

Challenges and Opportunities for Digital Learning Resource Development: An Analysis of AI Application in Vietnamese General Education

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Abstract

The global integration of Artificial Intelligence (AI) into education is catalyzing a paradigm shift in the creation and utilization of Digital Learning Resources (DLRs). While promising transformative potential, the adoption of AI in developing nations faces unique systemic challenges. This study provides a comprehensive analysis of the current landscape, challenges, and opportunities of AI-driven DLR development within the general education system of Central Vietnam, a region characterized by specific socio-economic constraints. Employing a sequential explanatory mixed-methods design, we synthesized quantitative data from a survey of 454 teachers and administrators with in-depth qualitative data from focus groups and semi-structured interviews. Our findings reveal a significant dichotomy: while grassroots enthusiasm for AI is evident in the widespread adoption of accessible tools like ChatGPT for content creation, systemic barriers severely impede broader integration. Key impediments include inadequate technological infrastructure, a lack of cohesive national policy, and insufficient pedagogical training for educators. The study highlights a critical tension between national digital transformation ambitions and the on-the-ground realities faced by teachers. We argue that in this context, systemic factors such as infrastructure and policy act as primary determinants of technology adoption, potentially overriding individual-level factors emphasized in traditional technology acceptance models (TAMs). The paper offers actionable recommendations for policymakers, school administrators, and professional development providers, aimed at fostering an equitable and sustainable ecosystem for AI in education. This research contributes a nuanced, context-specific perspective to the global discourse on educational technology, emphasizing the critical need for systemic support to unlock AI's full potential in resource-constrained environments.

Keywords: Artificial intelligence, Digital learning resources, Educational technology, General education, Vietnam.

1. INTRODUCTION

The Fourth Industrial Revolution has ushered in an era where Artificial Intelligence (AI) is no longer a futuristic concept but a pervasive force reshaping global industries, including education [1, 2]. AI's capacity to automate complex tasks, analyze vast datasets, and facilitate personalized experiences is fundamentally altering pedagogical paradigms and instructional design [3, 4]. This technological infusion has profound implications for the development of DLRs, which are central to modern, effective, and accessible education [5]. DLRs encompass a broad spectrum of materials, from simple digitized textbooks to sophisticated, interactive learning environments. The integration of AI into this domain promises to elevate DLRs from static content repositories to dynamic, adaptive, and highly engaging educational tools capable of catering to diverse learner needs [6].

Globally, educational systems are grappling with how to best harness AI's potential. In developed nations, research and implementation often focus on sophisticated applications like intelligent tutoring systems (ITS), personalized learning paths, and automated assessment tools [7]. However, the narrative and challenges are substantially different in developing countries. Here, the promise of AI is often tempered by persistent issues such as the digital divide, inadequate infrastructure, and a lack of specialized teacher training [8, 9]. Understanding the dynamics of AI adoption in these contexts is crucial for ensuring that technological advancements do not exacerbate existing educational inequities.

Vietnam serves as a compelling case study within this global landscape. The government has demonstrated strong political will to modernize its education system through the "National Digital Transformation Program by 2025, with a vision to 2030" [10]. This strategy explicitly prioritizes the integration of digital technologies, including AI, to enhance teaching quality and learning outcomes, aligning with the goals of its new general education curriculum [11]. While this top-down policy ambition is clear, its translation into classroom practice remains a complex and under-researched area, particularly outside the nation's primary economic hubs of Hanoi and Ho Chi Minh City. These metropolitan areas often benefit from greater investment in infrastructure and a higher concentration of tech-savvy educators, creating a different developmental trajectory compared to other regions [12].

Central Vietnam, a region with unique socio-economic and geographical characteristics, presents a critical context for investigation. It is a region that embodies the typical challenges faced by many developing areas: a mix of urban centers, rural towns, and remote mountainous districts, each with varying levels of access to technology and resources. The successful integration of AI for DLR development in such a diverse environment is contingent upon a complex interplay of factors, including infrastructure readiness, teacher competency, institutional support, and coherent policy frameworks [13]. Despite the national mandate, there is a significant gap in empirical research examining the on-the-ground realities of AI adoption by teachers in these specific regions. How are educators in Central Vietnam actually using AI? What are the practical barriers they face, and what opportunities do they perceive?

This study aims to address this critical knowledge gap. By conducting an in-depth, mixed-methods investigation into the application of AI for DLR development in Central Vietnam's general education

system, we seek to move beyond broad policy statements to uncover the nuanced experiences of educators. The research is guided by the following questions:

What is the current extent and nature of AI technology application by teachers in Central Vietnam for DLR creation?

What are the primary enablers and barriers, particularly systemic and individual factors, influencing the integration of AI into DLR development?

What are the perceived needs, attitudes, and challenges of teachers regarding the use of AI in their professional practice?

By answering these questions, this paper contributes a detailed, context-specific analysis that contrasts national policy ambitions with classroom realities. It provides empirical evidence on the state of AI adoption in a non-metropolitan region of a developing country, offering insights that are relevant not only for Vietnam but also for other nations facing similar digital transformation journeys. The findings inform actionable recommendations for policymakers, administrators, and teacher training institutions, aiming to foster a more equitable, effective, and sustainable digital education future.

2. LITERATURE REVIEW

To provide a robust foundation for this study, this section reviews the relevant literature, structured into four key areas. First, it traces the evolution of DLRs. Second, it provides a conceptual framework for AI-driven DLRs. Third, it discusses key theoretical models of technology adoption. Finally, it situates the research within the broader context of AI adoption in developing nations.

2.1 The Evolution of Digital Learning Resources (DLRs)

The rapid evolution of Information and Communication Technologies (ICTs) has profoundly impacted teaching methodologies and the nature of educational materials [14]. DLRs are broadly defined as any educational materials accessed via digital platforms, encompassing a wide range of formats from static e-textbooks and instructional videos to dynamic adaptive learning software [5, 15]. Early DLRs were often simple digitizations of analog content, serving as basic repositories of information. However, as technology advanced, so did the sophistication of DLRs. A useful tripartite typology categorizes DLRs into: (a) basic resources (e.g., digital textbooks, presentations), which form the core of digital instruction; (b) supplementary open resources (e.g., Open Educational Resources - OERs, MOOCs), which broaden access to knowledge; and (c) innovative learning resources that utilize emerging technologies like Virtual/Augmented Reality (VR/AR) and AI to create immersive and personalized learning experiences [16]. This evolution reflects a pedagogical shift from passive information consumption to active, learner-centric engagement [17].

2.2 AI-Driven DLRs: A Conceptual Framework and Typology

The infusion of AI marks the latest and perhaps most transformative phase in the evolution of DLRs. AI is increasingly central to both automating the development process and personalizing the learning experience [18]. AI-driven DLRs can be defined as educational materials and systems that leverage machine learning, natural language processing, and data analytics to create, deliver, and adapt content in response to individual learner interactions and performance data [19]. These resources are not static; they are dynamic ecosystems that learn and evolve.

For clarity, AI-driven DLRs can be categorized into several key types:

- (a) **Automated Content Generation Systems:** Tools like GPT-4 can rapidly generate lesson plans, assessment items, and explanatory texts, significantly reducing teacher workload [20]. Other AI tools can create images (e.g., DALL-E) or videos from text prompts, enriching the multi-media landscape of DLRs.
- (b) **Intelligent Tutoring Systems (ITS):** These systems provide step-by-step guidance and personalized feedback to students as they work through problems, mimicking the support of a human tutor [21].
- (c) **Adaptive Learning Platforms:** These platforms use AI algorithms to analyze a student's performance in real-time and dynamically adjust the difficulty and sequence of learning materials to create an optimized, individualized learning path [22].
- (d) **Immersive Learning Environments:** AI can power gamified simulations and virtual mentors within VR/AR environments, providing realistic, safe, and engaging spaces for skill development [23, 24].

2.3 Theoretical Underpinnings of AI Adoption in Education

Understanding the factors that influence educators' adoption of AI requires a theoretical lens. Two prominent frameworks are the TAM and the Unified Theory of Acceptance and Use of Technology (UTAUT). TAM posits that an individual's intention to use a technology is primarily determined by two beliefs: Perceived Usefulness and Perceived Ease of Use [25]. UTAUT expands on this by integrating elements from several models, proposing that behavioral intention is influenced by performance expectancy, effort expectancy, social influence, and facilitating conditions [26].

While these models have been widely applied, their explanatory power can be limited in certain contexts. In highly centralized or resource-constrained educational systems, systemic factors such as national policy, available infrastructure ('facilitating conditions' in UTAUT), and mandatory professional development can exert a more powerful influence than individual perceptions [27]. Therefore, a critical analysis of AI adoption must consider both the individual agency of teachers and the overarching structural realities that enable or constrain their actions.

2.4 AI in Education within Developing Contexts: A Comparative Perspective

The discourse on AI in education is often dominated by perspectives from the Global North. However, the challenges and opportunities in developing countries are distinct [8]. Studies across South-east Asia, Africa, and Latin America consistently highlight a core set of barriers: inadequate and unreliable internet connectivity, a scarcity of digital devices, a lack of locally relevant digital content, and a critical need for sustained, pedagogy-focused teacher training [9, 28]. For instance, research in Indonesia points to infrastructural deficits as the primary bottleneck for technology integration [29], while studies in Sub-Saharan Africa emphasize the challenge of teacher digital literacy [30].

At the same time, AI offers unique opportunities in these contexts, such as the potential to bridge learning gaps for marginalized students [31], and provide access to high-quality educational resources in remote areas. However, the successful integration of AI is heavily dependent on supportive policies, ethical guidelines to prevent bias [32], and strong institutional support [33]. This study in Central Vietnam, therefore, aims to contribute to this vital body of literature by providing a granular, empirically-grounded account of the complex dynamics of AI adoption in a specific developing region.

3. MATERIALS AND METHODS

3.1 Research Design

This study employed a mixed-methods research design, specifically a sequential explanatory strategy, to investigate AI application in DLR development in Central Vietnam's general education schools [34]. This two-phase approach began with a broad quantitative survey to identify general trends, patterns, and correlations. The findings from this phase then informed the development of the second, qualitative phase, which involved focus groups and interviews to provide in-depth explanations, context, and the lived experiences behind the quantitative data. This combination allowed for a comprehensive, multi-layered understanding of the phenomenon, synergizing statistical breadth with narrative depth [35].

3.2 Participants and Sampling

This study's target population consisted of teachers and educational administrators from primary, lower secondary, and upper secondary schools across three purposively selected provinces in Central Vietnam: Thua Thien Hue, Quang Nam, and Da Nang. These provinces represent a diverse range of socio-economic and educational development levels, encompassing major urban centers, provincial towns, and rural/mountainous districts, thereby providing a representative cross-section of the region.

For the quantitative phase, a multi-stage sampling technique was utilized. First, a stratified random sample of schools was selected from the chosen provinces, ensuring representation across school levels and geographical locations (urban, town, mountainous). Second, survey invitations were distributed to all teachers and administrators within these selected schools. From 490 invitations,

454 complete responses were collected, yielding a high response rate of 92.6%. The demographic profile of participants (TABLE 1) shows a diverse sample regarding gender, education, experience, and school location.

Table 1: General information of the survey sample regarding teachers in high education schools in the Central region of Vietnam

Criteria	Category	Frequency (N)	Percentage (%)
Gender	Male	173	38.1
	Female	281	61.8
Education	University Degree	349	76.9
Level	Postgraduate	78	17.1
	Other	27	6.0
Experience	Less than 5 years	31	6.8
	5-10 years	203	44.7
	10-15 years	151	33.3
	Over 15 years	69	15.2
Work Position	Teacher	413	90.9
	Management Staff	41	9.1
Resident	City	149	32.8
	Town	162	35.7
	Mountainous	143	31.5
Total	454	100	Total

For the qualitative phase, a purposive sampling strategy was employed to select 32 participants (24 teachers, 8 administrators) from the initial survey pool. Selection criteria were designed to ensure maximum variation in experience, including school location (urban, town, mountainous), years of teaching, and reported level of AI usage (from novice to early adopter). Data were collected through four focus group discussions (8 participants each) and eight in-depth, semi-structured interviews. This purposeful selection ensured that we captured a rich spectrum of perspectives, from enthusiastic early adopters to skeptical or resource-constrained educators.

4. RESULTS

This section presents the findings from both the quantitative survey and the qualitative interviews, organized thematically around the research questions. The data reveal the current state of DLR and AI tool utilization, the key factors influencing adoption, and the primary challenges perceived by educators.

4.1 Current Utilization of Digital Learning Resources and AI Tools

The survey data revealed a clear and distinct dichotomy in the use of digital resources among teachers in Central Vietnam. As illustrated in TABLE 2, there is widespread adoption of foundational resources, while more advanced, innovative tools remain largely unexplored. A substantial majority of teachers (84.5% combined 'Frequently' and 'Very frequently') reported using basic resources like presentations (e.g., PowerPoint). However, engagement drops significantly with more complex resources. For instance, 36.8% of teachers reported never using supplementary open resources like OERs, and a striking 45.2% have no experience whatsoever with innovative resources involving VR or AI.

Table 2: Frequency of using DLRs in high education schools in the Central region of Vietnam

Type of digital learning resources	Not used	Occasionally	Frequently	Very frequently
Basic Resources	15	237	146	56
Supplementary Open Resources	167	130	124	33
Innovative Learning Resources (VR, AI,...)	205	147	87	15

This gap was corroborated in interviews. A teacher from a mountainous district shared: We are encouraged to use digital tools, and we do use PowerPoint and Zalo,... But when it comes to things like AI our school's internet is too slow, and the computers are too old. Regarding specific AI tools (TABLE 3), adoption remains exploratory. The most notable finding is the widespread engagement with generative AI like ChatGPT; 54.0% of teachers are current users. In contrast, specialized tools like DALL-E for image generation (2.6% use) or AI for text-to-video (9.3% use) have much lower adoption rates (FIGURE 1).

Table 3: Survey of awareness and use of AI tools for learning in general education schools in the Central region of Vietnam.

AI Tool	Unaware	Aware but not used	Tried	Currently using
Text-to-Speech	0	159	134	161
Text-to-Video	0	278	134	42
DALL-E / Image AI	210	173	59	12
ChatGPT or other content creation tools	0	31	178	245

A young teacher from the urban center of Da Nang noted the practical benefits driving this trend: ChatGPT is a game-changer for brainstorming lesson ideas and creating draft exercises. It saves me hours. Of course, I have to check everything carefully for accuracy and make sure it fits my students, but it's an incredible starting point. It helps me overcome the 'blank page' problem. This sentiment encapsulates the core appeal of generative AI: it lowers the barrier to content creation and acts as a productivity enhancer.

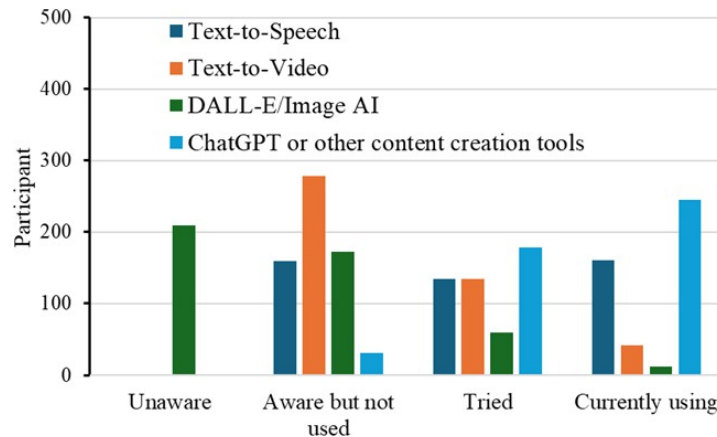


Figure 1: Survey of awareness and use of AI tools for learning in general education schools in the Central region of Vietnam

4.2 Influencing Factors

The study identified several interconnected factors that significantly influence AI adoption, with systemic issues emerging as the most dominant. As detailed in TABLE 4, and visualized in FIGURE 2, teachers perceive 'Policy and Technological Infrastructure' as the most critical factor, with a majority (60.8%) rating its impact as "Large." This was followed by 'Technological Competence and Teacher Awareness,' which 33.3% of respondents considered to have a large influence. Conversely, 'Organizational Culture' was perceived as the least influential factor, with a combined 68.7% rating its influence as "No" or "Little."

Table 4: Survey of factors influencing the application of AI

Influencing Factors	No Influence	Little Influence	Moderate Influence	Large Influence
Technological Competence and Teacher Awareness	0	0	303	151
Input Data and Standardization	33	168	156	97
Policy, Technological Infrastructure	0	55	123	276
Ethics and Legality	21	99	150	184
Organizational Culture	167	145	83	59

The qualitative data provided deep context to these ratings. The high ranking of infrastructure and policy reflects a feeling of dependency on top-down support. An ICT coordinator from a school in Thua Thien Hue explained this sentiment: Teachers are willing, but we are operating in a vacuum. We receive directives to innovate, but there are no clear guidelines on what AI tools are permissible or how to handle student data privacy. We also need the budget to upgrade our network and computer labs. Without that foundation, everything else is just talk. This highlights a critical disconnect between policy ambition and the provision of necessary facilitating conditions.

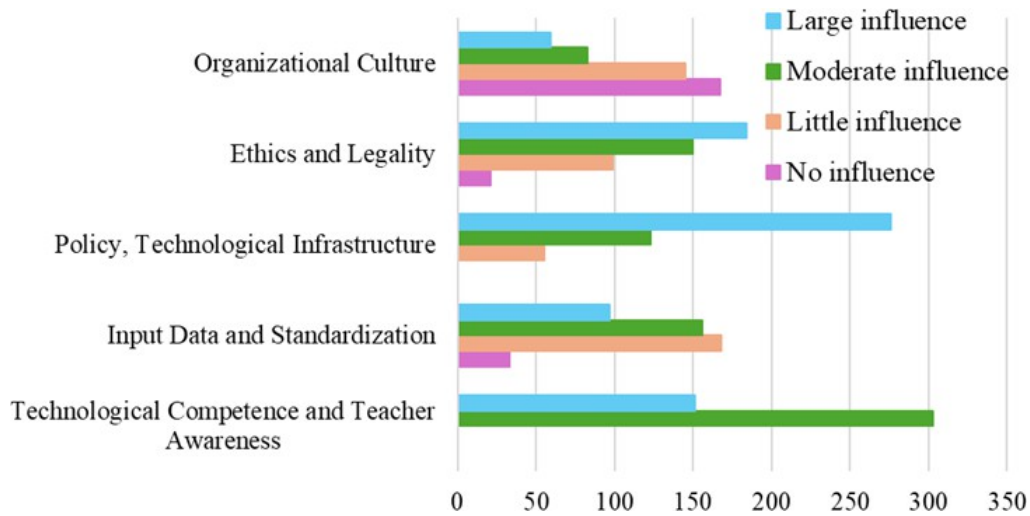


Figure 2: Survey of factors influencing the application of AI

4.3 Challenges

The primary challenges identified by educators are systemic and deeply interrelated, reinforcing the findings on influencing factors. As shown in TABLE 5, the most significant issues are 'Lack of legal framework' (rated as a 'Moderate' or 'Major' challenge by 64.0% of teachers), 'Lack of teacher competence' (70.5%), and 'Lack of data, standardized resources' (65.2%). These three challenges form a formidable barrier to meaningful AI integration.

Table 5: Survey of the impact of challenging factors

Challenge	Not a challenge	Minor challenge	Moderate challenge	Major challenge
Lack of teacher competence	45	89	189	131
Lack of legal framework	67	97	147	143
Lack of data, standardized resources	33	125	178	118

An experienced teacher in a focus group described the practical impact of these challenges as a “dual burden”: We have to learn the technology ourselves, often through YouTube or by asking younger colleagues. At the same time, we have to figure out the pedagogy—how to actually use this in a way that helps students learn, not just as a gimmick. It’s overwhelming without structured, continuous training that connects the tool to the curriculum. Furthermore, a Chi-square test for independence was performed to examine the relationship between school location (urban, town, mountainous) and the perceived challenge of “Lack of Teacher Competence.” The relationship was found to be statistically significant, $\chi^2(2, N = 454) = 14.28, p < 0.01$. This indicates that teachers in rural and mountainous areas reported a lack of competence as a major challenge more frequently than their urban counterparts (FIGURE 3), highlighting a significant equity gap in professional development and support.

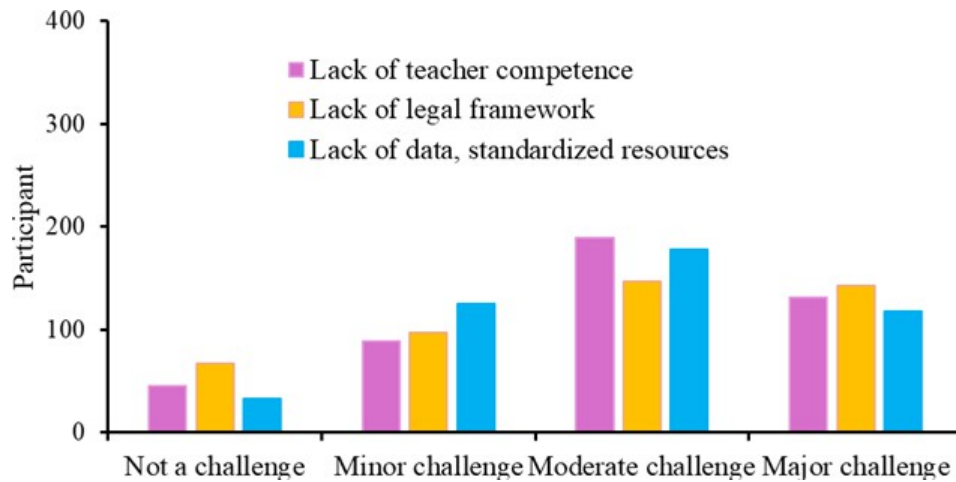


Figure 3: Surveyed results of challenging factors.

4.4 Perceived Benefits

Despite the considerable hurdles, teachers overwhelmingly recognized the potential of AI to enhance their professional practice. As depicted in FIGURE 4, the perceived benefits are heavily concentrated on efficiency and content enrichment. The benefit of “Accelerated compilation of learning materials” was the most highly valued, selected by all participants who identified benefits (reflecting a strong desire to reduce workload). This was closely followed by “Creation of engaging multimedia learning materials,” which was valued by 81.7% of teachers. These findings suggest

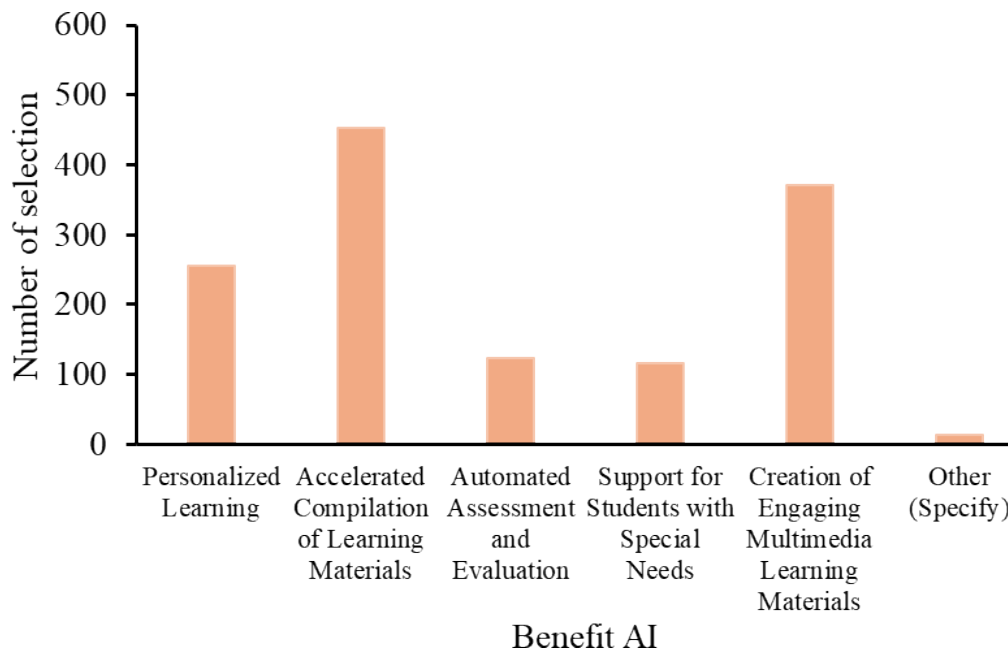


Figure 4: Surveyed results of perceived benefits of AI application

that educators primarily view AI as a powerful tool for content creation and preparation, rather than for more complex pedagogical functions like personalized learning or automated assessment, which were valued less.

A primary school teacher commented, “The ability to quickly find ideas or generate a simple story with pictures for my students is wonderful. It gives me more time to focus on the children in the classroom rather than spending all my evenings preparing materials.” This pragmatic perspective underscores the appeal of AI as a solution to the immediate and pressing problem of teacher workload.

5. DISCUSSION

This section interprets the research findings, connects them to the broader academic literature and theoretical frameworks, and explores their theoretical and practical implications. The discussion is structured around the key themes that emerged from the data: the contextual challenges to technology adoption models, the critical role of systemic factors, and the grassroots innovation driven by educators.

5.1 Theoretical Implications: Contextualizing Technology Acceptance Models

The findings of this study present a significant contextual challenge to mainstream TAMs like TAM and UTAUT, which often prioritize individual-level psychological factors such as perceived usefulness and ease of use [25, 26]. While these factors are clearly at play—evidenced by the rapid, bottom-up adoption of ChatGPT due to its high perceived usefulness and accessibility—our data reveal that their influence is heavily constrained by overriding systemic factors. The overwhelming emphasis that teachers placed on ‘Policy and Technological Infrastructure’ as the primary determinant of AI adoption suggests that in a centralized, developing educational context like Vietnam, ‘facilitating conditions’ are not merely an influencing variable but a foundational prerequisite. Without adequate infrastructure and a clear policy framework, individual willingness and positive perceptions toward AI have a limited ceiling for impact.

This study argues that the predictive power of models like TAM and UTAUT in such contexts is contingent upon a heavier weighting of systemic variables. The “dual burden” described by educators—the simultaneous need to master technology and develop new pedagogies in the absence of institutional support—highlights a critical imbalance where the pace of technological possibility outstrips the development of supportive educational and policy frameworks. This finding aligns with research from other developing nations which posits that structural barriers can effectively veto individual agency in technology adoption [8, 9]. Therefore, future theoretical work on technology adoption in education should consider developing context-sensitive models that more explicitly account for the hierarchical influence of national policy, resource allocation, and infrastructure as gating factors for successful integration.

5.2 Practical Implications

The findings from this study yield several actionable recommendations for different stakeholders in the Vietnamese education system and other similar contexts.

For Policymakers: The “vacuum” of clear guidelines is the most critical barrier to address. There is an urgent need for a comprehensive national framework on AI in education. This framework should provide clear directives on acceptable use, data privacy standards for student information, and guidelines for maintaining academic integrity. Crucially, this policy must be supported by a targeted funding strategy to upgrade technological infrastructure, with a specific focus on closing the gap between urban and rural/mountainous regions.

For School Administrators: Fostering a supportive and innovative organizational culture is key. Administrators can play a pivotal role in bridging the gap between policy and practice. They can create “sandbox” environments where teachers feel safe to experiment with new AI tools without fear of failure. Facilitating peer-to-peer learning communities, where early adopters can share their knowledge and best practices with colleagues, can be a highly effective and low-cost strategy for building collective capacity.

For Teacher Professional Development: Training programs must evolve beyond basic digital literacy. A future-ready professional development curriculum for AI in education should be three-pronged: (a) foundational skills in using a variety of AI tools beyond just generative text; (b) advanced pedagogical skills for effectively integrating these tools into different subject areas and lesson plans; and (c) critical AI literacy, which equips teachers to evaluate AI-generated content for bias, accuracy, and ethical implications [20, 32]. This training must be ongoing, context-specific, and readily accessible to all teachers, regardless of their geographical location.

5.3 Limitations and Future Research

This study has several limitations that offer avenues for future research. First, its reliance on self-reported data for AI usage and competence may be subject to social desirability bias. Future research could incorporate observational classroom-based studies to provide a more objective measure of AI integration in practice [36]. Second, its geographical focus on Central Vietnam, while providing depth, limits the generalizability of the findings to the entire country. A nationwide comparative study that examines the differences in AI adoption drivers and barriers between economically diverse regions would be highly valuable, directly addressing a key suggestion from the review process [37].

Third, the cross-sectional design of this study offers only a snapshot in time. Given the rapid pace of AI development, longitudinal studies are needed to track the evolution of AI adoption, teacher attitudes, and the impact of policy interventions over several years. Finally, future research should also focus more on the student perspective, exploring how AI-driven DLRs impact student engagement, learning outcomes, and the development of 21st-century skills.

6. CONCLUSION

In conclusion, this investigation confirms that while teachers in Central Vietnam demonstrate a strong willingness to innovate, the meaningful adoption of sophisticated AI technologies for DLR creation is significantly constrained by a triad of systemic challenges: inadequate infrastructure, ambiguous national policy, and a lack of comprehensive teacher competency development. Despite these formidable obstacles, the grassroots experimentation with accessible tools like ChatGPT signifies a powerful undercurrent of educator agency and a clear demand for technologies that can alleviate workload and enhance content creation. The key takeaway is that for AI to evolve from a peripheral tool into an integrated and transformative force, a systemic, multi-pronged approach is essential. This requires a synergistic combination of clear national policies, strategic infrastructure investment, and comprehensive, pedagogically-focused professional development that empowers teachers. By stepping back from the specifics to view the larger picture, we see that the future of digital education in contexts like Vietnam hinges not on the technology itself, but on building a resilient and equitable ecosystem to support it. This study's implications and recommendations point toward this systemic path, highlighting the remaining problems of policy-practice gaps and proposing future research directions to ensure that the promise of AI benefits all learners and educators.

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8. AUTHOR CONTRIBUTIONS

Conceptualization, T.H.N. Nguyen and T.H. Pham;
Methodology, T.H.N. Nguyen and T.H. Pham;
Validation, T.H.N. Nguyen and T.H. Pham; Survey and data analysis,
T.H.N. Nguyen and T.H. Pham; writing—original draft preparation.
The authors approved the final version of this paper.

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References

- [1] Spalevi ,  ., Milosavljevi , B., & Markovi , S. Legal Basis of Educational Processes of Artificial Intelligence Algorithms in E-Tourism. *International Journal of Cognitive Research in Science, Engineering and Education*. 2024;12:209-217.
- [2] Schwab K. *The Fourth Industrial Revolution*. Crown Business; 2017.
- [3] Wang S, Wang F, Zhu Z, Wang J, Tran T, et al. Artificial Intelligence in Education: A Systematic Literature Review. *Expert Syst Appl*. 2024a;252:124167.
- [4] Selwyn N. *Should Robots Replace Teachers? AI and the Future of Education*. Polity Press. 2019.
- [5] Luetkemeyer JR. *Digital Learning Resources: A Primer for K-12 Educators*. Rowman & Littlefield Publishing Group. 2016.
- [6] Chen L, Chen P, Lin Z. Artificial Intelligence in Education: A Review. *IEEE Access*. 2020;8:75264-78.
- [7] Zawacki-Richter O, Mar n VI, Bond M, Gouverneur F. Systematic Review of Research on Artificial Intelligence Applications in Higher Education—Where Are the Educators? *Int J Educ Technol Higher Educ*. 2019;16:39.
- [8] Ahmed F, Hussain S, Farid S. AI and the Digital Divide: Challenges in Developing Nations. *Educ Inf Technol*. 2022;27:413-432.
- [9] Tlili A, Shehata B, Adarkwah MA, Bozkurt A, Hickey DT, Huang R, et al. What if the Devil Is in the Details? A Constructive Critique of the Hype Around ChatGPT in Education. *Educ Technol Res Dev*. 2023;71:1-19.
- [10] <https://vanban.chinhphu.vn/default.aspx?pageid=27160docid=200162>
- [11] <https://luatvietnam.vn/giao-duc/thong-tu-32-2018-tt-bgddt-ban-hanh-chuong-trinh-giao-duc-pho-thong-moi-169745-d1.html>
- [12] <https://documents1.worldbank.org/curated/en/259751629470978457/pdf/Taking-Stock-Digital-Vietnam-The-Path-to-Tomorrow.pdf>
- [13] Gocen A, Aydemir F. An Investigation of the Effectiveness of a Professional Development Program on Technology Integration in Education. *Educ Inf Technol*. 2020;25:4643-4663.
- [14] Brynjolfsson E, Hitt LM. Beyond Computation: Information Technology, Organizational Transformation and Business Performance. *J Econ Perspect*. 2000;14:23-48.
- [15] Wang Y, Zhang L, Huang Z. Digital Learning Resources: A Classification Framework. *Br J Educ Technol*. 2020a;51(5):1430-46.
- [16] Wang S, Liu J, Chen H. A Tripartite Framework for Next-Generation Digital Learning Resources: Integrating Core, Open, and Innovative Elements. *J Educ Technol Soc*. 2020b;23:1-15.
- [17] Vinay SB. Application of Artificial Intelligence (AI) in School Teaching and Learning Process- Review and Analysis. *Int J Inf Technol Manag Inf Syst*. 2023;14:1-5.

- [18] Tan X, Cheng G, Ling MH. Artificial Intelligence in Teaching and Teacher Professional Development: A Systematic Review. *Artif Intell.* 2025;8:100355.
- [19] Ouyang F, Zheng L, Jiao P. Artificial Intelligence in Online Higher Education: A Systematic Review of Empirical Research From 2011 to 2020. *Educ Inf Technol.* 2022;27:7893-7925.
- [20] Davis E, Lee S. Designing Curricula With ChatGPT: Promises and Pitfalls. *Educ Technol Res Dev.* 2024;72:89-104.
- [21] Wollny S, Schneider J, Di Mitri D, Weidlich J, Rittberger M, et al. ARe We There Yet? A Systematic Literature Review on Chatbots in Education. *Front Artif Intell.* 2021;4:654924.
- [22] Alevin V, McLaren BM, Sewall J. Example-Tutor: A Tutor for Teaching From Worked Examples. *AI Mag.* 2017;38:17-30.
- [23] Klamma R, Lange P, Jarke M. Gamified Learning Environments and Ai-Driven Personalization for Computational Thinking. *Comput Educ.* 2020;149:103815.
- [24] Wang X, Xue H. Enhancing EFL Student Interaction Using Ai-Based Chatbots. *ReCALL.* 2024;36:18-37.
- [25] Davis FD. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Q.* 1989;13(3):319-340.
- [26] Venkatesh V, Morris MG, Davis GB, Davis FD. User Acceptance of Information Technology: Toward a Unified View. *MIS Q.* 2003;27(3):425-478.
- [27] Schmid M, Brianza E, Petko D. Self-Reported Technological Pedagogical Content Knowledge (Tpack) of Pre-Service Teachers in Relation to Digital Technology Use in Lesson Plans. *Comput Hum Behav.* 2021;115:106586.
- [28] Subedi D, Joshi K, Subedi M. A Review of Artificial Intelligence in Education in Developing Countries. *Int J Comput Appl.* 2020;175(3):1-7.
- [29] Purwanto A, Asbari M, Santoso PB. Education Management Research Review: A Bibliometric Analysis. *J Ind Eng Manag Res.* 2020;1:70-81.
- [30] Aruleba K, Jere N. A Review of the Challenges Affecting the Successful Integration of ICTs in Teaching and Learning in Sub-Saharan Africa. *Int J Inf Commun Technol Educ.* 2022;18:1-17.
- [31] Yuan L. Ai-Driven Language Support for Marginalized Learners. *J Appl Linguist Lang Res.* 2023;10:102-120.
- [32] Milicevic D, Jovanovic M, Popovic R. Ethical Issues in AI-Generated Educational Content. *Int J Cogn Res Sci Eng Educ.* 2024;12:209-217.
- [33] Lérias E, Guerra C, Ferreira P. Literacy in Artificial Intelligence as a Challenge for Teaching in Higher Education: A Case Study at Portalegre Polytechnic University. *Information.* 2024;15:205.
- [34] Creswell JW, Plano Clark VL. *Designing and Conducting Mixed Methods Research.* 3rd ed. Sage Publications. 2017.
- [35] Creswell JW. *A Concise Introduction to Mixed Methods Research.* Sage Publications. 2024.

- [36] Popenici SA, Kerr S. Exploring the Impact of Artificial Intelligence on Teaching and Learning in Higher Education. *Res Pract Technol Enhanced Learn.* 2017;12:22.
- [37] <https://www.scirp.org/reference/referencespapers?referenceid=3794881>