are more consistent if

affordances (e.g., spatial presence or 3D manipulation) are aligned with relevant materials and assessments (G. Li et al., 2025). Therefore, the implication of the Google Scholar pattern is the need for more detailed reporting on how teachers design task alignment with technological affordances and accounting for the duration and sustainability of interventions so that learning effects are not simply the result of technological novelty.

These implications are particularly relevant to vocational education and training, where technology-supported learning should be aligned with practical competencies, workplace-related tasks, and the resources available to educational institutions. AR/VR applications may support the visualization and simulation of technical procedures, while gamification can structure practice, feedback, and learner participation. AI-based tools may assist learning personalization and assessment, provided that their use remains subject to appropriate human oversight and data protection. However, the potential contribution of these technologies should not be equated with demonstrated effectiveness in vocational settings, because the present analysis examines narratives in article abstracts rather than directly evaluating learning interventions. Accordingly, technology selection should consider affordability, and long-term maintenance alongside pedagogical suitability. These considerations provide a contextual basis for interpreting the findings in relation to vocational education without extending the conclusions beyond the evidence analyzed.

4. CONCLUSION

This research reveals that narratives about emerging educational technologies in Indonesia, particularly AR/VR, gamification, and AI, have different characteristics depending on the publication database. Crossref mainly portrays technology as an object of measuring effectiveness with an evaluative approach, and Semantic Scholar links innovation with policy discourse and digital transformation. At the same time, Google Scholar emphasizes concrete classroom practices using media, applications, and strategies based on popular platforms. Three major themes were found through a combination of content analysis and thematic coding: AR/VR is framed as an immersive medium and abstract representation with the potential to enhance learning experiences, and gamification is positioned as a pedagogical strategy to manage student motivation and participation. At the same time, AI is seen as an adaptive ecosystem capable of personalizing learning while presenting data governance and ethics issues. This narrative is consistent with recent international literature, which emphasizes the importance of the fit between technological affordances, instructional design, and ethical governance in ensuring the sustainability of the benefits of digital-based education.

Overall, this study's results confirm that the digital transformation of Indonesian education is not simply a matter of device adoption but rather how technology is positioned, interpreted and integrated into learning practices, policies and data governance. This study contributes by presenting an interpretive analysis of publication abstracts, thus enriching the dominant quantitative-bibliometric studies.

Practical Implications

1. For Researchers

These results emphasize the need for more detailed instructional design reporting in educational technology research. VR/AR studies should include the briefing-scaffolding-debriefing stage, gamification studies report the elements used (points, badges, missions), while AI studies describe the data pipeline and bias mitigation mechanisms. In this way, Indonesian research can contribute to the global discourse with more comparable results across studies.

2. For Teachers and Practitioners

Teachers in Indonesia need to understand that the success of AR/VR, gamification, or AI does not lie in the novelty of the technology alone, but in the alignment between technological affordances and learning objectives. Gamification is not enough with online quizzes; it needs a design that supports student self-regulation. AI as a teaching assistant must be utilized with humans in the loop, not to replace the teacher's role, but to strengthen its pedagogical function.

3. For Policy Makers

The main implication is the importance of policies that encourage technology adoption and prepare an ecosystem of digital literacy and AI ethics. Ministries and higher education institutions need to develop data

governance protocols per the Personal Data Protection Law (PDP Law) and integrate AI literacy in teacher professional development programs. This aligns with the recommendations of recent systematic reviews that emphasise the integration of ethics, transparency, and accountability in AI policies in education

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