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Fostering Critical Thinking in Early Childhood Teacher Education: The Roles of Teaching Materials, Media Literacy, and AI-Enhanced Learning

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Research Article

Keywords: teaching materials, media literacy, AI in education, short story learning, critical thinking, PLS-SEM

Posted Date: September 4th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10567186/v1

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Additional Declarations: No competing interests reported.

Abstract

The growing integration of artificial intelligence (AI) in education has expanded opportunities for adaptive and personalized learning; however, its effectiveness in promoting critical thinking depends on instructional quality and learners' digital competencies. This study examines the relationships among teaching materials, media literacy, AI-enhanced learning, short story learning effectiveness, and critical thinking skills among 318 Early Childhood Teacher Education undergraduates in Indonesia. Employing a quantitative cross-sectional design analyzed through Partial Least Squares Structural Equation Modeling (PLS-SEM), findings reveal that teaching materials and media literacy significantly predict both AI-enhanced learning and narrative learning outcomes. Both AI-enhanced learning and short story learning effectiveness positively influenced critical thinking, with the latter emerging as the strongest predictor. The model demonstrated substantial explanatory power across all endogenous constructs. These findings advance an integrated pedagogical framework connecting instructional quality, digital competence, and narrative-based learning as interconnected determinants of critical thinking development within AI-supported teacher education contexts.

Introduction

The rapid advancement of artificial intelligence (AI) has transformed educational practices by facilitating more adaptive, personalized, and interactive learning environments (Crompton & Burke, 2023; Popenici & Kerr, 2017; Zawacki-Richter et al., 2019). AI technologies, including intelligent tutoring systems (Liu, 2025; Nhan, 2025), generative AI (Adekoya et al., 2026; Coenen & Pfenninger, 2025), automated feedback (Naseer & Khawaja, 2025), and personalized content recommendation, have been progressively incorporated into higher education to enhance student engagement, learning efficiency, and academic performance (Mncube et al., 2026; Ncube et al., 2025). AI presents significant opportunities in language and literacy instruction by enhancing learning experiences through dynamic content generation, immediate feedback, and interactive pedagogical support. The educational efficacy of AI is determined not just by technology advancement but also by the quality of pedagogy, the instructional resources employed, and students' capacity for critical analysis of digital information.

Critical thinking is a fundamental competency in 21st-century education, especially within teacher preparation programs. Future educators are required to critically analyze information, evaluate evidence, address pedagogical challenges, and make informed instructional decisions (Al Herz, 2025; Kyambade et al., 2025; Lupión-Cobos et al., 2026; Pollarolo et al., 2023). Critical thinking is vital for students in the Department of Early Childhood Teacher Education, as professional practice necessitates the ability to interpret developmental contexts, design learning experiences, and respond adaptively to diverse classroom situations. Previous studies indicate that many undergraduate students exhibit limited higher-order thinking skills, particularly in analytical reasoning, evaluation, and reflective judgment within digital learning environments (Al Herz, 2025; Hartono, 2022; Hossain, 2026; Nurkanti et al., 2025).

Recent study indicates that AI-enhanced learning environments can positively affect students' cognitive engagement and higher-order thinking by enabling personalized instruction, adaptive scaffolding, and immediate feedback mechanisms (Derakhshan & Taghizadeh, 2025; Tu et al., 2026; Yavich, 2025). Research indicates that AI-supported learning systems enhance academic motivation, learning autonomy, and conceptual understanding across various disciplines (Mncube et al., 2026; Yavich, 2025). Empirical findings remain inconsistent on whether AI integration directly enhances critical thinking or simply improves operational efficiency and learning convenience. This inconsistency indicates that the effectiveness of AI may be influenced by pedagogical and learner-related factors (Kalra et al., 2026; Sudirman, 2026; Yavich, 2025).

One essential factor is the quality of instructional materials. Well-structured instructional materials are essential for effective technology integration, as they facilitate cognitive processing, organize conceptual understanding, and offer scaffolding for meaningful learning. In AI-supported contexts, pedagogically aligned, contextually relevant, and cognitively stimulating teaching materials can enhance students' interaction with AI-generated content (Du et al., 2025; Gezer & Durdu, 2025; Kwak, 2025; T. Xu et al., 2025). Prior research has established that high-quality teaching materials have a beneficial impact on student engagement, comprehension, and learning outcomes. Nevertheless, few studies have investigated their role specifically in AI-enhanced short story learning environments (Engeness et al., 2025; Kwak, 2025).

Media literacy is a crucial factor, encompassing students' capacity to access, evaluate, analyze, and critically utilize digital information. In AI-driven learning environments, media literacy is essential as students are constantly exposed to algorithmically generated information, automated suggestions, and various digital sources that require critical assessment of their reliability (Ait Hattani & Ettaouass, 2026; Rafi et al., 2019). Previous studies indicate that increased media literacy enhances students' digital competence, information evaluation abilities, and learning autonomy (Rábago et al., 2026; Tiernan et al., 2023). Nonetheless, there is a paucity of comprehension regarding the function of media literacy in augmenting learning efficacy and promoting AI integration inside educational paradigms that employ narrative-based learning.

Short stories have been recognized as effective tools for improving literacy, fostering reflection, cultivating empathy, and enhancing analytical reasoning. In higher education, short story learning can promote interpretative discussion, inferential reasoning, and perspective-taking, thus enhancing the development of critical thinking (Beji, 2022; Fauzia et al., 2025; Mlotshwa & Motlhaka, 2025). The incorporation of AI into short story learning could enhance these advantages through adaptive story recommendations, personalized interpretation prompts, automated questioning, and immediate formative feedback (Jiao & Wang, 2025; Núñez-Hernández et al., 2025; J. Wu et al., 2025). Existing studies predominantly concentrate on AI within general learning contexts or on conventional literature instruction, with insufficient emphasis on the effectiveness of AI-enhanced short story learning as a mediating factor for the development of critical thinking (Berisha Qehaja, 2025; Hezam & Alkhateeb, 2024; Sağin et al., 2023).

Several research gaps can be identified. Prior studies primarily focus on AI adoption through the lens of technological acceptance, highlighting aspects such as usability, usefulness, and behavioral intention. However, they do not adequately explore the pedagogical mechanisms that contribute to the development of critical thinking (Ali et al., 2024; Budiman et al., 2025; Hamkah et al., 2025; Mnguni, 2025; Nurtanto et al., 2025; Sutrisno et al., 2025). Secondly, there is a scarcity of research that concurrently integrates teaching materials and media literacy as precursors to the effectiveness of AI-enhanced learning (C.-Q. Chen, 2025; Lin, 2022). Third, there is a scarcity of empirical studies examining AI-supported short story learning within teacher education contexts, especially among students in Early Childhood Teacher Education programs. The structural relationships among teaching materials, media literacy, AI-enhanced learning, short story learning effectiveness, and critical thinking are inadequately examined within an integrated framework (Trianggono et al., 2026; Zhao, 2026).

This study identifies current gaps by proposing and empirically validating a structural model that investigates the impact of teaching materials and media literacy on AI-enhanced learning and the efficacy of short story instruction, which subsequently influences critical thinking skills. In contrast to earlier research that views AI as a standalone technological intervention, this study frames AI integration within a comprehensive pedagogical ecosystem influenced by instructional quality and learners' digital competencies.

The originality of this study is evident in three primary contributions. It presents AI-enhanced short story learning as an innovative pedagogical framework that integrates narrative learning with AI-supported instructional design. Secondly, it establishes an integrated model that connects teaching materials, media literacy, AI-enhanced learning, the effectiveness of short story learning, and critical thinking within a unified framework. This study expands the existing corpus of AI-in-education research by concentrating on Early Childhood Teacher Education students, a demographic that has been relatively overlooked in investigations of AI-enhanced learning, despite their crucial influence on future educational methodologies. Their capacity to properly interact with AI technologies is crucial for potential educators, rendering this situation both timely and educationally pertinent. This study offers a refined knowledge of the interaction between pedagogical elements and digital competencies in shaping learning experiences inside AI-enhanced environments.

The findings provide significant theoretical insights into how teaching materials, media literacy, and AI-assisted learning processes facilitate meaningful educational outcomes. In addition to their theoretical significance, the findings offer practical insights for curriculum writers, teacher educators, and higher education institutions aiming to create AI-integrated learning environments. The study emphasizes the potential of integrating AI technologies with narrative-based instructional methods to enhance critical thinking, so equipping future educators for progressively technology-driven educational environments..

Theoretical Underpinning

Teaching Materials in AI-Supported Learning Environments

Teaching materials are essential instructional elements that influence students' cognitive engagement, conceptual understanding, and overall learning experiences. High-quality teaching materials are generally defined by their clarity, relevance, interactivity, pedagogical alignment, and adaptability to the needs of learners (Ding & Inoue, 2026; Hosna et al., 2026; Huang et al., 2025; Serra & Oliveira, 2025; Sukur et al., 2026; Trifonova & Kiryakova, 2025). In digital and AI-supported environments, teaching materials assume a strategic role as students increasingly engage with multimodal resources, Content generated by artificial intelligence and algorithms for adaptive learning. Constructivist learning theory asserts that knowledge is actively created through meaningful interaction with instructional material by learners. Teaching materials function not only as information carriers but also as cognitive scaffolds that promote reflection, exploration, and knowledge restructuring (Kudelová, 2020; Zajda, 2021). In AI-supported environments, well-structured and pedagogically coherent instructional materials can improve learners' capacity to effectively navigate AI systems, interpret automated feedback, and incorporate AI-generated information into meaningful learning processes.

Previous studies shown that instructional materials significantly influence learning efficacy, boost student motivation, and promote digital engagement. Digital instructional materials that incorporate intelligent systems enhance learner autonomy, comprehension, and the quality of interaction (Lüsse et al., 2025; L. Zhang et al., 2025). Well-designed learning materials can enhance AI utilization by offering conceptual guidance and contextual anchors for students using AI-based tools. In narrative learning contexts, teaching materials play a crucial role in facilitating short story comprehension, interpretation, and analytical engagement (Susanto et al., 2026; Wang et al., 2026). Materials that utilize story-based approaches, incorporating reflective prompts, guided questions, and contextual relevance, have the potential to enhance learning effectiveness by promoting deeper cognitive processing (Namaziandost & Çakmak, 2025; Park & Derakhshan, 2026). Teaching materials are anticipated to positively impact both AI-enhanced learning and the effectiveness of short story learning.

H1: Teaching materials positively influence AI-enhanced learning.

H2: Teaching materials positively influence short story learning effectiveness.

Media Literacy as a Determinant of Digital Learning Success

Media literacy encompasses the capacity to access, analyze, evaluate, create, and communicate information across diverse digital platforms and media channels (Dzogovic et al., 2025; Khan & Pandey, 2026; Mango-Quispe et al., 2024). In the current landscape of artificial intelligence and information proliferation, media literacy is crucial for higher education students, especially in managing algorithmically curated content, automated recommendations, and AI-generated information (Bhoi & Kumar, 2025). From a socio-cognitive perspective, media literacy enhances learners' ability to critically evaluate information credibility, identify bias, assess source reliability, and integrate knowledge across various digital contexts. These competencies are particularly pertinent in AI-supported learning, where students engage with dynamically generated content and automated learning assistance.

Numerous studies suggest that students possessing higher media literacy exhibit enhanced digital competence, improved information evaluation skills, and increased learning independence. Media literacy enhances academic performance by equipping students to strategically select, interpret, and validate digital resources. In AI educational environments, media literacy helps bolster learners' confidence and proficiency in the effective utilization of AI tools, rather than only passively receiving automated outputs. In the context of short story learning, media literacy can enhance students' interpretive skills (Rey et al., 2017), contextual analysis (Intveen & Illigens, 2025; Williams, 2020), and interaction with multimodal narrative content (Della Rocca et al., 2025; Lobo-Quintero et al., 2025; Wang et al., 2026). Students possessing robust media literacy skills are more adept at critically analyzing themes, perspectives, symbolism, and underlying meanings in digital storytelling contexts (Beikutova et al., 2024; Lyu, 2026; Silverblatt, 2018). Despite its acknowledged significance, there is a dearth of empirical research that simultaneously examines the influence of media literacy on AI-enhanced learning and the efficacy of short story learning. Consequently, the subsequent hypotheses are put forward:

H3: Media literacy positively influences AI-enhanced learning.

H4: Media literacy positively influences short story learning effectiveness.

2.3 AI-Enhanced Learning and Critical Thinking Development

AI-enhanced learning includes instructional methods improved by artificial intelligence technology, such as intelligent tutoring, generative AI tools, adaptive systems, automated feedback, and recommendation algorithms. Artificial intelligence has been progressively integrated into higher education to customize learning pathways (Alotaibi, 2024; Gutiérrez-Castillo et al., 2025; Mncube et al., 2026), enhance instructional efficiency (Flückiger, 2025), and foster learner autonomy (Abdallah et al., 2025; Kuka et al., 2022). AI systems can enhance learning by providing personalized scaffolding (Gkintoni et al., 2025; Kassenkhan et al., 2026), immediate feedback, and tailored instructional support that aligns with learner progress, as informed by cognitive load theory and adaptive learning principles (Feng, 2025; Han et al., 2025). These features may decrease unnecessary cognitive load while enhancing deeper conceptual engagement.

Recent studies indicate that AI-enhanced learning has the potential to enhance student motivation, engagement, problem-solving abilities, and overall learning efficiency (Abrar et al., 2025; Hong & Guo, 2025; Kassenkhan et al., 2025). AI-based systems can stimulate analytical reasoning by prompting students to compare outputs, evaluate alternatives, and iteratively refine their understanding. Nonetheless, the association between the utilization of AI and critical thinking continues to be a subject of debate. Some studies indicate positive effects on higher-order thinking, while others contend that excessive reliance on automation may diminish reflective judgment.

This inconsistency suggests that AI does not inherently enhance critical thinking; rather, it may do so when incorporated into pedagogically effective learning environments. In this study, AI-enhanced learning is defined as a structured educational experience in which AI serves as cognitive support rather

than substituting human reasoning. AI-enhanced learning is anticipated to positively impact students' critical thinking skills.

H5: AI-enhanced learning positively influences critical thinking skills.

2.4 Short Story Learning Effectiveness and Critical Thinking Skills

Short stories serve as a significant instructional medium for enhancing literacy, fostering reflection, cultivating empathy, and developing higher-order thinking (Aydın & Yıldız, 2024; Cabral Mier et al., 2026). Narrative learning promotes students' abilities to interpret meaning, evaluate character decisions, analyze conflict structures, infer implicit messages, and consider alternative perspectives. From a constructivist perspective, narrative texts offer significant opportunities for meaning-making and reflective inquiry (Smorczewska, 2018; Vijayan & Bhuvaneswari, 2026; L.-H. Wu et al., 2026). Short story analysis enables students to engage in interpretive reasoning, construct arguments, evaluate evidence, and compare perspectives, all of which are fundamental aspects of critical thinking.

Previous research demonstrates that literature-based learning markedly improves analytical reasoning, inferential skills, interpretive depth, and reflective judgment. Short story learning is effective due to concise narratives that facilitate focused analysis and ensure cognitive accessibility (Setyowati et al., 2025). In digital environments, AI-supported short story learning can enhance these benefits through adaptive questioning, automated discussion prompts, feedback generation, and personalized content recommendations.

Despite these advantages, empirical studies investigating the effectiveness of short story learning as a direct predictor of critical thinking in AI-supported environments are limited, particularly within the context of teacher education. Based on theoretical and empirical evidence, the effectiveness of short story learning is anticipated to markedly improve critical thinking skills.

H6: Short story learning effectiveness positively influences critical thinking skills.

Based on the preceding literature, this study proposes an integrated framework in which teaching materials and media literacy serve as antecedent variables influencing AI-enhanced learning and short story learning effectiveness. These two mediating constructs subsequently contribute to the development of critical thinking skills. This framework extends prior AI-in-education research by integrating pedagogical quality (teaching materials), learner digital competence (media literacy), AI-supported learning processes, and narrative learning effectiveness within a unified structural model. The framework is particularly relevant for teacher education contexts, where critical thinking is essential for future pedagogical decision-making.

Method

Research Procedure

This study utilized a quantitative cross-sectional research design to investigate the structural relationships among teaching materials, media literacy, AI-enhanced learning, short story learning effectiveness, and critical thinking skills in higher education (Harland & Heller, 2025). A quantitative approach was chosen as it facilitates the systematic measurement of latent constructs and the statistical analysis of causal relationships among various variables (Bloomfield & Fisher, 2019; Watson, 2015). The study employed a correlational explanatory design to evaluate the proposed conceptual framework and validate the hypothesized relationships (Baron, 2021). This design is appropriate for investigating predictive correlations across dimensions in educational technology research, particularly when the objective is to clarify how pedagogical and digital literacy elements influence students' critical thinking in AI-enhanced learning environments. The conceptual model was analyzed utilizing Partial Least Squares Structural Equation Modeling (PLS-SEM), a method frequently endorsed for predictive research, theory development, and the examination of complex models that incorporate multiple latent constructs and indicators (Hair et al., 2022; Sarstedt et al., 2022). The research framework can be see in Fig. 1.

Participants

The research encompassed 318 undergraduate students participating in Early Childhood Teacher Education programs at diverse higher education institutions in Indonesia. This group was selected due to the increasing demand for aspiring early childhood educators to develop digital proficiency, critical thinking skills, and AI literacy to address future educational difficulties. A random sampling technique was utilized to ensure that participants had relevant academic and learning experiences consistent with the research objectives (Slater & Hasson, 2025; Williamson, 2018). Participants were eligible for inclusion if they were actively enrolled in an Early Childhood Teacher Education program, had engaged in short story learning activities, and had prior experience with AI-based learning platform. The sample size of 318 surpasses the minimum recommendation for PLS-SEM analysis. According to the ten-times rule and statistical power guidelines, the necessary sample size must be a minimum of ten times the highest number of structural paths directed at a construct (Hair et al., 2017). Given that the model allowed for a maximum of two incoming paths, the sample size was deemed statistically sufficient and robust. The demographic of participants can be see in Table 1.

Table 1
The demographic of participants (N = 318)

Characteristic		Frequency	Percentage
Gender	Male	32	10.1%
	Female	286	89.9%
Age	17–19 years	91	28.6%
	20–21 years	154	48.4%
	22–23 years	58	18.2%
	> 23 years	15	4.8%
Academic Year	1st year	64	20.1%
	2nd year	103	32.4%
	3rd year	97	30.5%
	4th year	54	17.0%
AI Learning Experience	< 6 months	76	23.9%
	6–12 months	118	37.1%
	> 1 year	124	39.0%

The sample consisted primarily of females (89.9%, n = 286), which is consistent with the typical gender distribution in the field, whereas male students accounted for 10.1% (n = 32). Most participants were aged 20–21 years (48.4%, n = 154), followed by those aged 17–19 years (28.6%, n = 91), suggesting that the majority were in the initial phases of professional teacher preparation. Participants were selected from various academic years: 1st year (20.1%), 2nd year (32.4%), 3rd year (30.5%), and 4th year students (17.0%), ensuring a comprehensive representation of learning experiences. In terms of AI learning experience, 39.0% of respondents reported having over one year of experience, 37.1% indicated between six and twelve months of experience, and 23.9% had less than six months of experience. The sample comprises a diverse group of prospective early childhood educators with differing levels of academic maturity and familiarity with AI-supported learning technologies.

Instrument Validation and Reliability

Data were gathered using a structured questionnaire developed from established instruments in the areas of digital learning, artificial intelligence in education, media literacy, and critical thinking. The instrument was contextualized for AI-supported short story learning in Early Childhood Teacher Education programs, ensuring its relevance to the study setting and participants. Five latent constructs were measured using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). To

enhance response consistency and reduce potential misinterpretation, all questionnaire items were phrased positively. Research Instrument and Measurement Indicators can be see in Table 2.

Before the main data collection, the instrument underwent a rigorous validation process involving three experts with expertise in educational technology, literacy education, and AI-enhanced pedagogy. Their feedback was used to refine the wording, content relevance, and overall structure of the questionnaire. A pilot study with 35 undergraduate students was subsequently conducted to evaluate the clarity, reliability, and contextual suitability of the instrument. The pilot results confirmed that the questionnaire was understandable, internally consistent, and appropriate for investigating students' experiences with AI-supported learning in the context of short story instruction.

Table 2
Research Instrument and Measurement Indicators

Construct	Item	Measurement Item	Operational Definition	Source Adaptation
Teaching Materials (TM)	TM1	Clarity of short story materials	Measures the clarity and comprehensibility of instructional materials	Adapted from digital instructional design studies, curriculum alignment, e-learning engagement studies, AI pedagogy studies, instructional usability (L.-C. Chang et al., 2025; Hajiagha et al., 2026; Hamid et al., 2024; Lander et al., 2026; Purnamasari, 2023; Ramesh et al., 2016; Refat et al., 2020; Shi, 2025; Valenzuela-Arvizu et al., 2025; Zainuddin et al., 2020; J. Zhang, 2024)
	TM2	Alignment with learning objectives	Measures consistency between materials and intended outcomes	
	TM3	Interactivity of teaching materials	Measures level of learner interaction supported by materials	
	TM4	Integration of AI within materials	Measures how AI is embedded into instructional content	
	TM5	Ease of understanding	Measures student-perceived usability and accessibility	
Media Literacy (ML)	ML1	Ability to access digital information	Measures ability to locate digital learning resources	Adapted from media literacy scale, media literacy skill scale, media literacy self-assessment scale, digital and media literacy skills test, perceived social media literacy scale (Arshad et al., 2022; C.-S. Chang et al., 2011; Eliza et al., 2025; Gergul et al., 2025; Mutlu et al., 2025; Panczyk et al., 2025)
	ML2	Ability to analyze media content	Measures analytical ability toward digital information	
	ML3	Ability to evaluate information credibility	Measures capacity to assess source validity	
	ML4	Use of media for learning purposes	Measures productive educational media utilization	
	ML5	Awareness of media bias	Measures recognition of bias and misinformation	
AI-Enhanced Learning (AIL)	AIL1	PEOU of AI tools	Measures usability of AI technologies in learning	Adapted from TAM and AI adoption studies, AI tutoring, generative AI education studies, intelligent feedback systems, AI engagement

Construct	Item	Measurement Item	Operational Definition	Source Adaptation
	AIL2	AI helps in understanding short story content	Measures AI support in content comprehension	studies (B. Li et al., 2025; Nhan, 2025; Saddhono et al., 2024; Sumanth et al., 2024; X. Xu et al., 2025)
	AIL3	AI enhances creative writing skills	Measures AI contribution to writing development	
	AIL4	AI provides automated feedback	Measures usefulness of AI-generated feedback	
	AIL5	AI increases student engagement	Measures motivational impact of AI usage	
Short Story Learning Effectiveness (SSL)	SSL1	Understanding of short story elements	Measures conceptual understanding of narrative components	Adapted from literature learning studies, narrative analysis research, student engagement studies, creative writing assessment, learning motivation literature (Q. Li et al., 2026; Namaziandost & Çakmak, 2025)
	SSL2	Ability to analyze short stories	Measures analytical competence in literary interpretation	
	SSL3	Learning engagement	Measures student involvement in short story learning	
	SSL4	Ability to write short stories	Measures productive narrative writing ability	
	SSL5	Learning motivation	Measures motivational outcomes from story learning	
Critical Thinking Skills (CT)	CT1	Problem analysis	Measures analytical decomposition of issues	Adapted from critical thinking scales, reasoning assessment, higher-order thinking frameworks, problem-solving literature, and reflective learning studies (Barry Hultquist et al., 2026; Comstock & Grühn, 2026; Hitchcock, 2017; Rery & Anwar, 2021)
	CT2	Argument evaluation	Measures ability to assess logical validity	
	CT3	Drawing conclusions	Measures inferential reasoning ability	

Construct	Item	Measurement Item	Operational Definition	Source Adaptation
	CT4	Problem-solving ability	Measures solution generation capability	
	CT5	Reflective thinking	Measures reflective judgment and metacognition	

Collecting Data

A web-based questionnaire served as the primary instrument for data gathering, affording students across diverse higher education institutions throughout Indonesia a flexible and convenient means of participation. To maximize reach and optimize response rates, the survey was distributed through an integrated multi-channel approach encompassing institutional Learning Management Systems (LMS), WhatsApp group networks, social media platforms, electronic mail, and in-class announcements. This deliberately diversified dissemination strategy was designed to accommodate heterogeneous learning preferences and communication habits among the student population, while simultaneously reducing structural barriers to participation and strengthening the representativeness of the sample by minimizing systematic sampling bias.

The research was conducted in full accordance with established ethical principles governing educational inquiry involving human subjects. Before engaging with the questionnaire, participants received thorough briefings regarding the study's objectives, the entirely voluntary nature of their involvement, and the specific purposes for which the collected data would be employed. Written informed consent was obtained from all respondents prior to data collection, and participants were explicitly informed of their unconditional right to withdraw at any stage of the study without incurring academic or personal consequences. To uphold the highest standards of confidentiality and protect individual privacy, all responses were gathered on a strictly anonymous basis, with no personally identifiable information retained at any point. The resulting dataset was employed exclusively for scholarly inquiry, in strict adherence to the prevailing ethical regulations of the relevant institutional bodies.

3.5. Data Analysis

Quantitative data analysis was carried out using SmartPLS 4.0, following the widely adopted two-stage Partial Least Squares Structural Equation Modeling (PLS-SEM) framework to systematically examine both the measurement and structural components of the proposed model (Hair et al., 2017, 2022). The first stage centered on a rigorous evaluation of the measurement model to establish the psychometric adequacy of all constructs. This encompassed an examination of indicator reliability through outer loadings, an assessment of internal consistency via Cronbach's alpha and composite reliability coefficients, a determination of convergent validity through the Average Variance Extracted (AVE)

criterion, and an appraisal of discriminant validity employing the Heterotrait–Monotrait (HTMT) ratio. Subsequently, the structural model was interrogated in the second stage by scrutinizing path coefficients (β) alongside their corresponding t-statistics and p-values to empirically evaluate each of the hypothesized relationships. Inferential precision was ensured through a bootstrapping procedure of 5,000 resamples – an approach extensively recommended in the PLS-SEM literature for generating robust standard errors and stable confidence intervals –with statistical significance defined at a threshold of $p < 0.05$.

Result and Discussion

Measurement Model Evaluation

Prior to structural model examination, the measurement model was subjected to a comprehensive psychometric evaluation encompassing four key dimensions: indicator reliability, internal consistency reliability, convergent validity, and discriminant validity. Within the PLS-SEM framework, this preliminary assessment is methodologically indispensable, as it establishes the extent to which each construct is measured with sufficient accuracy and consistency before any structural relationships are interpreted. In alignment with widely accepted benchmarks in the PLS-SEM literature, outer loadings exceeding 0.70 are considered indicative of satisfactory indicator reliability, reflecting that each observed variable adequately captures the theoretical domain of its corresponding latent construct. The outcomes of the PLS-SEM estimation are visually summarized in Fig. 2, which presents the standardized factor loadings alongside the hypothesized structural pathways among the latent variables.

A detailed numerical account of the measurement model evaluation is provided in Table 3, reporting factor loadings (FL), Average Variance Extracted (AVE), Cronbach's alpha (CA), rho_A, and Composite Reliability (CR) for each construct. Collectively, the findings demonstrate that all constructs comfortably satisfy the established thresholds for both convergent validity and internal consistency reliability, affirming the overall psychometric soundness of the measurement model and its suitability for subsequent structural analysis.

Table 3
Evaluation of Measurement Model

Variable	Indicator	Convergent validity		Concistency reliability		
		FL (λ > 0.70)	AVE (> 0.50)	CA (α > 0.70)	ϕ_a (ϕ > 0.70)	CR (δ > 0.70)
Teaching Materials (TM)	TM1	0.826	0.649	0.865	0.866	0.903
	TM2	0.802				
	TM3	0.818				
	TM4	0.792				
	TM5	0.791				
Media Literacy (ML)	ML1	0.745	0.680	0.881	0.892	0.914
	ML2	0.888				
	ML3	0.766				
	ML4	0.889				
	ML5	0.825				
AI-Enhanced Learning (AIL)	AIL1	0.847	0.634	0.855	0.858	0.896
	AIL2	0.820				
	AIL3	0.779				
	AIL4	0.756				
	AIL5	0.773				
Short Story Learning Effectiveness (SSL)	SSL1	0.833	0.647	0.862	0.865	0.901
	SSL2	0.714				
	SSL3	0.857				
	SSL4	0.857				
	SSL5	0.750				
Critical Thinking Skills (CT)	CT1	0.857	0.631	0.853	0.859	0.895
	CT2	0.738				
	CT3	0.850				
	CT4	0.743				

	CT5	0.775

All indicator outer loadings surpassed the conventionally recommended threshold of 0.70, spanning a range from 0.714 to 0.889, thereby confirming that each indicator meaningfully contributes to its designated latent construct and adequately captures the intended conceptual domain. The most substantial loading was observed for ML4 (λ = 0.889), positioning it as the strongest representative indicator within the Media Literacy construct. At the lower end of the spectrum, SSL2 (λ = 0.714) returned the minimum loading value; nonetheless, as it comfortably exceeded the acceptable benchmark, its retention within the model remains well-justified. The uniformly high outer loadings observed across all indicators collectively attest to a strong and coherent relationship between the manifest variables and their respective underlying constructs.

Convergent validity was further substantiated through AVE examination, with all constructs surpassing the minimum criterion of 0.50, yielding values that ranged from 0.631 to 0.680. These figures indicate that each construct accounts for more than 63% of the variance embedded in its associated indicators, signifying adequate shared variance among the measurement items. Media Literacy yielded the highest AVE (0.680), reflecting the most pronounced degree of indicator convergence, followed sequentially by Teaching Materials (AVE = 0.649), Short Story Learning Effectiveness (AVE = 0.647), AI-Enhanced Learning (AVE = 0.634), and Critical Thinking Skills (AVE = 0.631). Taken together, these results furnish compelling evidence that the measurement items converge satisfactorily around their respective theoretical constructs.

Internal consistency reliability was found to be uniformly strong across all constructs. Cronbach's alpha coefficients ranged from 0.853 to 0.881, substantially exceeding the minimum acceptable threshold of 0.70. ϕ_a values, spanning from 0.858 to 0.892, further corroborated the stability and consistency of the latent variable scores. Composite Reliability estimates ranged from 0.895 to 0.914, reinforcing strong construct-level reliability. Media Literacy consistently returned the highest reliability indices across all three metrics (CA = 0.881; ϕ_a = 0.892; CR = 0.914), underscoring a particularly robust degree of internal coherence among its indicators. Notably, none of the CR values approached or exceeded the upper bound of 0.95, suggesting that while reliability is high, the constructs remain free from problematic item redundancy.

Collectively, these psychometric outcomes affirm the robust measurement quality of the proposed model. The convergence of high outer loadings, adequate AVE values, and strong reliability estimates provides compelling confirmation that the constructs of Teaching Materials, Media Literacy, AI-Enhanced Learning, Short Story Learning Effectiveness, and Critical Thinking Skills are operationalized with both accuracy and consistency. On this basis, the measurement model is deemed psychometrically valid and reliable, thereby establishing a sound empirical foundation for the subsequent examination of structural relationships within the proposed theoretical framework.

Discriminant validity was assessed using the Heterotrait–Monotrait (HTMT) ratio, which is widely regarded as one of the most rigorous approaches to evaluating construct distinctiveness within PLS-SEM. Drawing on the criteria advanced by Henseler et al. (2015, 2016), HTMT values remaining below 0.90 are interpreted as evidence that theoretically related constructs are nonetheless empirically distinguishable from one another. As reported in Table 4, all inter-construct HTMT values fell within the range of 0.721 to 0.891, uniformly remaining beneath the stipulated threshold and thus providing robust empirical support for discriminant validity across the entire measurement model.

Table 4
Heterotrait–Monotrait (HTMT) ratio

Constructs	**TM**	**ML**	**AIL**	**SSL**	**CT**
Teaching Materials (TM)	-				
Media Literacy (ML)	0.782	-			
AI-Enhanced Learning (AIL)	0.846	0.801	-		
Short Story Learning Effectiveness (SSL)	0.768	0.842	0.874	-	
Critical Thinking Skills (CT)	0.721	0.756	0.883	0.891	-

The results demonstrate that each construct encompasses a distinct conceptual domain, notwithstanding the theoretically anticipated relationships among them. The lowest HTMT value was recorded between Teaching Materials (TM) and Critical Thinking Skills (CT) (HTMT = 0.721), indicating that although instructional materials play a role in students' learning experiences, they are a construct that is distinctly separate from higher-order cognitive outcomes like critical thinking. Likewise, the associations between Teaching Materials and Media Literacy (HTMT = 0.782) and between Media Literacy and Critical Thinking Skills (HTMT = 0.756) suggest moderate correlations while ensuring adequate empirical distinction.

Multiple construct pairs exhibited notable associations, indicating the theoretical interconnectedness of the proposed framework. AI-Enhanced Learning (AIL) demonstrated significant correlations with Teaching Materials (HTMT = 0.846) and Media Literacy (HTMT = 0.801), indicating that effective AI-supported learning environments are strongly associated with the quality of instructional resources and students' capacity to critically engage with digital information. However, the HTMT values stayed below the critical threshold, indicating that these constructs are related yet distinct.

The highest HTMT values were recorded between Critical Thinking Skills and Short Story Learning Effectiveness (HTMT = 0.891), as well as between Critical Thinking Skills and AI-Enhanced Learning (HTMT = 0.883). These findings hold theoretical significance as narrative-based learning activities and AI-supported instructional environments are anticipated to promote higher-order thinking processes. The closeness of these values to the 0.90 threshold suggests a robust conceptual relationship; however, the values remain within acceptable limits, indicating that the constructs maintain sufficient discriminant

validity. Although the effectiveness of short story learning and AI-enhanced learning each make meaningful independent contributions to the cultivation of critical thinking competencies, these constructs do not capture the same underlying phenomenon and therefore remain conceptually and empirically distinguishable. The HTMT analysis corroborates this interpretation by demonstrating that all constructs embedded within the proposed model, while theoretically interrelated, maintain clear empirical boundaries from one another. The absence of any HTMT value breaching the 0.90 threshold further suggests that concerns pertaining to multicollinearity and construct overlap are not substantively problematic within this measurement framework. Accordingly, the measurement model satisfies the requisite criteria for discriminant validity, lending additional weight to its overall psychometric integrity and affirming its readiness for the subsequent evaluation of structural pathways and the empirical testing of the hypothesized relationships.

Structural Model Evaluation

The structural model was examined to interrogate the hypothesized relationships and assess the predictive dynamics among teaching materials, media literacy, AI-enhanced learning, short story learning effectiveness, and critical thinking skills. Consistent with established PLS-SEM protocols, hypothesis testing was executed via a bootstrapping procedure employing 5,000 resamples, which yields robust estimates of standard errors, t-statistics, and significance levels associated with the path coefficients.

Structural pathways were evaluated against path coefficients (β), standard deviation (STDEV), t-statistics, and p-values, whereby a path was considered statistically significant when the t-statistic exceeded 1.96 and the corresponding p-value fell below 0.05. As presented in Table 5 and illustrated in Fig. 3, all hypothesized structural relationships attained statistical significance at $p < 0.001$, furnishing strong empirical support for the integrity of the proposed research model.

Table 5
Path Coefficients and Hypothesis Testing

Hypotheses	Path	β-value	Sample mean	Standard dev.	t-statistics	p-values	Decision
H_1	TM → AIL	0.517	0.516	0.059	8.736	0.000	Supported
H_2	TM → SSL	0.238	0.239	0.061	3.900	0.000	Supported
H_3	ML → AIL	0.397	0.401	0.061	6.468	0.000	Supported
H_4	ML → SSL	0.645	0.646	0.058	11.138	0.000	Supported
H_5	AIL → CT	0.257	0.257	0.028	9.035	0.000	Supported
H_6	SSL → CT	0.749	0.749	0.027	28.131	0.000	Supported

The results revealed that Teaching Materials exerted a significant and positive influence on AI-Enhanced Learning (β = 0.517, t = 8.736), thereby lending full support to H1. This finding suggests that well-organized, clearly articulated, and interactively designed instructional materials that incorporate AI-oriented features meaningfully enhance students' perceptions of and engagement with AI-supported learning environments. In contrast, the effect of Teaching Materials on Short Story Learning Effectiveness, while statistically significant, was comparatively modest (β = 0.238, t = 3.900), providing support for H2. This indicates that although instructional materials contribute to learning outcomes, their direct bearing on narrative-based learning is relatively limited in comparison to other learner-centered variables.

A significant positive association was established between Media Literacy and AI-Enhanced Learning (β = 0.397, t = 6.468), corroborating H3. This outcome implies that students equipped with stronger competencies in accessing, critically analyzing, and evaluating digital content are more predisposed to engage productively with AI-assisted learning tools. Furthermore, Media Literacy demonstrated a notably strong influence on Short Story Learning Effectiveness (β = 0.645, t = 11.138), supporting H4. This finding underscores the pivotal role of students' digital critical competencies in deepening engagement, enhancing interpretive capacity, and improving learning outcomes within narrative-based instructional settings.

AI-Enhanced Learning yielded a statistically significant positive effect on Critical Thinking Skills (β = 0.257, t = 9.035), thereby supporting H5. Despite reflecting a moderate effect magnitude, this result confirms that AI-mediated learning environments meaningfully foster the development of analytical reasoning, problem-solving abilities, and reflective cognition through mechanisms such as adaptive scaffolding, automated feedback, and personalized instructional support. Short Story Learning Effectiveness emerged as the most influential predictor of Critical Thinking Skills within the model (β = 0.749, t = 28.131), offering robust support for H6. Representing the largest path coefficient across the entire structural model, this finding underscores the centrality of effective narrative-based learning in cultivating higher-order thinking capacities. The strength of this relationship suggests that pedagogical activities anchored in literary engagement – including story analysis, textual interpretation, and reflective writing – substantially enhance students' ability to evaluate arguments, synthesize information, and navigate complex problem-solving tasks.

Among all estimated structural pathways, the most pronounced effect was observed between Short Story Learning Effectiveness and Critical Thinking Skills, while the weakest association was identified between Teaching Materials and Short Story Learning Effectiveness. The statistical significance and theoretical coherence of all hypothesized paths collectively affirm that the structural model possesses strong predictive validity and robustly substantiates the proposed conceptual framework. Broadly, these findings illuminate that the cultivation of critical thinking within AI-enriched educational contexts is shaped not merely by technological adoption, but by a dynamic interplay of instructional quality, students' media literacy proficiencies, and the effectiveness of narrative-based pedagogical experiences.

To determine the adequacy of the proposed structural model, a suite of global model fit indices was examined, encompassing the Standardized Root Mean Square Residual (SRMR), the Normed Fit Index (NFI), and RMS Theta. These indices collectively provide empirical evidence regarding the degree to which the theoretical model aligns with the observed data and whether the posited inter-construct relationships are substantiated empirically.

As presented in Table 6, the SRMR value of 0.061 falls comfortably below the recommended upper bound of 0.08, indicative of satisfactory model fit. Given that SRMR quantifies the mean discrepancy between observed and model-implied correlations, a lower value reflects the model's capacity to reproduce the empirical correlation matrix with high fidelity. The obtained value suggests that deviations between the observed data structure and the estimated model are negligible, affirming that the theorized relationships among Teaching Materials, Media Literacy, AI-Enhanced Learning, Short Story Learning Effectiveness, and Critical Thinking Skills are well-represented by the data.

Table 6
Model Fit Results

Index	Value	Threshold	Interpretation
SRMR	0.061	< 0.08	Good fit
NFI	0.912	> 0.90	Good fit
RMS Theta	0.108	< 0.12	Acceptable

Further corroboration of model adequacy is provided by the NFI value of 0.912, which exceeds the widely accepted threshold of 0.90. The NFI benchmarks the proposed model against a null model that presupposes no inter-construct relationships; an NFI surpassing 0.90 therefore signifies that the proposed framework yields substantially greater explanatory power over the observed covariance structure relative to the baseline. This outcome affirms that the theoretical model offers a meaningful and parsimonious representation of the pedagogical, technological, and cognitive factors implicated in critical thinking development.

The RMS Theta value of 0.108, falling beneath the recommended ceiling of 0.12, indicates acceptable outer model quality. RMS Theta gauges the degree of residual correlation among reflective measurement indicators, where lower values imply fewer specification errors and greater coherence between the measurement model and empirical data. The obtained value confirms that residual correlations remain within tolerable bounds and that the reflective constructs are appropriately specified. Although the value approaches the upper margin of acceptability, it remains within the permissible range, attesting to adequate measurement reliability and construct specification.

Considered in concert, the SRMR, NFI, and RMS Theta indices converge to indicate that the proposed model achieves an adequate to good overall fit. The combination of a low SRMR, a strong NFI, and an acceptable RMS Theta confirms that both the measurement and structural components of the model are

statistically defensible and theoretically coherent. These results bolster confidence in the validity of the proposed framework and support the continued interpretation of structural relationships, explanatory power, predictive relevance, and hypothesis-testing outcomes. Moreover, the model fit statistics affirm that the integration of teaching materials, media literacy, AI-enhanced learning, and short story learning effectiveness constitutes a theoretically sound and empirically robust explanatory framework for understanding the development of critical thinking skills within AI-supported teacher education contexts.

To appraise the model's explanatory capacity, the coefficient of determination (R^2) was examined for all endogenous constructs. As shown in Table 7, the model accounted for 68.8% of the variance in AI-Enhanced Learning, reflecting moderate to substantial explanatory power and indicating that Teaching Materials and Media Literacy jointly provide a compelling account of students' engagement with AI-supported learning environments. For Short Story Learning Effectiveness, an R^2 of 0.702 was obtained, signifying that 70.2% of its variance is attributable to Teaching Materials and Media Literacy — a finding that underscores the dual importance of instructional quality and students' digital literacy competencies as determinants of narrative-based learning success. The strongest explanatory power was observed for Critical Thinking Skills, with an R^2 of 0.871, indicating that AI-Enhanced Learning and Short Story Learning Effectiveness collectively explain 87.1% of the variance in critical thinking. Consistent with established interpretive benchmarks, this value reflects high predictive accuracy and suggests that the proposed model offers a particularly robust account of critical thinking development within AI-enriched educational settings.

Table 7
Evaluation of measurement based on R^2, Q^2, and f^2

Variable	R^2		Q^2		f^2 (effect size)		
	Value	Level	Value	Level	AIL	SSL	CT
Teaching Materials (TM)	-	-			0.356	0.079	
Media Literacy (ML)	-	-			0.210	0.518	
AI-Enhanced Learning (AIL)	0.688	Moderate–Substantial	0.423	Large			0.142
Short Story Learning Effectiveness (SSL)	0.702	Substantial	0.451	Large			1.214
Critical Thinking Skills (CT)	0.871	Strong	0.547	Large			

Beyond explanatory capacity, predictive relevance was assessed through Stone–Geisser's Q^2 statistic, derived via blindfolding procedures. All Q^2 values exceeded zero, thereby confirming the model's predictive relevance across all endogenous constructs. AI-Enhanced Learning yielded a Q^2 of 0.423 and Short Story Learning Effectiveness returned a Q^2 of 0.451, both indicative of substantial predictive

relevance. Critical Thinking Skills registered the highest Q^2 value (0.547), reflecting the model's strong out-of-sample predictive capability in accounting for students' critical thinking performance.

Effect sizes (f^2) were subsequently computed to evaluate the practical significance of each structural pathway. Considerable variation in effect magnitude was observed across the estimated relationships. The path from Teaching Materials to AI-Enhanced Learning produced a large effect size ($f^2 = 0.356$), suggesting that instructional material quality substantially shapes students' AI-mediated learning experiences. In contrast, the effect of Teaching Materials on Short Story Learning Effectiveness was negligible ($f^2 = 0.079$), implying that although statistically significant, its practical contribution to narrative learning outcomes remains comparatively modest. Media Literacy demonstrated a medium effect on AI-Enhanced Learning ($f^2 = 0.210$) and a large effect on Short Story Learning Effectiveness ($f^2 = 0.518$), highlighting the centrality of students' digital competencies in both AI interaction and narrative comprehension. Within the outcome construct, AI-Enhanced Learning exerted a small-to-medium effect on Critical Thinking Skills ($f^2 = 0.142$), indicating that while AI-supported environments meaningfully contribute to critical thinking, their role is complementary rather than dominant. The most substantial effect size in the entire model was recorded for the pathway from Short Story Learning Effectiveness to Critical Thinking Skills ($f^2 = 1.214$), denoting a very large practical effect and confirming that engagement with narrative-based learning constitutes the single most influential determinant of critical thinking development.

Collectively, the convergence of satisfactory model fit indices, high explanatory power, strong predictive relevance, and substantial effect sizes affirms that the proposed structural model is statistically robust, theoretically meaningful, and possesses considerable predictive utility. These findings validate the integrated framework linking teaching materials, media literacy, AI-enhanced learning, short story learning effectiveness, and critical thinking skills as a coherent and empirically well-supported explanatory model.

Discussion

This study examined the structural relationships between teaching materials, media literacy, AI-enhanced learning, short story learning effectiveness, and CT skills within the framework of AI-supported short story learning among Early Childhood Teacher Education students in Indonesia. The findings indicate that all hypotheses were supported, demonstrating that both pedagogical quality and digital literacy competencies are essential in optimizing AI-supported learning environments and enhancing higher-order thinking skills. The initial significant finding indicated that Teaching Materials had a considerable impact on AI-Enhanced Learning. This result indicates that well-structured instructional materials are essential in AI-supported education, despite the availability of advanced technological tools. Teaching materials that exhibit clarity, alignment with learning objectives, interactivity, AI integration, and ease of understanding enhance students' capacity to engage meaningfully with AI tools. This finding aligns with constructivist learning theory, which asserts that the construction of knowledge is improved when learners engage with structured and cognitively supportive instructional resources

(Jumaah, 2024; J. Zhang, 2024). In AI-supported learning, teaching materials serve as scaffolding mechanisms that assist students in interpreting AI-generated content, navigating learning tasks, and integrating automated feedback into their knowledge construction processes.

This finding aligns with prior research indicating that instructional quality has a significant impact on students' digital learning engagement and technology-supported learning outcomes (Schmid et al., 2022; Wekerle et al., 2022; Yang et al., 2023). Previous studies have highlighted that technology by itself does not ensure meaningful learning; rather, it is the pedagogical design that dictates the effective integration of digital tools into learning processes (Wekerle et al., 2022; X.-Y. Wu, 2024; Yu & Tian, 2026). The present study advances the existing body of scholarship by establishing that the quality and design of teaching materials constitute a meaningful determinant of AI-enhanced learning effectiveness within narrative-based instructional contexts. Concurrently, teaching materials were found to exert a significant, albeit comparatively modest, influence on short story learning effectiveness, suggesting that while instructional resources remain a relevant pedagogical variable, their direct contribution to narrative learning outcomes is more circumscribed relative to their impact on AI-mediated engagement. This indicates that although instructional materials play a role in learning effectiveness, the success of short story learning is affected by content quality, learner competencies, interpretive skills, and engagement with narrative processes. Narrative learning necessitates advanced interpretation, inference, and reflection, potentially accounting for the limited direct impact of teaching materials relative to broader learner-related factors (Ocaña et al., 2025; Tonglo et al., 2020).

A second substantive finding of the present study pertains to the significant influence of Media Literacy on both AI-Enhanced Learning and Short Story Learning Effectiveness, underscoring the strategic relevance of students' digital competencies within contemporary AI-enriched educational environments. Students who demonstrate higher levels of media literacy exhibit markedly stronger capabilities in locating, critically appraising, analyzing, and interpreting digital information – proficiencies that, in turn, facilitate more purposeful and effective utilization of AI-powered learning tools while simultaneously fostering deeper and more meaningful engagement in narrative-based learning activities. Of particular theoretical significance is the pronounced effect of Media Literacy on Short Story Learning Effectiveness, which suggests that narrative learning in digitally mediated contexts is increasingly contingent upon students' capacity to critically interrogate digital content, discern the credibility of information sources, and navigate the inherent complexity of the contemporary information landscape. In AI-enhanced environments, students encounter dynamically generated content, automated suggestions, and various digital sources, rendering media literacy crucial to prevent passive acceptance of AI outputs (Banerjee et al., 2020; H.-L. Chen & Pan, 2024; Ko et al., 2025; Mwakalinga & Mabilika, 2025; Yuan & Li, 2024).

This finding supports socio-cognitive perspectives that assert digital competence extends beyond mere technical access to encompass critical interpretation and reflective judgment (Martínez-Bravo et al., 2022; Tomczyk & Eger, 2020). Previous studies have demonstrated that media literacy enhances academic performance, information evaluation, and learning independence (A. Chen et al., 2024;

Kozhakhanova et al., 2026; Martinez-Abad et al., 2016; Mecklenburg & Scheithauer, 2026). Nonetheless, this study enhances previous research by empirically establishing that media literacy serves not only as an ancillary skill but as a fundamental factor influencing the effectiveness of both AI-supported learning and narrative learning (Mecklenburg & Scheithauer, 2026; Meyers et al., 2013; Özel, 2025; Rey et al., 2017). A further noteworthy finding concerns the significant positive contribution of AI-Enhanced Learning to the development of Critical Thinking Skills, lending empirical credence to the proposition that artificial intelligence, when deliberately integrated as a pedagogical instrument rather than deployed as a surrogate for human reasoning, holds meaningful potential for fostering higher-order cognitive growth. Specific AI functionalities –encompassing adaptive scaffolding, automated and contextualized feedback, personalized instructional support, and dynamically interactive content – are posited to create conditions that encourage students to engage in iterative reflection, systematic problem analysis, and the progressive refinement of disciplinary knowledge, thereby cultivating the cognitive dispositions that underpin critical thinking (Jai Lamimi et al., 2025; Jia & Tu, 2024; Panit, 2024).

Nevertheless, the magnitude of AI-Enhanced Learning's effect on Critical Thinking Skills was notably less pronounced relative to that of Short Story Learning Effectiveness, a disparity that carries important theoretical implications. This finding suggests that artificial intelligence, in and of itself, does not inherently or automatically engender critical thinking; rather, its contribution to higher-order cognitive development is fundamentally contingent upon the extent to which AI is meaningfully embedded within substantive and well-designed pedagogical activities. This observation resonates with an increasingly prominent discourse within the contemporary AI-in-education literature, wherein a growing body of scholarly opinion cautions that uncritical or excessive dependence on AI-driven tools risks attenuating learner autonomy and undermining the reflective cognitive processes essential to deep learning. The present findings therefore suggest a more nuanced interpretation: AI can serve as a genuine catalyst for critical thinking development, but only insofar as it is purposefully integrated into high-quality instructional environments that foreground pedagogical rigor and actively cultivate learner competencies.

The most consequential finding to emerge from this study is the identification of Short Story Learning Effectiveness as the most powerful predictor of Critical Thinking Skills (Jai Lamimi et al., 2025; Lyu, 2026; Rosmayanti, 2026; Z. Wu, 2026), a result that provides compelling empirical validation for narrative-based pedagogy as a particularly efficacious approach to fostering higher-order intellectual capacities. Engagement with short story learning appears to cultivate a broad and interconnected repertoire of cognitive competencies, encompassing analytical reasoning, inferential thinking, critical evaluation of argumentation, reflective judgment, and creative problem-solving – capacities that collectively constitute the intellectual foundations of critical thought.

This finding supports existing literature indicating that literature-based learning enhances cognitive engagement. The relationship between Short Story Learning Effectiveness and Critical Thinking implies that narrative learning may serve as a mediating pedagogical pathway through which AI and digital competencies facilitate cognitive development (Bahtiar et al., 2025; Cabral Mier et al., 2026; Tonglo et al.,

2020). In summary, although AI and media literacy enhance learning processes, it is the efficacy of short story learning that most directly correlates with critical thinking outcomes.

This finding represents a theoretically significant contribution of the present study to the broader scholarly conversation surrounding AI in education. A substantial portion of the extant literature in this domain has concentrated predominantly on dimensions of technological adoption, including perceived usefulness, system usability, and behavioral intention toward AI tools. The present study deliberately redirects analytical attention toward the underlying pedagogical mechanisms, demonstrating that the educational efficacy of AI is not intrinsic to the technology itself but is rather shaped by the broader instructional ecosystems within which it operates – ecosystems constituted by the quality of teaching materials, the depth of learners' digital competencies, and the richness of narrative learning experiences. The study further contributes contextually by centering its inquiry on Early Childhood Teacher Education students, a population that remains conspicuously underrepresented in the AI education research landscape. This demographic focus carries particular significance, given that prospective early childhood educators require well-developed critical thinking capacities to design developmentally appropriate learning environments, exercise informed pedagogical judgment, and respond adaptively to the multifaceted demands of professional classroom practice. The findings thus carry meaningful practical implications for teacher education institutions seeking to embed AI purposefully and effectively within curriculum architecture.

From an applied standpoint, the outcomes of this study yield several actionable implications for educational policy and practice. Higher education institutions are encouraged to prioritize the development of AI-integrated instructional materials that are pedagogically coherent, interactively designed, and broadly accessible to diverse learner populations. Concurrently, media literacy development should be systematically embedded within teacher education curricula, equipping prospective educators with the critical evaluative capacities needed to engage discerningly with AI-generated and broader digital content. Equally, narrative-based pedagogical strategies – including structured short story analysis, reflective dialogic discussion, and creative writing – warrant sustained institutional investment and curricular prominence, given their demonstrated efficacy in cultivating higher-order thinking dispositions.

Considered holistically, this study advances the understanding that the cultivation of critical thinking within AI-supported educational environments is most productively conceptualized not as the product of any singular variable, but as an emergent outcome of the dynamic interplay among instructional quality, learners' digital competencies, AI-mediated learning processes, and the effectiveness of narrative-based pedagogy. Accordingly, AI ought not to be regarded as a self-contained educational solution, but rather as an integral component of a broader, coherently designed pedagogical framework – one oriented toward fostering substantive, meaningful learning and the progressive development of higher-order cognitive capacities.

Conclusion

The present study examined the structural interrelationships among teaching materials, media literacy, AI-enhanced learning, short story learning effectiveness, and critical thinking skills within a sample of Early Childhood Teacher Education students in Indonesia. The empirical findings confirmed statistically significant support for all proposed hypotheses, collectively affirming that both pedagogical quality and learners' digital literacy competencies constitute indispensable determinants of critical thinking development within AI-supported educational environments. Teaching Materials were found to exert significant influence over both AI-Enhanced Learning and Short Story Learning Effectiveness, suggesting that instructional resources characterized by coherent structure, interactivity, and purposeful AI integration are foundational to the facilitation of meaningful and cognitively demanding learning experiences. Media Literacy emerged as a significant predictor of both AI-enhanced engagement and narrative learning outcomes, reinforcing the imperative for students to cultivate robust competencies in accessing, analyzing, evaluating, and critically appropriating digital information within contemporary educational landscapes. Furthermore, AI-Enhanced Learning was demonstrated to positively and significantly contribute to Critical Thinking Skills, affirming that artificial intelligence holds genuine potential for advancing higher-order cognitive development when deliberately employed as a pedagogical instrument rather than merely as a technological convenience. Notwithstanding this contribution, Short Story Learning Effectiveness was identified as the most powerful predictor of critical thinking within the model, thereby reaffirming the indispensable pedagogical value of narrative-based learning in nurturing analytical reasoning, reflective judgment, evaluative argumentation, and complex problem-solving capacities.

Limitations and Future Research Agenda

Notwithstanding the valuable empirical contributions of the present study, several inherent limitations warrant transparent acknowledgment. First, the sample was drawn exclusively from Early Childhood Teacher Education students within the Indonesian higher education context, a delimitation that may constrain the transferability of the findings to other academic disciplines, institutional settings, or broader sociocultural environments. Second, the adoption of a cross-sectional research design fundamentally precludes the establishment of causal directionality across temporal dimensions, rendering longitudinal interpretations of the observed relationships speculative at best. Third, the study's reliance on self-reported perceptual data introduces the potential for response bias, which may have influenced the precision and objectivity of the obtained measures. In light of these limitations, several productive directions for future scholarly inquiry are proposed. Longitudinal and experimental research designs are strongly encouraged to rigorously investigate the sustained and developmental effects of AI-supported narrative learning on the progressive cultivation of critical thinking skills over time. Subsequent investigations would benefit from incorporating additional theoretically relevant variables – including but not limited to digital self-efficacy, intrinsic learning motivation, cognitive engagement, and trust dispositions toward AI systems – thereby enriching the explanatory depth of AI-supported learning ecosystem models. Cross-cultural and multi-disciplinary replication studies would further strengthen the generalizability of the present findings across diverse educational contexts.

Declarations

Ethics, Consent to Participate, and Consent to Publish:

Ethical approval for this study was granted by the Research Ethics Committee of Universitas Pahlawan Tuanku Tambusai. The research was deemed ethically sound in accordance with the WHO (2011) ethical standards and the CIOMS (2016) guidelines, encompassing the core principles of social value, scientific validity, risk minimization, equitable participant selection, confidentiality, and informed consent. All procedures involving human participants were carried out in full compliance with applicable institutional and national research ethics regulations, including Law of the Republic of Indonesia No. 11/2019 on the National System of Science and Technology, and in alignment with institutional standards consistent with prior approvals issued by the Ethics Committee of Universitas Pahlawan Tuanku Tambusai with approval number: 145/LPPM/UPTT/VII/2025.

Prior to any data collection, all participants were comprehensively informed regarding the study's aims, procedures, foreseeable risks and anticipated benefits, data protection measures, and their unconditional right to withdraw at any stage of the research without incurring academic or personal consequences. Written informed consent was secured from all participants before data collection commenced. Because the some participants in this study were minors (students under 18 years of age), written informed consent was obtained from their parents or legal guardians prior to data collection. Participation was entirely voluntary, and all requisite institutional permissions were obtained through appropriate academic channels. No incentives were offered, and no form of coercion was employed in the recruitment process. To preserve confidentiality and protect individual privacy, all data were gathered anonymously, with no personally identifiable information recorded at any point. The data were securely stored and utilized exclusively for scholarly purposes. Only aggregated and non-identifiable findings are presented in this manuscript, ensuring that participants' identities remain fully protected and that their involvement carries no bearing on their academic standing or future outcomes. All authors have reviewed and approved the final manuscript for submission. The authors affirm that this work is original, has not been previously published, and is not currently under consideration for publication in any other venue. All participants provided informed consent for the anonymized use of their data for research and publication purposes, and no personally identifiable information appears anywhere within this manuscript.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this manuscript, the authors utilized Grammarly and Quilbot to improve grammatical accuracy and enhance overall readability. Following the application of this tool, the authors thoroughly reviewed and revised the content as necessary and assume full responsibility for the integrity and accuracy of the published work.

Data availability:

Data generated or analyzed in the course of this study are available from the corresponding author upon reasonable request.

Conflict of interest statement:

The authors have no conflicts of interest to disclose.

Funding:

did not receive any funding.

Author Contribution

Nurmalina: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing – Original Draft, Visualization, Project Administration.Putri Asilestari: Literature Review, Validation, Writing – Review & Editing, Language Editing, Investigation.Deddy Gusman: Methodology, Software, Formal Analysis, Data Validation, Visualization, Writing – Review & Editing.Gyöngyi Bujdosó: Supervision, Conceptualization, Validation, Writing – Review & Editing, Resources.All authors contributed to the study conception and design, critically reviewed the manuscript, approved the final version of the manuscript, and agreed to be accountable for all aspects of the work.

Acknowledgment:

not applicable.

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Figures

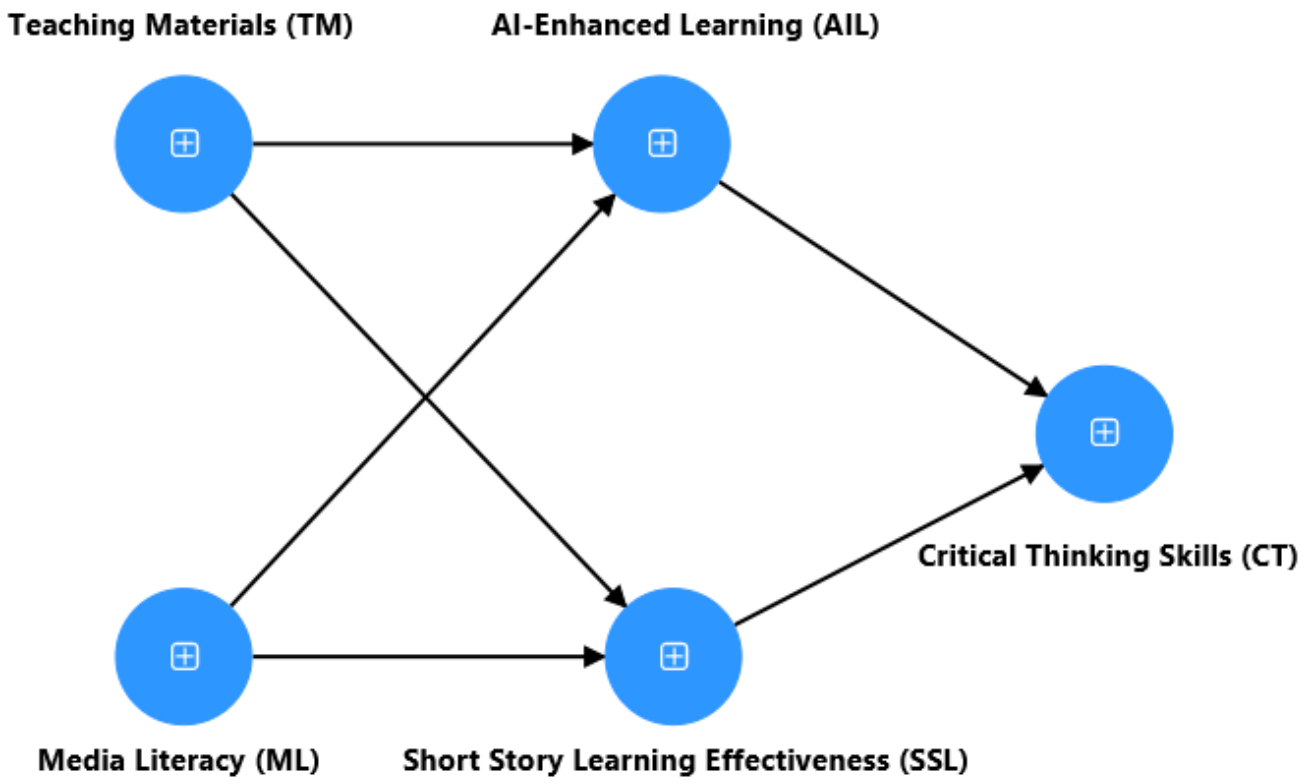


Figure 1

Research Framework

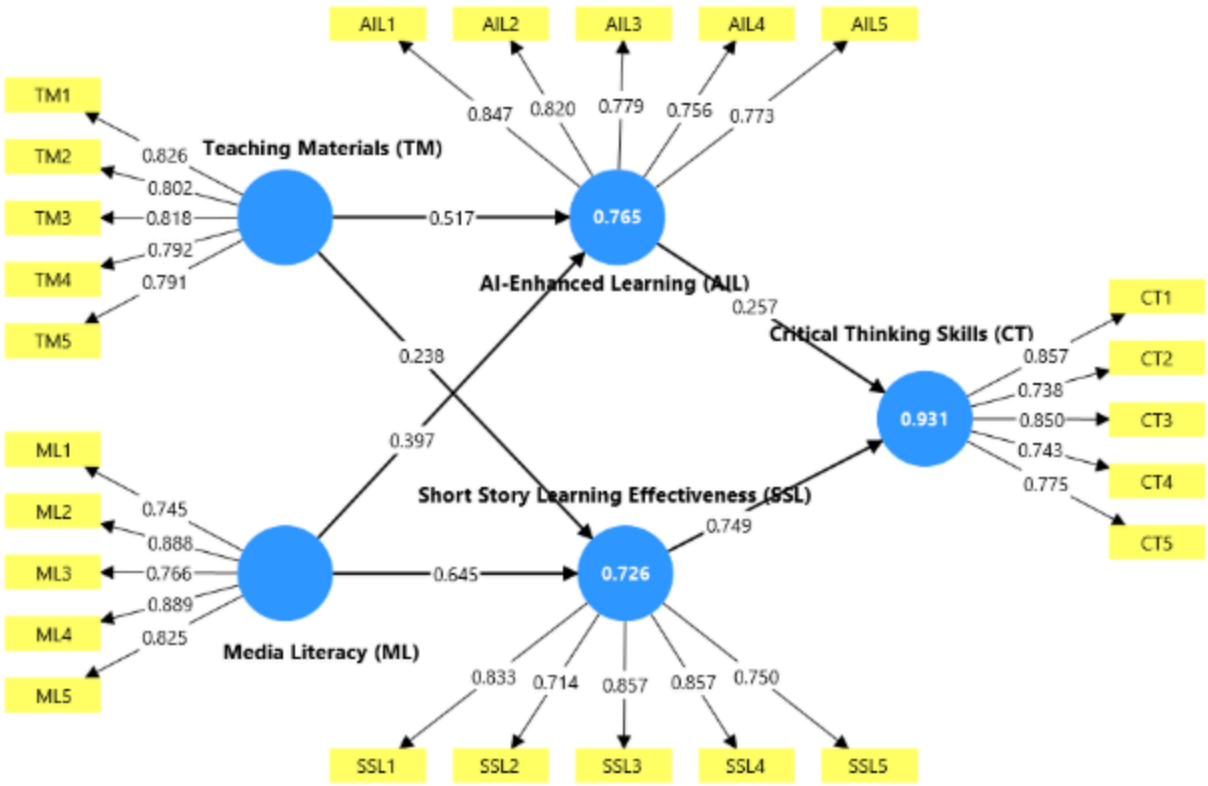


Figure 2

Results of factor loading and composite reliability

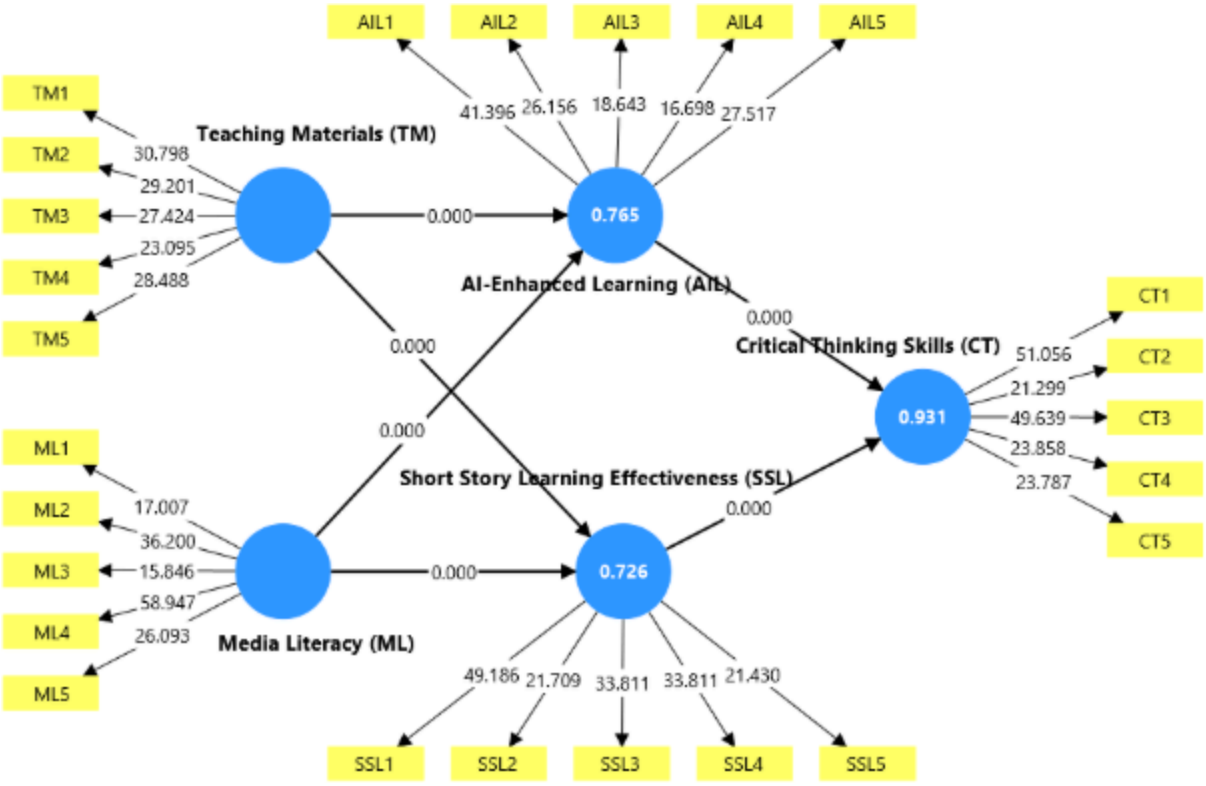


Figure 3

Hypothesis Testing