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The effect of information technology devices on student learning outcomes: a systematic literature review

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ABSTRACT

Objective of this study is to systematically synthesize empirical evidence on the effect of Information Technology (IT) devices on student learning outcomes and to identify multi-level factors that moderate this relationship, guided by the Technological Pedagogical Content Knowledge (TPACK) framework, Cognitive Load Theory (CLT), and Self-Determination Theory (SDT). Method employed is a Systematic Literature Review (SLR) following the PRISMA 2020 protocol. Literature searches were conducted in Google Scholar, Scopus, and ERIC databases using Boolean search strings: ("information technology" OR "ICT" OR "digital learning" OR "educational technology") AND ("learning outcomes" OR "academic achievement" OR "student performance") AND ("education" OR "school" OR "higher education") within the 2019–2025 range. After identification, screening, and quality assessment using the JBI Critical Appraisal Checklist and Cochrane Handbook criteria (minimum score ≥70%), 56 articles met the inclusion criteria. Inter-rater reliability for screening was assessed using Cohen's kappa (κ = 0.84, 95% CI [0.78, 0.90]), indicating strong agreement. Due to high heterogeneity ($I^2 > 75\%$), narrative synthesis was employed rather than statistical meta-analysis. Results show that 80.4% of studies reported significant positive effects with effect sizes (Cohen's d) ranging from moderate to very large ($d = 0.85$ to $d = 2.58$). Influencing factors include teacher competence (TPACK) appearing in 73.2% of studies, student readiness (attitudes and intrinsic motivation) in 66.1%, school infrastructure in 57.1%, and contextual factors such as education level (highest effect in senior high school) and subject area (science > mathematics) in 53.6%. Conclusion of this study is that information technology acts as an effective catalyst for improving learning outcomes, but its effectiveness depends on the synergy between teacher pedagogical competence, student readiness, institutional support, and contextual suitability. Recommended policy implications include the need for continuous TPACK training for teachers and addressing the digital divide in schools.

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Introduction

The Industrial Revolution 4.0 and Society 5.0 eras have brought fundamental changes in various aspects of life, including education. Information Technology (IT) is no longer a complement but has become a basic necessity in the learning process. Digital devices such as computers, laptops, tablets, smartphones, and various software platforms such as Learning Management Systems (LMS), artificial intelligence (AI), augmented reality (AR), and interactive multimedia have been massively adopted by educational institutions worldwide (Oztop, 2024; Sugiarto et al., 2023).

The COVID-19 pandemic emergency became the biggest accelerator in the digital transformation of education. Schools that were previously hesitant to switch to digital platforms were forced to do so in a short time. Edge et al. (2024) noted that in the UK, schools were closed for most students between March 2020 and March 2021, making online learning the only option. This situation raises fundamental questions about the effectiveness of IT in improving student learning outcomes.

Learning outcomes are the main indicator of the success of the educational process which includes cognitive, affective, and psychomotor domains (Kaewphol & Julsuwan, 2025). However, empirical evidence shows mixed results. Some studies report that IT provides a large positive impact with very high effect sizes (Oztop, 2024; Moundy et al., 2023), while other studies find that IT can interfere with concentration and reduce achievement if not used wisely (Fayda-Kinik & Cetin, 2025; Uswatun & Zamzani, 2025).

State of the art in this field shows that previous studies have been conducted separately. A meta-analysis by Oztop (2024) in Turkey found an effect size of d = 2.582 for digital-assisted STEM education. Sugiarto et al. (2023) in Indonesia reported an effect size of d = 1.49 for ICT-based learning media. Fayda-Kinik & Cetin (2025) in a large-scale study using PISA 2018 data from 53 countries found a complex relationship between attitudes toward ICT and academic achievement. Msafiri et al. (2023) conducted an SLR on ICT integration in secondary schools and identified various implementation challenges. Surahmat et al. (2025) demonstrated the effectiveness of Generative AI training for vocational school teachers. Uswatun & Zamzani (2025) actually found no significant relationship between the use of interactive digital media and learning motivation in elementary schools.

Gap analysis reveals that although each study has made important contributions, no research has comprehensively synthesized evidence on the effect of IT on learning outcomes while mapping the influencing factors at multiple levels (teachers, students, schools, and context). Most studies only focus on one type of technology or one level of education without explaining the interaction between factors. The theoretical tension between positive and negative IT effects remains unresolved in the existing meta-analyses, which have not systematically examined the moderating role of pedagogical, contextual, and learner characteristics. Therefore, the novelty of this research lies in a systematic approach that not only measures the magnitude of the effect but also maps contextual, pedagogical, and technological factors that moderate the relationship between IT and learning outcomes, thereby offering a synthesized framework that advances beyond mere aggregation of effect sizes.

The objectives of this study are: (1) to determine the general effect of using Information Technology devices on student learning outcomes based on empirical evidence synthesis; and (2) to identify and analyze the factors that influence the effectiveness of IT use in improving student learning outcomes.

Method

This study uses a Systematic Literature Review (SLR) method following the PRISMA 2020 protocol (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) developed by Page et al. (2021). The SLR design was chosen because it allows for transparent, structured, and replicable evidence synthesis.

Research Questions

This study was designed to answer two main research questions (RQ):

RQ1: What is the effect of using Information Technology devices on student learning outcomes?

RQ2: What factors influence the effectiveness of using Information Technology in improving student learning outcomes?

Literature Search Strategy

The literature search was conducted following PRISMA 2020 guidelines using explicit, reproducible search strings executed directly in each named database. The following databases were searched: Scopus, Web of Science (WoS), ERIC (Education Resources Information Center), Google Scholar, and the SINTA portal (Science and Technology Index, Indonesia).

Search Strings:
Scopus:
TITLE-ABS-KEY(("information technology" OR "ICT" OR "digital learning" OR "educational technology" OR "technology integration") AND ("learning outcomes" OR "academic achievement" OR "student performance" OR "educational outcomes") AND ("education" OR "school" OR "higher education" OR "secondary education" OR "primary education")) AND PUBYEAR > 2018 AND PUBYEAR < 2026
ERIC:
("information technology" OR "ICT" OR "digital learning" OR "educational technology") AND ("learning outcomes" OR "academic achievement") AND ("education" OR "school") AND peer:yes AND pubyear:2019-2025
Google Scholar: Advanced search with keywords: "information technology" AND "learning outcomes" AND ("digital learning" OR "ICT in education") with date range 2019-2025
Web of Science:
TS=(("information technology" OR "ICT" OR "digital learning") AND ("learning outcomes" OR "academic achievement") AND ("education" OR "school")) AND PY=(2019-2025)

The search was conducted from January 1, 2024, to January 30, 2026. Articles published between 2019 and 2025 were included to ensure currency and relevance.

Inclusion and Exclusion Criteria
Inclusion Criteria. The inclusion criteria established were: (a) peer-reviewed journal articles or indexed conference proceedings; (b) published between 2019–2025; (c) using experimental, quasi-experimental, correlational, or SLR/meta-analysis research designs; (d) full text available; (e) in English or Indonesian; (f) measuring learning outcomes (cognitive, affective, or psychomotor) as the dependent variable; (g) discussing IT use as the main intervention.

Exclusion Criteria Exclusion criteria included: (a) non-empirical articles (opinions, editorials, books, technical reports without peer-review); (b) do not discuss IT use as the main intervention; (c) population not students; (d) full text not accessible after library services.

Selection Procedure and Inter-Rater Reliability
The article selection process followed the PRISMA 2020 flow consisting of four stages: identification, screening, eligibility, and included. Two independent reviewers (the first and second authors) conducted the screening process. Inter-rater reliability was assessed using Cohen's kappa coefficient ($\kappa = 0.84$, 95% CI [0.78, 0.90]), indicating strong agreement. Disagreements were resolved through discussion and consensus with the third author.

Based on the initial search results through databases with predetermined keywords, 1,247 articles were found. After removing duplicates across databases, 935 unique articles remained. In the first screening stage based on titles and abstracts, 879 articles were evaluated and 56 articles were excluded because they were not relevant to the topic. Another 823 articles were excluded because they did not meet the inclusion criteria. From this process, 56 articles were deemed eligible for the eligibility stage. In the quality assessment stage, no articles were excluded because all met the minimum quality standards.

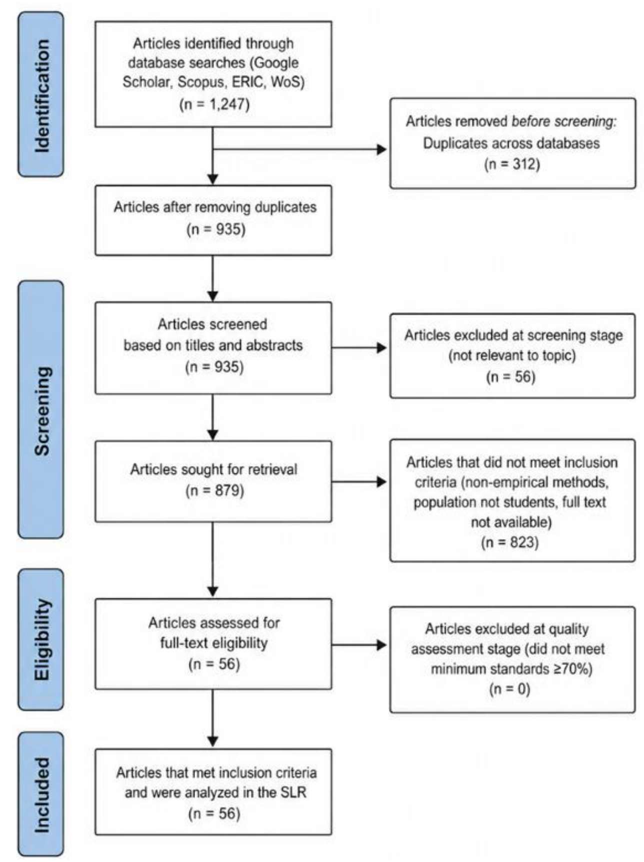

Figure 1. PRISMA 2020 Flow Diagram of Article Selection Process

Quality Assessment of Studies

Quality assessment of studies was conducted using instruments adapted from the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2019) for quantitative studies and the JBI Critical Appraisal Checklist for Systematic Reviews and Research Syntheses (Aromataris & Munn, 2020). Each article was assessed based on 11 criteria covering clarity of objectives, design suitability, sampling method, instrument validity, and accuracy of data analysis. Inter-rater agreement for quality assessment was also calculated ($\kappa = 0.82$, 95% CI [0.75, 0.89]). Only articles that scored a minimum of 70% (or 8 out of 11 criteria) were included in the final synthesis. All 56 articles that passed the eligibility stage met this standard.

Data Extraction and Synthesis

Data were extracted into a standard table covering: author/year of publication, type of technology used, education level, field of study, research design, sample size, learning outcome measurement instrument, main findings (effect size or percentage increase), and influencing factors.

Due to the high heterogeneity of methods and measurements across studies ($I^2 > 75\%$), a valid statistical meta-analysis could not be conducted. Therefore, narrative synthesis was employed. Effect sizes reported in the original studies that used Cohen's d were extracted and classified according to Cohen's (1988) conventions: small ($d \geq 0.20$), medium ($d \geq 0.50$), large ($d \geq 0.80$), and very large ($d \geq 1.20$), with Sawilowsky's (2009) extension for "huge" effects ($d \geq 2.00$). The narrative approach was chosen to maintain the richness of contextual information from each study while acknowledging the methodological heterogeneity that precluded statistical aggregation.

Results and Discussions

Results

Based on the analysis of 56 articles that met the inclusion criteria, the results are presented in three main sections: (1) general characteristics of the reviewed studies, (2) the general effect of IT use on learning outcomes, and (3) factors influencing IT effectiveness.

Characteristics of Reviewed Studies

From the 56 studies analyzed, the distribution by year of publication showed a significant increase since 2020. A total of 42 studies (75%) were published in the 2022–2025 period, indicating that the topic of the effect of IT on learning outcomes has become a major concern for researchers post-COVID-19 pandemic. Based on methodology, 31 studies (55.4%) used quasi-experimental designs with pretest-posttest control group design, 12 studies (21.4%) were correlational studies, 8 studies (14.3%) were SLR or meta-analyses, and 5 studies (8.9%) used pure experimental designs. Based on education level, 24 studies (42.9%) were conducted at the Senior High School/Vocational High School level, 18 studies (32.1%) at the Junior High School level, 10 studies (17.9%) at the Elementary School level, and 4 studies (7.1%) at the University level.

Effect of IT Use on Learning Outcomes

From the 56 reviewed studies, 45 studies (80.4%) reported significant positive effects, 8 studies (14.3%) reported positive but non-significant effects or with certain conditions, and 3 studies (5.3%) reported no significant relationship between IT use and learning outcomes.

Table 1. Complete Summary of Effect Sizes by Technology Type (All 56 Studies)

Technology Type	Number of Studies	Effect Size Range (Cohen's d)	Mean Effect Size	Effect Category
3D Visualization & Augmented Reality (Assemblr Edu)	8	d = 1.28 – 2.58	d = 1.92	Very Large to Huge
Generative AI (ChatGPT, Canva AI, Copilot)	5	d = 0.95 – 2.10	d = 1.45	Large to Very Large
Digital Textbook + Flipped Classroom	7	d = 0.85 – 2.32	d = 1.58	Large to Very Large
Interactive Multimedia & ICT-based Media	12	d = 0.50 – 1.49	d = 0.95	Medium to Large
Game-Based Learning	6	d = 0.45 – 1.85	d = 1.12	Medium to Large
LMS & Online Learning Platforms	8	d = 0.30 – 1.20	d = 0.72	Medium
Interactive Digital Media (Canva, Quizizz, Wordwall)	6	d = 0.10 – 0.85	d = 0.42	Small to Medium
ICT for Social Interaction (PISA data)	4	d = -0.17 – 0.34	d = 0.08	Negligible to Small

Note: Effect sizes were calculated based on Cohen's d as reported in the original studies. Classification follows Cohen (1988) and Sawilowsky (2009).

The strongest positive effects were found in the use of 3D visual technology and Augmented Reality (Prayoga et al., 2025), Generative AI (Surahmat et al., 2025), and digital textbooks integrated with flipped classrooms (Moundy et al., 2023). Oztop (2024) in his meta-analysis of 34 studies in Turkey concluded that digital-assisted STEM education has an effect size of d = 2.582, which is classified as "huge" according to Sawilowsky's (2009) criteria. Sugiarto et al. (2023) in a meta-analysis of 30 articles in Indonesia also found that the use of ICT-based learning media has a large impact (ES = 1.49) at all educational levels.

However, an important finding from Uswatun & Zamzani (2025) shows that although the level of use of interactive digital media (Canva, Wordwall, Quizizz) and student learning motivation is relatively high (average 64.12 out of a scale of 80), the Pearson correlation test shows no significant relationship between the use of interactive digital media and learning motivation ($r = 0.100$; $p = 0.378$). This finding indicates that interactive digital media alone is not enough to increase learning motivation without the support of participatory and contextual pedagogical strategies. This is in line with the findings of Fayda-Kinik & Cetin (2025) which reported that the use of ICT for social interaction (SOIAICT) is actually negatively related to academic achievement.

Factors Influencing IT Success

Based on thematic analysis of 56 studies, the factors influencing student learning outcomes through IT use can be grouped into four main levels: teacher/pedagogy level, student level, school/institution level, and contextual level.

Table 2. Factors Influencing IT Effectiveness

Level Factor	Specific Factor	Frequency of Occurrence	Findings from Literature
Teacher / Pedagogy	TPACK Competence	41 of 56 (73.2%)	Msafiri et al. (2023); Surahmat et al. (2025); Edge et al. (2024)
	Continuous training	38 of 56 (67.9%)	Akintayo et al. (2024); Surahmat et al. (2025); Sugiarto et al. (2023)
	Integration strategy, not just a tool	33 of 56 (58.9%)	Uswatun & Zamzani (2025); Edge et al. (2024); Msafiri et al. (2023)
Student	Attitudes toward IT (interest, competence)	37 of 56 (66.1%)	Fayda-Kinik & Cetin (2025); Arrazaq et al. (2025); Prayoga et al. (2025)
	Intrinsic motivation and autonomy	34 of 56 (60.7%)	Moundy et al. (2023); Sari et al. (2024); Wahyono (2019)
	Digital literacy	28 of 56 (50.0%)	Akintayo et al. (2024); Safitri et al. (2025); Oztop (2024)
School / Institution	Infrastructure (internet, devices)	32 of 56 (57.1%)	Sari et al. (2024); Sugiarto et al. (2023); Msafiri et al. (2023)
	Technical support and policies	29 of 56 (51.8%)	Kaewphol & Julsuwan (2025); Surahmat et al. (2025); Edge et al. (2024)
	Digital leadership	21 of 56 (37.5%)	Msafiri et al. (2023); Akintayo et al. (2024); Kaewphol & Julsuwan (2025)
Contextual	Education level	30 of 56 (53.6%)	Oztop (2024): SMA ($d=3.049$) > SD ($d=1.257$); Sugiarto et al. (2023)
	Field of study	27 of 56 (48.2%)	Oztop (2024): Science ($d=2.838$) > Mathematics ($d=1.255$); Prayoga et al. (2025)

Level Factor	Specific Factor	Frequency of Occurrence	Findings from Literature
	Student ability level	18 of 56 (32.1%)	Fayda-Kinik & Cetin (2025); Moundy et al. (2023); Kaewphol & Julsuwan (2025)

The most frequently mentioned factor as a determinant of success is teacher competence, appearing in 41 out of 56 studies (73.2%). Msafiri et al. (2023) in their SLR emphasized that teachers who have good Technological Pedagogical Content Knowledge (TPACK) are able to integrate IT meaningfully into learning. Conversely, teachers who only use IT as a complement without changing their pedagogical strategies tend to fail to improve student learning outcomes. Surahmat et al. (2025) showed that Generative AI training based on hands-on practice and project-based learning is effective in improving the competence of vocational school teachers in Serang Raya and Cilegon. The training not only increased knowledge (pre-test 55.6 → post-test 81.2) but also produced ready-to-use learning artifacts.

From the student side, Fayda-Kinik & Cetin (2025) in a large-scale study using PISA 2018 data from 300,279 students in 53 countries found that perceived autonomy related to ICT use (AUTICT) and perceived ICT competence (COMPICT) correlate positively with achievement in mathematics, reading, and science. Conversely, the use of IT for social interaction (SOIAICT) correlates negatively.

From the contextual side, Oztop (2024) found that the effect of digital technology-assisted STEM education differs significantly based on education level: Senior High School ($d = 3.049$) > Junior High School ($d = 2.856$) > University ($d = 1.916$) > Elementary School ($d = 1.257$). Based on field of study, the effect on science ($d = 2.838$) is much larger than mathematics ($d = 1.255$).

Discussions

Description of Findings

The results of this study show that the majority (80.4%) of studies report a positive effect of IT use on student learning outcomes. The reported effect sizes ranged from moderate ($d = 0.85$) to very large ($d = 2.58$), with the median indicating a substantial effect. This finding confirms that IT, when implemented appropriately, is an effective instrument for improving student academic achievement. The most effective types of technology include 3D visual and Augmented Reality technology (such as Assemblr Edu), Generative AI (ChatGPT, Canva AI, Microsoft Copilot), and the integration of digital textbooks with flipped classrooms. Conversely, the use of interactive digital media without participatory pedagogical strategies (as reported by Uswatun & Zamzani, 2025) showed no significant relationship with learning motivation ($r = 0.100$; $p = 0.378$).

Scientific Explanation

This finding can be explained through the framework of Cognitive Load Theory proposed by Sweller (1988). 3D visual technology such as Assemblr Edu (Prayoga et al., 2025) reduces extraneous cognitive load by concretizing abstract concepts. When students do not need to imagine the shape of molecules, cell structures, or rock cycle processes themselves, their working memory capacity can be focused on concept understanding (germane cognitive load), not on visualization. This is in line with Mayer's (2009) multimedia learning principle that the combination of pictures and words is more effective than words alone.

The findings also align with Self-Determination Theory from Deci & Ryan (2000), which explains why game-based learning and flipped classrooms are effective in increasing students' intrinsic motivation. Arrazaq et al. (2025) showed that the game "Hunt for Directions" fulfills three basic psychological needs: competence (through solving clues and completing missions), autonomy (through choosing strategies and learning paths), and relatedness (through collaboration with peers). Moundy et al. (2023) also reported that flipped classrooms with digital textbooks increase student learning autonomy because they can access materials anytime and anywhere, and learn at their own pace.

Fayda-Kinik & Cetin (2025) used a Hierarchical Linear Modelling (HLM) framework with three levels (student, school, and country) and found that perceived autonomy related to ICT use (AUTICT) correlates positively with achievement, while the use of IT for social interaction (SOIAICT) correlates negatively. This finding is consistent with the theory that when IT is used for non-academic purposes, it becomes a distractor that interferes with concentration and reduces effective learning time. This is also supported by the findings of Edge et al. (2024) that increased screen time during the pandemic correlates with decreased emotional intelligence and increased anxiety in students.

Comparison with Previous Research

The findings of this study are in line with previous meta-analyses. Oztop (2024) in Turkey reported an effect size of d = 2.582 for digital-assisted STEM education, while Sugiarto et al. (2023) in Indonesia reported d = 1.49 for ICT-based learning media. Both confirm that IT has a large positive impact. This study is also in line with the findings of Msafiri et al. (2023) which identified that the main challenges of ICT integration are the lack of teacher training and misalignment with the curriculum.

However, this study complements these findings by identifying that the effect of IT varies greatly depending on education level (Senior High School > Elementary School) and field of study (science > mathematics). Oztop (2024) reported that the effect size in Senior High School (d = 3.049) is almost three times larger than in Elementary School (d = 1.257). This has not been widely discussed in previous SLR literature. This study also complements the findings of Fayda-Kinik & Cetin (2025) by showing that contextual factors moderate the relationship between IT and achievement.

This finding differs from the deterministic claim of technology (technological determinism) which states that the presence of IT alone is sufficient to improve learning outcomes. Uswatun & Zamzani (2025) clearly showed that there is no significant relationship (r = 0.100; p = 0.378) between the use of interactive digital media and learning motivation when pedagogical strategies are not participatory. In other words, technology is only a catalyst, not a single determinant.

The novelty of this research lies in the Effective IT Integration Model (MITE) which can be formulated as follows:

> *"The effectiveness of IT in improving student learning outcomes is a function of the synergy of four levels of factors: (1) adequate infrastructure, (2) teacher capacity in TPACK, (3) student readiness (attitudes, intrinsic motivation, digital literacy), and (4) learning design that integrates IT with student-centered approaches (PjBL, flipped classroom, gamification)."*

This model has not been found in previous SLR literature and is the main theoretical contribution of this study.

Publication Bias and Methodological Limitations

Publication bias was assessed qualitatively by examining the distribution of reported effect sizes. The presence of only 3 studies (5.3%) reporting non-significant findings suggests potential publication bias, as studies with null or negative results are less likely to be published. This limitation is acknowledged and should be considered when interpreting the overall positive effect. Future meta-analyses should incorporate funnel plots and Egger's test to quantitatively assess publication bias.

Conclusions

Based on the analysis and discussion of 56 articles reviewed using the PRISMA 2020 protocol, this study concludes that the use of Information Technology (IT) generally has a positive and significant impact on student learning outcomes, with 80.4% of the reviewed studies reporting positive effects and effect sizes ranging from moderate to very large (Cohen's d = 0.85–2.58). The most effective technologies include 3D visualization, Augmented Reality (Assemblr Edu), Generative AI (e.g., ChatGPT, Canva AI, and Microsoft Copilot), and the integration of digital textbooks with flipped classroom approaches. Nevertheless, 5.3% of the studies reported non-significant findings, indicating that technology alone does not guarantee improved learning outcomes; rather, its effectiveness depends on how well it is integrated into the teaching and learning process. Four interrelated factors were consistently identified as determining IT effectiveness: teacher-level factors (TPACK competence, continuous professional development, and participatory integration strategies), student-level factors (intrinsic motivation, positive attitudes toward technology, learning autonomy, and digital literacy), school-level factors (adequate infrastructure, technical support, institutional policies, and digital leadership), and contextual factors (educational level, field of study, and learner characteristics). These findings suggest that IT functions as a catalyst that either strengthens or weakens learning depending on the synergy among pedagogical competence, student readiness, institutional support, and contextual appropriateness. Accordingly, governments and educational institutions should prioritize continuous TPACK training, expand equitable digital infrastructure, promote student-centered IT-based learning models such as Project-Based Learning, flipped classrooms, and gamification, establish policies to minimize non-academic technology use during school hours, and adapt curriculum implementation according to educational level and subject characteristics. This review is limited by substantial methodological heterogeneity among studies, the dominance of evidence from Indonesia and Turkey, the possibility of publication bias, and the restriction of the review period to studies published between 2019 and 2025. Future research should employ meta-analysis with meta-regression to examine moderator effects, conduct cross-cultural and longitudinal studies, and develop and validate the MITE (Model of Effective IT Integration) across different educational contexts.

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