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The impact of digital learning on numeracy: A meta-analysis from the perspective of Indonesian education policy implementation

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ABSTRACT

Although various studies have discussed digital learning in mathematics education, to date there has been no comprehensive meta-analysis that systematically measures the impact of digital interventions on Indonesian students' numeracy skills and their relationship to national education policies. This study presents a meta-analysis of 25 empirical studies involving 1,387 participants, aimed at measuring the effectiveness of digital learning in improving Indonesian students' numeracy skills from 2015 to 2025The analysis shows an average effect size of 1.218, which is considered high, indicating that the integration of digital media has a significant impact on students' conceptual understanding and numerical reasoning. The most effective digital interventions identified were the Wordwall application, educational TikTok content, and augmented reality flipbooks, which combine interactivity, visualization, and active student engagement. Overall, the meta-analysis confirms that digital media integration effectively improves students' numeracy skills and aligns with the implementation of the Independent Curriculum and the Digital Education Transformation policy. However, the relevance of these findings should be reconsidered in light of ongoing policy changes and technological developments. Further research is needed to examine moderating variables such as gender, socioeconomic background, and the digital literacy of both teachers and students.

KEYWORDS

Numeracy, digital learning, meta-analysis, Indonesia numeracy

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INTRODUCTION

The development of digital technology over the past decade has significantly transformed mathematics teaching and learning practices in various countries, including Indonesia. This transformation is supported by national policies such as the National Numeracy Movement, Digital Education Transformation, the Independent Curriculum, which emphasizes deep learning, and the implementation of the Minimum Competency Assessment (AKM) and the Academic Competency Test (TKA), which position numeracy as an essential 21st-century competency. Although these policies are designed to improve students' numeracy literacy, their implementation at the classroom level still faces challenges in integrating digital technology in a meaningful pedagogical way. This gap between policy direction and classroom practice highlights the urgency of this study, which examines how numeracy can be effectively developed through learning approaches aligned with national policy demands and responsive to global technological developments. Numeracy in this study is understood not only as computational ability but also as the capacity for critical, logical, reflective, and contextual thinking in solving real-life problems (Yoka, 2025), as well as an indicator of students' readiness to face increasingly complex social, economic, and technological challenges (Jimenez & Kemmery, 2013).

In the Indonesian context, although national policies prioritize strengthening numeracy and digital learning, students' numeracy achievement remains relatively low. Contributing factors include limited meaningful integration of technology in pedagogy, dominance of teacher-centered instruction, insufficient emphasis on higher-order thinking skills, and disparities in access to quality learning resources. The 2022 PISA results show that Indonesian students' mathematics performance remains below the OECD average, with scores ranging from 366–379 compared to approximately 472 (OECD, 2023). and only a small proportion of students reaching minimum proficiency levels. Although Indonesia's ranking has improved compared to previous cycles, this improvement is largely due to declines in other countries rather than substantial national progress.

These findings reveal a gap between the ideal conditions envisioned in digital transformation policies—where technology supports interactive, contextual, and higher-order thinking-based learning—and actual classroom practices, where technology is often used only for content delivery or administrative purposes (Nuraini et al., 2025). Low numeracy achievement is influenced not only by access to technology but also by teachers' limited digital pedagogical competence, lack of problem-solving-based instruction, and unequal infrastructure across schools (Nugraha & Rudhito, 2025). This discrepancy emphasizes the need for empirical research on how digital technology can be pedagogically integrated to improve numeracy skills effectively.

Various international studies have shown that digital learning can improve numeracy skills when combined with pedagogical approaches that emphasize reasoning, contextual problem-solving, and active student engagement (Singh et al., 2021; Morata, 2024; Miller, 2018). Based on these findings, this study aims to develop an effective model of digital learning implementation for numeracy development, identify pedagogical factors influencing numeracy achievement, and provide practical recommendations for strengthening technology-based mathematics learning. A global meta-analysis by Juhaevah et al. (2025) reported a small to moderate effect of educational technology on numeracy (Hedges' $g = 0.31$), while Dorris et al. (2024emphasized that effectiveness depends heavily on pedagogical quality. Therefore, further research is needed in the Indonesian context to examine variations in digital media effectiveness and identify optimal pedagogical integration strategies.

Seitz and Weinert, (2022) found that technology-based practice of mathematical facts positively influences learning outcomes and can serve as an effective instructional intervention. Similarly, adaptive learning technologies have been shown to significantly improve basic numeracy skills. These findings confirm that the effectiveness of digital learning is highly dependent on instructional design and interactivity (Burns et al., 2024).

In Indonesia, various digital innovations have been developed to improve numeracy skills. Rohima and Nugraheni (2022) found that augmented reality-based flipbooks significantly improved students' numeracy skills. Widyasari (2025) reported that the Wordwall application effectively enhances literacy and numeracy skills at the elementary level. Nuraini et al. (2025) also developed a culturally based interactive flipbook that improved student engagement in contextual numeracy learning. However, these findings remain fragmented and have not been synthesized at the national level through a comprehensive meta-analysis.

From a policy perspective, the Independent Curriculum with deep learning is a strategic effort to strengthen literacy and numeracy through digital integration (Yoka, 2025). This aligns with national programs such as the National Literacy and Numeracy Movement, AKM, and TKA, which emphasize critical thinking, problem-solving, and contextual data use. Digital media supports differentiated and contextual learning while enhancing 21st-century skills such as critical thinking, independence, and creativity (Yoka, 2025). This aligns with national programs such as the National Literacy and Numeracy Movement, AKM, and TKA, which emphasize critical thinking, problem-solving, and contextual data use. Digital media supports differentiated and contextual learning while enhancing 21st-century skills such as critical thinking, independence, and creativity (Ulya et al., 2025). AKM also shifts educational assessment from content mastery to reasoning and functional literacy (Permendikbudristek, 2021).

However, implementation still faces challenges, including limited infrastructure, unequal digital access, and low teacher digital literacy (Fatimah, 2025). Teacher competence is also a key factor; Rahmawati et al. (2025) found that low digital competence among teachers is influenced by both external constraints (limited training and access) and internal factors (low confidence and generational gaps).

Digital learning should therefore be integrated into the National Numeracy Movement, which aims to develop the ability to understand, apply, and interpret mathematical concepts in daily life (Permendikbudristek, 2021). The National Numeracy Movement and digital learning

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are complementary: the former provides policy direction, while the latter provides technological support for implementation. However, success depends on human resource readiness, infrastructure equity, and sustained policy support that ensures meaningful integration across schools.

International research further highlights the importance of context. Burns et al. (2024) found that digital learning benefits are greater in high-resource environments, while Kuş (2025) emphasized that technology without teacher training and policy support has minimal impact. These findings are highly relevant to Indonesia's efforts to balance innovation with educational equity.

Although many meta-analyses on digital learning and numeracy exist, most remain partial and do not provide a comprehensive synthesis of their overall impact (Kuş, 2025; Özdemir, 2025; Younas et al., 2025). Indonesian studies also tend to focus on general reviews or bibliometric analyses without directly measuring empirical effects (Juhaevah et al., 2025; Widiawati et al., 2025). Thus, there is still a lack of comprehensive evidence on how digital learning and pedagogical strategies interact to improve numeracy skills.

Therefore, this study employs a quantitative meta-analysis using the PRISMA protocol to address this gap. By analyzing empirical studies from 2015 to 2025, this research aims to (1) measure the effect of digital learning on Indonesian students' numeracy skills, (2) identify the most effective digital interventions, (3) examine effect variations based on sample size, educational level, instructional models, and digital media, and (4) analyze the role of national education policies in strengthening digital learning effectiveness.

The results of this meta-analysis are expected to provide empirical evidence for more targeted educational policy development. Furthermore, this study contributes theoretically to understanding the relationship between technological innovation, pedagogical strategies, and policy contexts in numeracy education, and offers practical implications for developing a more inclusive and equitable digital education ecosystem in Indonesia.

METHODS

Based on the findings of previous studies, this research aims to provide a comprehensive overview of the effectiveness of digital technology integration in improving students' numeracy skills. Therefore, a meta-analytic approach is employed to systematically and quantitatively synthesize the results of various empirical studies. The following section describes the methodological procedures, including study selection criteria, data collection techniques, and data analysis methods.

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Research Design

This study uses a quantitative meta-analysis approach to synthesize empirical research examining the impact of digital learning on students' numeracy skills in Indonesia between 2015 and 2025. Meta-analysis is a research technique that statistically combines the results of two or more previous studies (Brignardello-Petersen & Guyatt, 2025; Widodo et al., 2025). This approach enables researchers to integrate findings from multiple independent studies to obtain more accurate and generalizable effect estimates (Jin & Yu, 2025).

The research procedure followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines as recommended by Güzel et al. (2025) ensuring that study selection, screening, data extraction, and analysis were conducted systematically, transparently, and reproducibly.

Eligibility Criteria

Based on a comprehensive literature review, specific eligibility criteria were established to examine the relationship between digital learning and numeracy skill improvement. To minimize publication bias, both published and unpublished studies were considered (Kuş, 2025). Studies were included if they met the following criteria:

a. The study focused on the impact of digital learning or information technology-based learning media on numeracy skills.
b. The study empirically measured the effect of digital learning interventions on numeracy outcomes (not purely descriptive or conceptual).
c. The study employed experimental, quasi-experimental, or single-group designs with control/comparison groups, allowing effect size (ES) calculation based on t-tests, F-tests, correlation coefficients, or other convertible statistics.
d. The study reported sample size (N), statistical results, and the type of digital media used.
e. The study was published in peer-reviewed scientific journals (national or international) or had recognized academic credibility.
f. The study was conducted in the Indonesian educational context (elementary, junior high, or senior high school). International studies were included only if they explicitly involved Indonesian students.
g. The article was available in Indonesian or English and accessible in full text through online sources such as Google Scholar.

Data Sources and Search Strategy

Data were obtained from online databases, primarily Google Scholar. Search keywords were developed in both Indonesian and English, including: “numeracy,” “numerasi,” “digital numeracy,” “digital,” “Indonesian numeracy,” and “numerasi Indonesia.” The search process involved screening titles, abstracts, and full texts (Freelon, 2013). In cases of duplicate records, only peer-reviewed versions were retained.

Search Results

At the identification stage, a total of 1,510 articles were retrieved from Google Scholar using the specified keywords within the 2015–2025 publication range. During the initial screening stage, 521 duplicate or irrelevant articles were removed using the Publish or Perish software, leaving 989 articles.

During title and abstract screening, 673 articles were excluded due to lack of relevance to digital numeracy, educational context, or appropriate research design, leaving 316 articles for eligibility assessment.

At the eligibility stage, full-text screening was conducted to assess methodological suitability and data availability. Ten articles were excluded due to access limitations or technical incompatibility, resulting in 306 articles for detailed evaluation.

Further assessment led to the exclusion of 281 articles for the following reasons: 172 articles were outside the study scope (not focused on digital numeracy learning), 89 articles did not use experimental or quasi-experimental designs, 12 articles were review papers or meta-analyses, and 8 articles lacked sufficient statistical data for effect size calculation.

Finally, 25 studies met all inclusion criteria and were included in the meta-analysis. These studies demonstrated adequate methodological quality and provided sufficient data for effect size estimation of digital numeracy learning effectiveness.

The overall selection process is illustrated in Figure 1. This rigorous screening reduced the initial 1,510 studies to 25 eligible articles, reflecting the study’s emphasis on data quality, validity, and relevance. The relatively low inclusion rate (approximately 1.66%) indicates that experimentally based research on digital numeracy learning remains limited, highlighting the need for further studies in this field.

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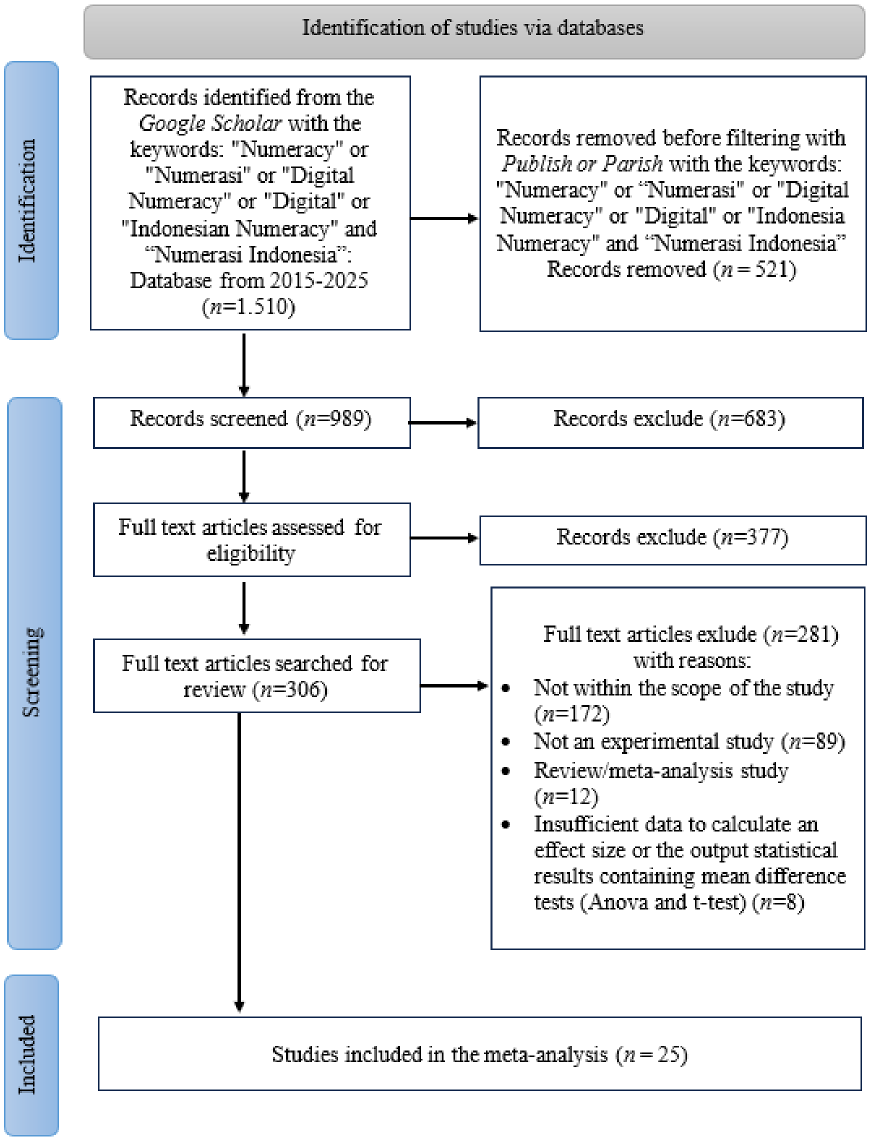

Figure 1. PRISMA diagram to illustrate the process of filtering articles regarding the impact of digital learning on numeracy skills (PRISMA flow diagram adapted from (Kuş, 2025))

Data from the selected studies were then coded using seven categorical moderator variables, including: (a) author name and year of publication; (b) research title; (c) publication source; (d) sample characteristics; (e) educational level; (f) type of digital media used; and (g) learning model employed. These variables were used to identify the characteristics and context of each study, which form the basis of this meta-analysis.

Data Analysis

The data analysis procedures in this meta-analysis were guided by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, which includes determining inclusion criteria, identifying data sources, and conducting the selection, screening, collection, and extraction of relevant information (Veroniki et al., 2025; Güzel et al.,

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2025). A detailed application of the PRISMA stages is presented in Figure 1.

After the relevant data were obtained, statistical analysis was conducted by calculating effect sizes based on predefined criteria, followed by interpretation and conclusion drawing from the analysis results (Gogtay & Thatte, 2017; Borenstein et al., 2021; Collins et al., 2021; Widodo et al., 2025).

Table 1. Calculation of Effect Size from *t*-test, *F*-test and *r*

Types of Statistical Test	Formula of Effect Size
r	$$ES = \frac{2}{\sqrt{1-r}}$$ Information: *r: the result of r*
t-test	$$ES = t\sqrt{\frac{1}{n_E}+\frac{1}{n_C}}$$ Information: t: *the result of the t-test* n_E: *sample size of the experimental group* n_C: *sample size of the control group*
F-test	$$ES = F\sqrt{\frac{2}{n}}$$ Information: t: *the result of the F test* n: *sample size*

Data analysis was conducted to calculate effect size as an indicator of the magnitude of the effect of the variables under study (Tan et al., 2025). Effect size is used to determine the extent to which digital media and the combination of learning models with digital media influence students' numeracy skills.

In this study, the effect size was calculated by converting the F value into t and r values and then estimating the magnitude of the effect while accounting for sampling variation. The formula used for effect size calculation is presented in Table 1 (Cooper et al., 2009; Widodo et al., 2025). All calculations were performed using Microsoft Excel to ensure accuracy and consistency of the results. The obtained effect sizes were then interpreted according to the criteria presented in Table 2 (see Widodo et al., 2025)

Table 2. Effect Size Criteria

Range	Effect Size (ES) Criteria
$-0.15 \leq ES < 0.15$	Very Low
$0.15 \leq ES < 0.40$	Low
$0.40 \leq ES < 0.75$	Medium
$0.75 \leq ES < 1.10$	High
$1.10 \leq ES < 1.45$	Very High
$ES \geq 1.10$	Extra Ordinary

RESULT AND DISCUSSION

Result

Before discussing the findings in detail, Table 3 presents a summary of the meta-analysis results from 25 studies related to digital media-based learning models. Table 3 provides information on the authors, year of publication, educational level, learning model, type of digital media, policy basis, source, sample size (N), and statistical test results, including F-test, t-test, correlation (r), and effect size.

This data is expected to provide a comprehensive overview of the variety of learning models and digital media used, as well as their influence on student learning outcomes.

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Table 3. Article Characteristics by Author, Year, Education Level, Learning Model, Digital Media, Policy Context, Source, Sample, and Statistical Results

No	Author & Year of Publication	Level	Learning Model	Digital Media	Policy Basis	*N*	*F-test*	*t-test*	*r*	*Effect Size*
1	Aziz et al. (2025)	SS	Realistic Mathematics Education	GeoGebra	Independent Curriculum	76	-	1.515	-	0.348
2	Muhaimin & Fadiana (2025)	JS	-	Kahoot	Minimum Competency Assessment	64	-	4.992	-	1.248
3	Wahyuni et al. (2024)	JS	Realistic Mathematics Education	E-Booklet	Minimum Competency Assessment	74	3.043	-	-	0.707
4	Rohima & Nugraheni (2025)	ES	Problem Base Learning	Augmented Reality Flipbook	Computer-Based National Assessment	38	-	9.196	-	3.021
5	Widiastuti & Kurniasih (2021)	JS	Problem Base Learning	Cabri 3D	Numeracy Literacy Movement	80	-	4.621	-	1.033
6	Ambarwati & Kurniasih (2021)	JS	Problem Base Learning	YouTube	Numeracy Literacy Movement	72	-	3.339	-	0.787
7	Jainuddin et al. (2025)	JS	Technology Base Learning	GeoGebra Quizis	Independent Curriculum, Teaching Campus	48	-	1.671	-	0.482
8	Sape (2024)	SS	-	Khan Academy	Digital Education Transformation	60	-	9.159	-	1.672
9	Yulianto et al. (2025)	ES	-	Math Games	Numeracy Literacy Movement	70	3.690	-	-	0.882
10	Milala et al. (2025)	ES	-	Game Edukasi Digital	Minimum Competency Assessment	84	-	2.97	-	0.648
11	Sapruddin et al. (2025)	ES	Problem Base Learning	Game Math Adventure	Independent Curriculum , Teaching Campus	14	-	3.075	-	1.644

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No	Author & Year of Publication	Level	Learning Model	Digital Media	Policy Basis	*N*	*F-test*	*t-test*	*r*	*Effect Size*
12	Sutiyawan & Supardi (2024)	SS	-	Virtual Phet	Minimum Competency Assessment	70	-	2.971	-	0.710
13	Siswanto et al. (2024)	SS	-	TikTok	Digital Education Transformation	60	-	15.408	-	3.979
14	Lestari et al. (2025)	JS	-	Game Educaplay	Minimum Competency Assessment	61	-	4.526	-	1.159
15	Masnia et al. (2025)	JS	Problem Base Learning	Social media	Numeracy Literacy Movement	60	4.519	-	-	1.167
16	Rahim et al. (2024)	ES	-	PainT 3D	Numeracy Literacy Movement	8	1.321	-	-	0.934
17	Widyasari (2025)	ES	Model ELPSA	Woodwall App	Digital Education Transformation	48	18.424	-	-	4.215
18	Putri & Zuhdi (2024)	ES	-	Interactive Video	Numeracy Literacy Movement	42	5.916	-	-	1.826
19	Sari et al. (2025)	ES	-	Educative Game	Digital Transformation Education	40	5.072	-	-	1.604
20	Lestari & Aini (2024)	ES	-	Flipbook	Minimum Competency Assessment	36	4.293	-	-	1.431
21	Pratiwi et al. (2025)	ES	Teams Game Tournamen	Wordwall App	Minimum Competency Assessment	10	8.28	-	-	1.050
22	Shahira et al. (2024)	JS	Creative Problem Solving	Permath App	Independent Curriculum	62	1.703	-	-	0.433
23	Dantes & Handayani (2021)	ES	Blendeed Learning	Online Resources	Digital Education Transformation	60	3.429	-	-	0.885

No	Author & Year of Publication	Level	Learning Model	Digital Media	Policy Basis	*N*	*F-test*	*t-test*	*r*	*Effect Size*
24	Safitri et al. (2023)	ES	Project Base Learning	Animated video	Minimum Competency Assessment	50	-	3.575	-	1.011
25	Rifki et al. (2023)	ES	Flipped Clasroom	Interactive video	Numeracy Literacy Movement	40		4.413		1.396
Total						1327				30.445
Average						53.080				1.218

ES: Elementary school
JS: Junior high school
SS: Senior high school

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Discussions

The Effect of Digital Learning on Students' Numeracy Ability

The results of a meta-analysis of 25 empirical studies involving 1,387 participants show that the average effect size of digital learning on students' numeracy skills in Indonesia is 1.218, which falls into the large effect category according to Cohen (1988). These findings confirm that the integration of digital technology contributes significantly to improving students' numeracy skills.

In general, digital media enrich mathematics learning by providing visual representations, interactive simulations, and immediate feedback that are difficult to obtain in conventional instruction (Burns et al., 2024). This is consistent with James et al., (2025) who suggest that digital learning creates an interactive, adaptive, and collaborative environment in which students are not merely recipients of information but active participants in knowledge construction. Other findings by Oumelaid et al. (2025) supported by Omarovna and Aynabekovna (2024) also show that digital-based interactive games significantly increase students' cognitive engagement and can be applied in various educational contexts, including general and special education.

Furthermore, variation in effect sizes across studies (0.348 to 4.215) indicates that the effectiveness of digital learning is not uniform and depends strongly on the implementation context. Studies with strong pedagogical integration, such as the ELPSA model combined with the Wordwall App (Widyasari, 2025) show substantially higher effect sizes compared to studies using digital tools without clear pedagogical frameworks, such as GeoGebra (Aziz et al., 2025). This suggests that the success of digital learning depends not only on the technology itself but also on how it is integrated with instructional strategies and learning contexts. This aligns with the Technological Pedagogical Content Knowledge (TPACK) framework Rosenberg and Koehler (2015) which emphasizes the balance between content, pedagogy, and technology.

In addition, the positive impact of digital learning on numeracy is closely related to increased student engagement and self-directed learning. Chao et al. (2016), state that digital technology enhances learning motivation by providing personalized learning experiences that increase confidence, interest, and enjoyment. Interactive applications such as Quizizz, Kahoot, and Math Games promote exploratory learning and healthy competition, which improves numeracy engagement (Morata, 2024; Muhaimin & Fadiana, 2025; Singh et al., 2021). Thus, digital learning functions not only as a technological tool but also as a pedagogical medium that fosters numeracy and critical thinking among students.

The Most Effective Types of Digital Interventions

An in-depth analysis of digital media types shows that the Wordwall App, educational TikTok, and Augmented Reality Flipbook are the three interventions with the highest effect sizes, reaching 5.318, 3.979, and 3.021, respectively. These media share a common characteristic: high interactivity and strong student engagement. Wordwall supports game-based learning that strengthens memory and conceptual reinforcement, while AR Flipbooks enable visualization of geometric concepts in three-dimensional space. This aligns with by Moreno and Mayer, (2007) who argue that effective digital learning combines visual, verbal, and kinesthetic elements that support dual coding processes.

In contrast, more static tools such as GeoGebra and e-booklets show moderate effect sizes (0.348 and 0.707). Although these tools support mathematical visualization, they offer more limited interaction and exploration. These findings indicate that higher levels of active participation and emotional engagement lead to stronger improvements in numeracy skills. This is consistent with Sailer and Homner (2020), who emphasize that the effectiveness of digital media depends on its ability to create meaningful learning experiences rather than merely delivering content.

Moreover, teacher readiness and pedagogical competence play a crucial role in determining the effectiveness of digital media. Priyanda et al. (2025) found that teachers with strong TPACK competencies can transform simple digital tools into reflective learning instruments that promote higher-order thinking. Similarly Jafri (2022). emphasizes that technology should function as a cognitive tool rather than merely a teaching aid. This aligns with Juhaevah et al., (2025) and Fadda et al., (2022) who highlight that successful technology integration depends on the synergy between content knowledge, pedagogy, and technological skills.

Differences in Effects Based on Sample Size, Education Level, and Learning Model

The analysis shows that the Problem-Based Learning (PBL) model consistently produces a high effect size (mean = 1.53) when integrated with interactive digital media such as Cabri 3D, educational YouTube, and Math Adventure Games. This indicates that PBL is highly adaptive to technology-enhanced learning environments. PBL encourages students to investigate, explore, and solve contextual problems, thereby strengthening higher-order mathematical thinking, including reasoning, conceptual connections, and meaningful representation of ideas (Savery, 2016).

In the context of this research, which focuses on improving numeracy skills, the effectiveness is not only related to the motivational aspect or general HOTS, but is directly related to the core components of numeracy, namely the ability to understand contextual data-based problems, choose appropriate problem-solving strategies, reason logically, and represent mathematical solutions meaningfully in various forms. The integration of PBL with digital media allows for concept visualization, exploration of real-life situations, and simulation-based interactions that strengthen the process of numerical reasoning and quantitative decision-making. Thus, the relevance of the motivational aspect and higher-order thinking skills in this research lies in the pedagogical mechanisms that facilitate the improvement of students' numeracy skills in a measurable and contextual manner, not as additional variables outside the main focus of the research.

The integration of PBL and interactive digital media enables students to construct knowledge through dynamic visualizations and simulation-based experiments, thereby deepening conceptual understanding (Dwiyanti & Setyasto, 2025). This is in line with the findings (Chaiarwut et al., 2025) which emphasizes that problem-based learning enriched with digital technology helps students internalize abstract mathematical concepts through visual representations and contextual learning experiences.

The integration of PBL and digital media has significant implications for improving numeracy learning. Digital media such as Cabri 3D allows students to directly manipulate geometric objects in three-dimensional space (Widiastuti & Kurniasih, 2021), while educational YouTube provides dynamic visualizations and contextual narratives that help bridge abstract concepts to concrete experiences (Ambarwati & Kurniasih, 2021). In addition, Math Adventure Game fosters intrinsic motivation through a challenge-based approach that combines cognitive and affective aspects of learning (Sapruddin et al., 2025). This finding is in line with research Kolbaek (2018) which emphasizes that problem-based learning in digital environments encourages metacognitive reflection and social collaboration, which strengthens student engagement. Thus, PBL can be viewed as an optimal pedagogical foundation for utilizing technology to sustainably improve numeracy literacy and higher-order thinking skills.

From the perspective of sample size and group formation, studies with small numbers of

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participants (N < 30) and more limited study groups tend to report higher effect sizes than larger-scale studies. This finding aligns with some literature suggesting that small groups, typically consisting of 3 to 5 students, allow for more intensive interaction, faster feedback, and more focused mentoring, potentially increasing the impact of learning interventions (Burns et al., 2024). However, these results need to be carefully controlled, as high effect sizes in small samples may also be influenced by data variability and limitations of the research design used. This phenomenon can be explained by small sample bias (Borenstein et al., 2021), where learning effects appear to be stronger due to the intensity of interaction and greater control of variables in small groups. Tamur et al. (2025) also supports these findings, stating that digital learning is more effective in small classes where teachers can provide individual and collaborative guidance on students' numerical explorations. However, in the context of national education, this small-scale effectiveness needs to be reexamined to ensure that digital learning can be implemented on a large scale without losing its pedagogical effectiveness.

The meta-analysis results show that the greatest effect of digital learning on improving students' numeracy occurs at the elementary school level, with an average effect size of 1.62, compared to junior high school (1.06) and high school (0.93). This finding indicates that digital learning has the strongest formative potential at the elementary education stage, when cognitive structures and attitudes toward mathematics are being intensively formed (Sudbery & Whittaker, 2018). At the concrete operational development stage (around 7–11 years of age), elementary school students require visual, kinesthetic, and interactive stimuli to understand abstract numerical concepts. Digital media such as interactive flipbooks, educational games, and animated learning videos play a crucial role because they provide multimodal representations combining text, images, sound, and movement, helping children build meaningful mathematical mental models (Moreno & Mayer, 2007).

Although the highest effectiveness was found at the secondary level, the greatest potential for digital learning lies at the elementary school level, when the foundations of numerical and logical thinking begin to form. Early, gradual, and sustained digital learning interventions have the potential to foster integrated mathematical thinking and digital literacy habits from the beginning of the learning period. This is in line with the findings Ayaz et al. (2016), which reveals that interactive technology at elementary school age helps children develop visual and spatial thinking skills, which lay the foundation for understanding mathematical concepts at subsequent levels. Therefore, a progressive digital numeracy curriculum is needed, starting from game-based exploration to the application of simulation-assisted problem-solving concepts so that numeracy skills are not temporary but internalized in students' thinking structures and learning habits.

The Role of National Education Policy on Digital Numeracy Learning

Policy analysis shows that digital interventions in this study are aligned with national programs such as the National Literacy and Numeracy Movement (GLN/GNN), Minimum Competency Assessment (AKM), the Independent Curriculum, and Digital Transformation in Education. AKM promotes competency-based learning that emphasizes reasoning in real-life contexts (Kemendikbud, 2020). while the Independent Curriculum supports contextual and technology-based learning innovation (Kemendikbud Riset dan Tekhnologi, 2023).

Studies aligned with Digital Transformation policies (e.g., TikTok, Wordwall, Khan Academy) show the highest average effect size (ES = 2.39), indicating the importance of strong policy support for effective digital integration. Watson et al. (2014) similarly argue that systemic digital education policies improve literacy and numeracy outcomes sustainably.

Post-2024 studies show an increase in effect size from 1.01 to 1.45, reflecting the positive influence of policy implementation on digital learning effectiveness (Juhaevah et al., 2025). Thus, GNN provides conceptual direction, while digital learning provides operational implementation tools.

Despite this progress, challenges remain, particularly in infrastructure inequality, teacher readiness, and digital access in 3T regions (Rahim et al., 2023; Ramdhani et al., 2024) Therefore, improving teacher digital competence and infrastructure remains essential for equitable implementation.

Although this meta-analysis shows strong effects of digital learning on numeracy skills, several limitations should be noted. Variations in study design, limited reporting quality, and small sample sizes may influence effect size estimates. Most studies were also conducted in urban areas, limiting generalizability to rural or 3T regions. In addition, advanced digital innovations such as AI-based tutoring and learning analytics remain underrepresented.

CONCLUSION

Based on a meta-analysis of 25 studies involving 1,387 participants, digital learning has a significant positive effect on students' numeracy skills in Indonesia (ES = 1.218, large effect). This effectiveness is influenced by the integration of technology, pedagogy, and content (TPACK). The most effective interventions are Wordwall, educational TikTok, and Augmented Reality Flipbooks, characterized by high interactivity and engagement. PBL is the most effective learning model (ES = 1.53), as it supports exploration and conceptual reasoning. The strongest effects are found at the elementary level (ES = 1.62), highlighting the importance of early numeracy development. Smaller classes tend to show higher effects due to intensive interaction. From a policy perspective, the synergy between GNN, AKM, the Independent Curriculum, and digital transformation strengthens numeracy learning outcomes, with post-policy studies showing an increase in effect size from 1.01 to 1.45.

REFERENCES

Ambarwati, D., & Kurniasih, M. D. (2021). Pengaruh Problem Based Learning Berbantuan Media Youtube Terhadap Kemampuan Literasi Numerasi Siswa [The Effect of Problem Based Learning Assisted by YouTube Media on Students' Numeracy Literacy Skills]. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *5*(3), 2857–2868. https://doi.org/10.31004/cendekia.v5i3.829

Ayaz, M., Şekerci, H., & Oral, B. (2016). The Effect of Using of Instructional Technology to Elementary School Students' Academic Achievement: A Meta-Analysis Study. *İnönü Üniversitesi Eğitim Fakültesi Dergisi*, *17*(1). https://doi.org/10.17679/iuefd.17131503

Aziz, A., Septian, A., Rohani, S., Awaliyah, R., Tatiana, M., & Nurhalimah, R. (2025). Application of RME to Improve Numeracy and Reduce Math Anxiety using Liveworksheets and Geogebra. *Prisma*, *14*(1), 64. https://doi.org/10.35194/jp.v14i1.4993

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H. R. (2021). Introduction to meta-analysis. *John Wiley & Sons*. https://doi.org/10.1016/S1134-2072(09)71285-X

Brignardello-Petersen, R., & Guyatt, G. H. (2025). Introduction to network meta-Analysis: Understanding what it is, how it is done, and how it can be used for decision-making. *American Journal of Epidemiology*, *194*(3), 837–843. https://doi.org/10.1093/aje/kwae260

Burns, M. K., Duesenberg-Marshall, M. D., Romero, M. E., Sussman-Dawson, K. J., & Singell, E. (2024). Meta-Analysis of the Effect of Technology-Based Mathematical Fact Practice on Mathematics Outcomes. *Journal of Special Education Technology*, *40*(3), 332-343. https://doi.org/10.1177/01626434241288199

Chaiarwut, S., Srikoon, S., Siritaratiwat, A., & Kwangmuang, P. (2025). Enhancing executive mathematics problem-solving through a constructivist digital learning platform: Design, development and evaluation. *Social Sciences and Humanities Open*, *11*(February), 101338. https://doi.org/10.1016/j.ssaho.2025.101338

Chao, T., Chen, J., Star, J. R., & Dede, C. (2016). Using Digital Resources for Motivation and Engagement in Learning Mathematics: Reflections from Teachers and Students. *Digital Experiences in Mathematics Education*, *2*(3), 253–277. https://doi.org/10.1007/s40751-016-0024-6

Cohen, J. (1988). *Staistical Power Analysis for The Behavioral Sciences*. Lawrence Erlbaum Associates Publishers.

Collins, S. P., Storrow, A., Liu, D., Jenkins, C. A., Miller, K. F., Kampe, C., & Butler, J. (2021). *Handbook of Meta-Analysis*.

Cooper, H., Hedges, L. V., & Valentine, J. C. (Eds.). (2009). *The Handbook of Research Synthesis and Meta-Analysis 2nd Edition*. Russell Sage Foundation.

Dantes, N., & Handayani, N. N. L. (2021). Peningkatan Literasi Sekolah Dan Literasi Numerasi Melalui Model Blanded Learning Pada Siswa Kelas V Sd Kota Singaraja. *Widyalaya: Jurnal Ilmu Pendidikan.*, *1*(3), 269–283. Retrieved from https://ekadanta.org/jurnal/index.php/Widyalaya/article/view/121

Dwiyanti, N., & Setyasto, N. (2025). The Effectiveness of the Problem-Based Learning Model Assisted by Augmented Reality on Learning Outcomes of the Natural Sciences Subject of Plant Body Parts Material. *Jurnal Penelitian Pendidikan IPA*, *11*(3), 9–18.

https://doi.org/10.29303/jppipa.v11i3.10335

Fadda, D., Pellegrini, M., Vivanet, G., & Zandonella Callegher, C. (2022). Effects of digital games on student motivation in mathematics: A meta-analysis in K-12. *Journal of Computer Assisted Learning*, *38*(1), 304–325. https://doi.org/10.1111/jcal.12618

Fatimah, A. N. (2025). *Learning Through Digital Media: Opportunities and Challenges among Indonesian Citizens*. Atlantis Press SARL. https://doi.org/10.2991/978-2-38476-372-6_4

Freelon, D. (2013). ReCal OIR: Ordinal, interval, and ratio intercoder reliability as a web service. *International Journal of Internet Science*, *8*(1), 10–16. http://www.ijis.net/ijis8_1/ijis8_1_freelon_pre.html

Gogtay, N. J., & Thatte, U. M. (2017). An Introduction to Meta-Analysis. *Journal of The Association of Physician of India*, *65*, 78–85.

Güzel, O., Vizuete-Luciano, E., & Merigó-Lindahl, J. M. (2025). A systematic literature review of the Pay-What-You-Want pricing under PRISMA protocol. *European Research on Management and Business Economics*, *31*(1), 100266. https://doi.org/10.1016/j.iedeen.2024.100266

Jafri, M. (2022). Addressing issues of missing values in the survey research of high school mathematics teachers' digital competencies. *Waikato Journal of Education*, *27*(2), 79–84. https://doi.org/10.15663/wje.v27i2.936

Jainuddin, J., Anita, I. W., & Nurfauziah, P. (2025). Pengaruh Pembelajaran Berbasis Teknologi pada Mata Pelajaran Matematika melalui Program Kampus Mengajar terhadap Peningkatan Literasi dan Numerasi Siswa SMP. *Wilangan: Jurnal Inovasi Dan Riset Pendidikan Matematika*, *6*(1), 79-91. https://doi.org/10.62870/wjirpm.v6i1.31966

James, W., Oates, G., & Schonfeldt, N. (2025). Improving retention while enhancing student engagement and learning outcomes using gamified mobile technology. *Accounting Education*, *34*(3), 366–386. https://doi.org/10.1080/09639284.2024.2326009

Jimenez, B. A., & Kemmery, M. (2013). Building the Early Numeracy Skills of Students with Moderate Intellectual Disability. *Education and Training in Autism and Developmental Disabilities*, *48*(4), 479–490. https://doi.org/10.1177/215416471304800406

Juhaevah, F., Tahmir, S., & Talib, A. (2025). The effect of learning media on students' early numeracy skills: Meta-analysis. *Journal of Mathematics and Science Teacher*, *5*(2), em079. https://doi.org/10.29333/mathsciteacher/16059

Kemendikbud. (2020). AKM dan Implikasinya pada Pembelajaran. In *Pusat Asesmen Dan Pembelajaran Badan Penelitian Dan Pengembangan Dan Perbukuan Kementerian Pendidikan Dan KebudayaanPembelajaran Badan Penelitian Dan Pengembangan Dan Perbukuan Kementerian Pendidikan dan Kebudayaan*. Pusmendik.

Kemendikbud Riset dan Tekhnologi. (2023). Peraturan Direktur Jenderal Guru dan Tenaga Kependidikan. *Peraturan Pemerintah*, 1–14.

Kolbaek, D. (2018). Problem-based learning in the digital age. In *IADIS International Conference Cognition and Exploratory Learning in Digital Age 2018*, 278–285. Retrieved from https://www.iadisportal.org/digital-library/problem-based-learning-in-the-digital-age

Kuş, M. (2025). A meta-analysis of the impact of technology related factors on students' academic performance. *Frontiers in Psychology*, *16*, 1524645. https://doi.org/10.3389/fpsyg.2025.1524645

Lestari, G. D., & Aini, N. (2024). Pengaruh Flipbook Literasi Dan Numerasi Terhadap Hasil Akm Peserta Didik Kelas V di SDN Ploso Wonoayu. *Jurnal Pendidikan Dasar*, *12*(1), 49–63. https://doi.org/10.46368/jpd.v12i1.1918

Lestari, N. M., Nindiasari, H., & Fathurrohman, M. (2025). Efektivitas Game Educaplay dalam Meningkatkan Kemampuan Numerasi pada Siswa Sekolah Menengah Pertama. *JIIP - Jurnal Ilmiah Ilmu Pendidikan*, *8*(7), 8763–8773. https://doi.org/10.54371/jiip.v8i7.8581

Masnia, L., Suratno, S., Prastiti, T. D., & Utomo, A. P. (2025). The Effect of the Project-Based Learning Model with Digital Learning Media on Science Literacy and Numeracy Skills in Madrasah Ibtidaiyah. *Al-Adzka: Jurnal Ilmiah Pendidikan Guru Madrasah Ibtidaiyah*, *15*(1), 1–16. https://doi.org/10.18592/aladzkapgmi.v15i1.14201

Milala, E. B., Lisnasari, S. F., & Tarigan, J. E. (2025). *Pengaruh Game Edukasi Digital Terhadap Kemampuan Numerasi Siswa Kelas V UPT SD Negeri 060972 Simalingkar B T . P 2024 / 2025*. In *Prosiding Seminar Nasional PSSH (Pendidikan, Saintek, Sosial dan Hukum)* (Vol. 4, No. 1, pp. 42-1).

Miller, T. (2018). Developing numeracy skills using interactive technology in a play-based learning environment. *International Journal of STEM Education*, *5*(1), 39. https://doi.org/10.1186/s40594-018-0135-2

Morata, J. A. (2024). Enhancing the Numeracy Skills of Grade 8 Students through Quizizz: An Interactive Learning Approach for Improved Mathematical Proficiency. *Journal of Interdisciplinary Perspectives*, *2*(12), 382–390. https://doi.org/10.69569/jip.2024.0581

Moreno, R., & Mayer, R. E. (2007). Cognitive-affective theory of learning with media. *The Cambridge Handbook of Multimedia Learning*, 161–177.

Muhaimin, D., & Fadiana, M. (2025). Pengaruh Model Pembelajaran Realistic Mathematics Education Berbantu Media Kahoot! terhadap Kemampuan Literasi Numerasi Siswa. *JIIP - Jurnal Ilmiah Ilmu Pendidikan*, *8*(9), 10693–10699. https://doi.org/10.54371/jiip.v8i9.9225

Nugraha, A. S., & Rudhito, M. A. (2025). Unveiling Numeracy Competency Domains of High School Students in Indonesia : A Clustering Analysis Approach. *JMPM: Jurnal Matematika dan Pendidikan Matematika*, *10*(2), 161–179. https://doi.org/10.26594/jmpm.v10i2.5972

Nuraini, N. L. S., Cholifah, P. S., Permata, S. D., Aurelia, D., Nabilla, S., & Huzaimah, C. (2025). Exploration of numeracy in digital cultural content. *Educational Challenges*, *30*(1). https://doi.org/10.34142/2709-7986.2025.30.1.03

OECD. (2023). Pisa 2022 Results. In *Factsheets: Vol. I*. OECD. Retrieved from https://www.oecd-ilibrary.org/education/pisa-2022-results-volume-i_53f23881-en%0Ahttps://www.oecd.org/publication/pisa-2022-results/country-notes/germany-1a2cf137/

Omarovna, T. G. & Aynabekovna, B. E. (2024). The impact of the use of digital technologies in teaching mathematics at school. *Eurasian Science Review*, *2*(3), 187–197. https://doi.org/10.63034/esr-72

Oumelaid, N., Boukari, B. E. L., & Ghordaf, J. E. L. (2025). Assessing the impact of teacher characteristics, learner methods, and self-guided learning on technology adoption in mathematics instruction. *Multidisciplinary Science Journal*, *7*(3), 1–11. https://doi.org/10.31893/multiscience.2025110

Özdemir, O. (2025). Kahoot! Game-based digital learning platform: A comprehensive meta-analysis. *Journal of Computer Assisted Learning*, *41*(1), 1–24. https://doi.org/10.1111/jcal.13084

Permendikbudristek. (2021). Peraturan Menteri Pendidikan, Kebudayaan, Riset, Dan Teknologi Republik Indonesia Nomor 17 Tahun 2021 Tentang Asesmen Nasional Asesmen Nasional. *Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi*, 1–10.

Perpres. (2023). Peraturan Presiden Nomor 82 Tahun 2023 tentang Percepatan Transformasi Digital dan Keterpaduan Layanan Digital Nasional. *Jdih.Setneg.Go.Id*, *132281*, 1–3. Retrieved from https://peraturan.bpk.go.id/Details/273981/perpres-no-82-tahun-2023

Pratiwi, C. E., Rosmaiyadi, R., & Nirawati, R. (2025). Pengaruh Model TGT Berbantuan Wordwall dan Quizizz terhadap Kemampuan Numerasi dan Minat Belajar Siswa SD. *Jurnal Pendidikan MIPA*, *15*(4), 1517–1522. https://doi.org/10.37630/jpm.v15i4.3487

Priyanda, R., Herman, T., Amalia, R., & Ihsan, I. R. (2025). Exploring teachers' pedagogical reasoning in mathematics education using the TPACK framework. *Frontiers in Education,* *10*, 552760. https://doi.org/10.3389/feduc.2025.1552760

Putri, S. D. C. & Zuhdi U. (2024). Pengaruh Penggunaan Video Pembelajaran Terhadap Kemampuan Literasi Numerasi Siswa Kelas 6 Sekolah Dasar. *Jurnal Penelitian Pendidikan Guru Sekolah Dasar*, *12*(8).

Rahim, A., Mangampang, E. T., Swandi, A., Rahmadhanningsih, S., & Salim S, S. (2023). Analysis of Learning Difficulties of Mathematics for Vocational School Students in the 3T Area. *Indonesian Journal of Educational Studies (IJES)*, *26*(1), 44–54. http://doi.org/10.26858/ijes.v26i1.47104

Rahim, A., Putri, S. N., & Melinda, A. (2024). Pengaruh Penggunaan Media Digital dalam Meningkatkan Kemampuan Numerasi di SDN 3 Tinigi. *Jurnal Teknologi Pendidikan Madako*, *3*(1), 1–6. Retrieved from https://ojs.fkip.umada.ac.id/index.php/jtpm/article/view/270

Rohima, A. & Nugraheni, N. (2025). Enhancing Numeracy Abilities through Problem-Based Learning Model with Augmented Reality Flipbook Media in Drupadi Cluster. *Jurnal Pendidikan MIPA*, *26*(1), 708–720. https://doi.org/10.23960/jpmipa.v26i1.pp708-720

Rahmawati, S., Prestridge, S., Abdullah, A. G., & Widiaty, I. (2025). Unpacking the digital competence challenge in vocational education: A case from Indonesia. *Social Sciences and Humanities Open*, *12*(July), 101803. https://doi.org/10.1016/j.ssaho.2025.101803

Ramdhani, L. I., Soeharno, S., Refni, E., Sarifah, I., & Mahdiyah, M. (2024). Meta-Analysis The Effectiveness of Digital Learning Media on Literacy Numeracy: Implications for Education Based Technology. *Jurnal Penelitian Pendidikan*, *41*(2), 153–161. https://doi.org/10.15294/jpp.v41i2.18926

Rifki, K., Rasiman, & Sulianto, J. (2023). *Kefektifan Model Pembelajaran Flipped Calssroom Berbantu Vidio Pembelajaran untuk Meningkatkan Pemahaman Konsep Matematika dan Kemampuan Literasi Numerasi Siswa Kelas VI Gugus Ki Hajar Dewantara Kec. Wonotunggal*. *Didaktik: Jurnal Ilmiah PGSD STKIP Subang*, *9*(1), 580-594.

https://doi.org/10.36989/didaktik.v9i1.719

Rosenberg, J. M., & Koehler, M. J. (2015). Context and technological pedagogical content knowledge (TPACK): A systematic review. *Journal of Research on Technology in Education*, *47*(3), 186–210. https://doi.org/10.1080/15391523.2015.1052663

Safitri, L., Nirawati, R., & Utama, E. G. (2023). Penerapan Model Projecdt Based Learning Berbantuan Video Animasi Untuk Meningkatkan Kemampuan Literasi Numerasi Siswa Pada Materi Luas Bangun Datar Kelas V. *Pendas: Jurnal Ilmiah Pendidikan Dasar*, *9*(3), 2130-2141. https://doi.org/10.23969/jp.v9i3.17785

Sailer, M., & Homner, L. (2020). The Gamification of Learning: a Meta-analysis. *Educational Psychology Review*, *32*(1), 77–112. https://doi.org/10.1007/s10648-019-09498-w

Sape, H. (2024). Pengaruh Platform Digital Terhadap Kemampuan Literasi Numerasi Siswa. *Jurnal Penalaran Dan Riset Matematika*, *3*(2), 73–80. https://doi.org/10.62388/prisma.v3i2.490

Sapruddin, A. Z., Rahmawati, F. P., Hidayati, Y. M., Desstya, A., & Nisa, C. (2025). Peningkatan literasi Numerasi Siswa Kelas 4 dengan Math Adventures Berbasis Problem Based Learning. *Penamas: Journal of Community Service*, *5*(1), 65–75. https://doi.org/10.53088/penamas.v5i1.1517

Sari, N., Amir, A., & Syarifnur. (2025). *Meningkatkan Kemampuan Literasi Numerasi Siswa Kelas IV di SD Inpres Morowa Melalui Pengenalan Metode Pembelajaran Berbasis Game Edukasi Interaktif*. *JDISTIRA-Jurnal Pengabdian Inovasi dan Teknologi Kepada Masyarakat*, *5*(2), 330-336. Retrieved from https://www.rumahjurnal.or.id/index.php/JUDISTIRA/article/view/1400

Savery, J. R. (2016). Overview of Problem-based Learning: Devinition and Distinction. *Interdisciplinary Journal of Problem-Based Learning,* *1*(1), 9-20. https://doi.org/10.7771/1541-5015.1002

Seitz, M., & Weinert, S. (2022). Numeracy skills in young children as predictors of mathematical competence. *British Journal of Developmental Psychology*, *40*(2), 224–241. https://doi.org/10.1111/bjdp.12408

Shahira, S. P., Sumaji, & Ulya, H. (2024). *Efektivitas Model Pembelajaran Creative Problem Solving Berbantuan Media Permath Apps terhadap Kemampuan Numerasi Matematis*. *Kognitif: Jurnal Riset HOTS Pendidikan Matematika*, *4*(3), 1287-1299. https://doi.org/10.51574/kognitif.v4i3.1720

Singh, P., Hoon, T. S., Md Nasir, A., Md Ramly, A., Md Rasid, S., & Meng, C. C. (2021). Card game as a pedagogical tool for numeracy skills development. *International Journal of Evaluation and Research in Education*, *10*(2), 693–705. https://doi.org/10.11591/ijere.v10i2.20722

Siswanto, D. H., Wahyuni, N., & Alghiffari, E. K. (2024). Pengaruh Aplikasi Tiktok Terhadap Kemampuan Numerasi Matematika Siswa. *Papanda Journal of Mathematics and Science Research*, *3*(2), 71–80. https://doi.org/10.56916/pjmsr.v3i2.833

Sudbery, J., & Whittaker, A. (2018). Piaget's theory of cognitive development. *Human Growth and Development*, 297–300. https://doi.org/10.4324/9780203730386-15

Sutiyawan, A., & Supardi, U.S. (2024). Upaya Peningkatan Kemampuan Numerasi Siswa Kelas XI SMAN Jakarta Melalui Metode Eksperimen Virtual PhET. *ACADEMIA: Jurnal Inovasi Riset Akademik*, *4*(3), 95–103. https://doi.org/10.51878/academia.v4i3.3617

Tamur, M., Subaryo, Marzuki, Ngao, A. I., & Castulo, N. J. (2025). The Future of Augmented Reality Immersive Technology-Based Mathematics Learning: A Meta-Analysis Study. *JTAM (Jurnal Teori Dan Aplikasi Matematika)*, *9*(3), 1013–1027. https://doi.org/10.31764/jtam.v9i3.31033

Tan, C. Y., Hong, X., Gao, L., & Song, Q. (2025). Meta-analytical insights on school SES effects. *Educational Review*, *77*(1), 274–302. https://doi.org/10.1080/00131911.2023.2184329

Ulya, N., Suhailah, S. E., Putri, V. J., & Revita, R. (2025). Peran Media Pembelajaran Digital dalam Pembelajaran Matematika di Era Merdeka Belajar : Systematic Literature Review. *Algoritma : Jurnal Matematika, Ilmu Pengetahuan Alam, Kebumian Dan Angkasa*, *3*(4), 21–31. https://doi.org/10.62383/algoritma.v3i4.548

Veroniki, A. A., Hutton, B., Stevens, A., McKenzie, J. E., Page, M. J., Moher, D., McGowan, J., Straus, S. E., Li, T., Munn, Z., Pollock, D., Colquhoun, H., Godfrey, C., Smith, M., Tufte, J., Logan, S., Catalá-López, F., Tovey, D., Franco, J. V. A., … Tricco, A. C. (2025). Update to the PRISMA guidelines for network meta-analyses and scoping reviews and development of guidelines for rapid reviews: a scoping review protocol. *JBI Evidence Synthesis*, *23*(3), 517–526. https://doi.org/10.11124/JBIES-24-00308

Wahyuni, I., Suwarno, & Afdhila, D. (2024). Realistic Mathematics-Based E-Booklets to Improve Students' Mathematical Literacy Ability. *Mosharafa: Jurnal Pendidikan Matematika*, *13*(1), 151–162. https://doi.org/10.31980/mosharafa.v13i1.1983

Watson, J., Pape, L., Murin, A., Gemin, B., & Vashaw, L. (2014). *Keeping pace with K-12 digital learning: An annual review of policy and practice*. Evergreen Education Group. Retieved from https://eric.ed.gov/?id=ED558147

Widiastuti, E. R., & Kurniasih, M. D. (2021). Pengaruh Model Problem Based Learning Berbantuan Software Cabri 3D V2 terhadap Kemampuan Literasi Numerasi Siswa. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *5*(2), 1687–1699. https://doi.org/10.31004/cendekia.v5i2.690

Widiawati, H., Sujarwo, & Saptono, B. (2025). Numeracy Literacy Innovations in Primary Education: A Bibliometric Exploration of Future Trends and Directions. *Educational Process: International Journal*, *18,* e2025431. https://doi.org/10.22521/edupij.2025.18.431

Widodo, S. A., Sari, Y. N., Chiphambo, S. M., Fitriani, N., Sulistyowati, F., Murtafiah, W., & Pratama, D. F. (2025). The effect of teaching props on the mathematical problem-solving skills: A meta-analysis study. *Infinity Journal*, *14*(1), 235–258.

https://doi.org/10.22460/infinity.v14i1.p235-258

Widyasari, N. (2025). Efektivitas Model Pembelajaran ELPSA Berbantuan Aplikasi Wordwall dalam Meningkatkan Kemampuan Literasi Numerasi Siswa. *Al-Khwarizmi: Jurnal Pendidikan Matematika dan Ilmu Pengetahuan Alam*, *13*(2), 101–116. https://doi.org/10.24256/jpmipa.v13i2.5556

Yoka, P. A. (2025). *Deep Learning for Numeracy : A Roadmap to Asta Cita in Primary Education*. *8*(2), 275–284. https://doi.org/10.23887/jlls.v8i2.99932

Younas, M., Ismayil, I., El-Dakhs, D. A. S., & Anwar, B. (2025). Exploring the Impact of Artificial Intelligence in Advancing Smart Learning in Education: A Meta-Analysis with Statistical Evidence. *Open Praxis*, *17*(3), 594–610. https://doi.org/10.55982/openpraxis.17.3.842

Yulianto, K. I., Santoso, E., Hastutik, S., Purwoko, B., & Bachtiar, A. (2025). Peningkatan Literasi Numerasi Anak Desa Melalui Media Edukatif Berbasis Digital. *CivicAction Jurnal Pengabdian dan Inovasi Masyarakat*, *1*(2), 52–57. https://doi.org/10.59696/civicaction.v1i2.157