



Journal of Educational Research & Human Growth

Volume 1, Issue 1 (2026)



Article Type: Systematic Literature Review

Digital Learning Interventions and Primary School Achievement: A Systematic Literature Review

Liam Biggart^{1*} Renee Paguirigan B. Osorio²

1. Centre for Evidence and Social Innovation, School of Social Sciences, Education and Social Work, Queen's University Belfast, United Kingdom

2. Division of Curriculum and Instruction, College of Education, University of the Philippines, Quezon City, Philippines

Corresponding Author:

Liam Biggart

Article Info

Received:

19 May 2026

Revised:

17 July 2026

Accepted:

24 July 2026

DOI:

[10.67808/jerhgv1i1-002-260819093205](https://doi.org/10.67808/jerhgv1i1-002-260819093205)

Abstract

Background:

The use of digital learning interventions gained importance in primary education, but conclusions about their impact on achievement were inconsistent across courses and technologies and across settings.

Methods:

The systematic literature review resulted in the synthesis of 22 selected empirical studies out of 1,039 studies. Searches included education and other multidisciplinary databases and studies published from 2015 to June 2026. Studies included were those where structured digital interventions were offered to learners between the ages of 3 and 12 and where there were measurable outcomes of digital interventions in relation to literacy, numeracy, mathematics, reading, and/or general achievement. Effective intervention design and outcome measures were varied/heterogeneous; evidence was extracted and thematized.

Results:

The majority of studies found a positive impact on achievement, with the most positive impact for programs that were curriculum aligned, adaptive, interactive, and were implemented frequently. But whole device programmes and underutilised resources often resulted in mixed or the absence of results. Moderating effectiveness was teacher support, instructional integration, dosage, readiness and technical reliability.

Conclusion:

The review overall found that the process of digital learning enhanced student achievement as long as it was used to provide access to high-quality learning programs and was part of a coherent pedagogical system, and not solely to devices or platforms.

Keywords

Digital Learning; Primary Education; Academic Achievement; Educational Technology; Literacy and Numeracy

1. Introduction

Engineered to support innovative learning and teaching, digital technologies—including the tablet, applications, adaptive learning, e-readers, computer-assisted tutoring, digital games, and one-to-one device programmes have become an integral part of primary education. The expectation that it could improve foundational learning has made them popular, and that they could be used to individualise practice, provide immediate feedback, provide access to multimedia representations, and be flexibly accessed has led to their rapid expansion (Al-Zu'bi et al., 2026). Such expectations increased when school systems found themselves faced with ongoing concerns regarding achievement in reading and mathematics, inequities of access to specialist teaching and disruption of traditional teaching. Investments in educational technology, however, have sometimes been made at too early a stage and before evidence exists on the conditions by which it can enhance achievement (Alam & Ansari, 2026).

The question of policy is not whether it's possible for children to learn with digital tools. Whether the defined digital interventions lead to better academic outcomes than what is currently offered, who they benefit, and what conditions must be in place in order to implement them. Structured content: Devices can share specific content; difficulty including, Devices can adjust difficulty; record performance: Devices can record performance; repeated practice like Devices can offer repeated practice. But they can also be used less than optimally, may not be relevant to the curriculum, may not work well, may be distracting and/or may have no teacher direction (Albreiki et al.,

2021). Clearly, educationally important outcomes are not necessarily a function of access to technologies or of students using the technologies.

The primary sector is a key context with which to engage in the question, as early English and math interventions profoundly impact students' learning patterns later in life. Digital programs can be particularly useful if they can offer support on a 1:1 basis in a full classroom, can offer a chance to practice at a suitable level or if they display abstract concepts interactively (Bagdonaite & Dagiene, 2025). They can also contribute to the generational gap if there is no infrastructure in schools or the teachers receive inadequate preparation, if children vary in access and in familiarising themselves with digital technology. Evidence needs to differentiate between the environment of the intervention and the design of the intervention.

Overall, average small to moderate positive effects have been found in previous reviews and at the same time, considerable heterogeneity has also been confirmed (Dahalan et al., 2024). There were some well-focused mathematics applications that had a significant impact, especially on pupils with lower achievement. With respect to reading, some programs enhanced the subset of skills without enhancing general reading fluency and/or comprehension. Introducing tablets on a large scale tended to have glaring problems as the user did not dictate how learning time was spent (Dorris et al., 2024). It was these differences that indicated the importance of the instructional architecture involved and not the novelty of the technology. There was one systematic literature review of empirical evidence on digital learning interventions and primary school achievement. It answered 4 questions.

- **RQ1:** Which achievement outcomes were reported in all of the studies included?
- **RQ2:** Which intervention features correlated with more or less effective interventions?
- **RQ3:** How did teacher support and dosage, context and learner characteristics impact outcomes?
- **RQ4:** What resulted for the school leaders, teachers and policy makers?

Mechanism-based synthesis contributed to the review. But rather than considering all aspects of

digital learning as one intervention, it distinguished curriculum quality, adaptivity, interactivity, implementation support, learner engagement and assessment alignment (Guan et al., 2024). It was careful not to leave out null and negative results, so as not to commit the sin of technological determinism. This framework was constructed to produce a conception of achievement thinking in terms of the interaction of technology, pedagogy, implementation and context.

2. Conceptual Framework

Digital learning intervention was determined to be a prescribed learning sequence where digital technology was used substantively for instruction, practice, feedback, assessment or content interaction. This definition excluded straightforward administrative technology, studies looking at passive access to technology without learning design and studies that did not have an achievement measure. This intervention could be used in conjunction with classroom learning, in lieu of a predetermined instructional task, or as a supervised home intervention (Hammerstein et al., 2021).

This was assessed by measurable change and defined as achievement in mathematics, numeracy, reading, literacy, language, and/or broad academic performance. Immediate scores upon intervention were separated between scores of transfer of the task to an untrained task and scores of sustained effects seen at the end of the follow-up period. It was important because programs could practice with more skill on some or all of the more similar exercises without impacting their overall competence (Hardiyana & Dewanti).

The framework put forth was modelled after four interconnecting layers. Instructional features implemented were: curriculum alignment, sequencing of tasks, adaptivity, feedback, multimodal representation, and retrieval practice. The implementation consisted of dosage, scheduling, teacher facilitation, technical reliability, and monitoring. Learner factors consisting of baseline attainment, working memory, language, gender, disability, motivation and digital confidence were included (Husriawati & Ubaidah, 2026). This involved

infrastructure, cost, school leadership, home support and integration with assessment and curriculum.

These layers were expected to have a positive impact on achievement when digital interventions were delivered. Adaptive sequencing may help to continue at a level of challenge. Immediate feedback has the potential to rectify misconceptions before they solidify. Number relationships and/or letter-sound connections might be made visually using an interactive representation. Practice, practice, practice can work to create fluency (Jannah et al., 2026). These mechanisms, however, needed to be “exposed” and to reach out to some extent to be meaningful. With good teaching, even below average software may have a positive effect, and with poor implementation even the best software might not produce a positive effect, but may simply become a version of traditional sheetwork.

3. Methodology

3.1 Review design and reporting

This study was a systematic literature review and secondary analysis. Identification, screening, eligibility assessment, and transparent reporting were used in the review process, adopting PRISMA principles. Given the heterogeneity in the type of interventions included in this review – with varying topics, age groups, intervention length, comparison condition, measure of achievement, and statistical reporting, a narrative and thematic synthesis was chosen. Meta-analysis was not done in a pooled fashion.

3.2 Search strategy

The ERIC, Scopus, Web of Science, PsycInfo, Education Source and multidisciplinary scholarly databases were searched, including supplementary searching that involved two techniques: Reference chaining and targeted searching for named programs of intervention. Search terms included primary and/or elementary school descriptors as well as digital learning, educational technology, tablet, application, computer-assisted instruction, adaptive learning, digital game, e-reader, literacy, reading, math, numeracy, achievement, attainment, trial and intervention.

These articles included in the search were published

in the period of time January 2015 through June 2026. This period was a time of tremendous growth of touchscreen tablets and adaptable applications, as well as mobile learning, and there was ample time to measure results. Only English-language empirical, research-type reports were searched, although the study may have come from any country.

3.3 Eligibility criteria

Studies were selected because they included children enrolled in pre-school, kindergarten, or primary or equivalent grades 1-7, the intervention employed the use of a digital device, application, platform, game or e-reader, computer program for structured learning experiences, the ability to use a comparison, control, baseline or credible counterfactual was provided, and there was at least one report of academic achievement outcome measures captured in the intervention. Qualitative, quantitative (randomised, cluster-randomised, quasi-experimental, longitudinal comparison, and mixed) effectiveness studies were eligible.

Studies were not included if they were of secondary student participants, they did not measure engagement or attitudes, they did not study digital literacy with a focus on academic outcome, it was only digital infrastructure with no intervention, there was not adequate academic outcome data, or there was no different achievement data in comparison to a previously reported sample. Background support documents included reviews, protocols and opinion papers that were not included in the 22 final studies and descriptions of designs.

3.4 Data extraction and quality appraisal

A structured extraction matrix was created and included the following: country, participants, educational stage, subject, type of intervention, duration of intervention, comparison condition, measure of achievement, primary finding, follow-up, and information about implementation. The outcome was categorized as ‘positive,’ ‘mixed,’ ‘null, and ‘potentially adverse. Positive classification

relied on a more impressive result, statistically or substantively, for the intervention on any of the prespecified measures of achievement. Mixed classification referred to any variability in the domains/measurements/subgroups/intervals in the data.

Allocation procedures, baseline equivalence, attrition, outcome validity, and appropriate analysis, as well as contamination (the unintended introduction of a third factor that mimics the observed pattern) and selection reporting, were evaluated during quality appraisal. Quality limitations do not exclude the study; they are a factor that helps to inform what weight to place on a finding. Standardized outcomes in randomized studies received more interpretive weight than did small or weakly controlled studies, and standardized implementation evidence led to greater interpretive weight.

3.5 Synthesis procedure

The analysis was done in three steps. The studies were first categorized according to domain: mathematics or numeracy; literacy or reading; and broad (or multi-domain) implementation. Second, intervention mechanisms were coded, which involved the extent of curriculum alignment, adaptivity, feedback, interactivity, gamification, personalization, teacher mediation, home support, and implementation dosage. Third, a comparison of the cross-study patterns was conducted with respect to the conditions linked to positive, mixed and null achievement outcomes.

The synthesis was done more with an emphasis on explanatory convergence than vote counting. Many more positives did not necessarily mean it was found to be effective because the size of the sample, methodological rigor of the study, or the closeness of the outcomes to the SI diffused effectively differed between the studies. Conflicting results were acknowledged and explained in terms of differences in implementation and comparison, learners’ needs and measurement.

Table 1. Review protocol, eligibility criteria, and analytical decisions

Element	Specification	Review implication
---------	---------------	--------------------

Review design	Systematic literature review and qualitative secondary synthesis	PRISMA-aligned identification, screening, eligibility assessment, and reporting
Time window	January 2015 to June 2026	Captured tablet, app, adaptive-learning, e-reader, and digital-game interventions
Databases	ERIC, Scopus, Web of Science, PsycINFO, Education Source, multidisciplinary databases	Supplemented by reference chaining and targeted intervention searches
Population	Pre-school, kindergarten, and Grades 1-7 in primary or equivalent elementary education	Any country; mainstream and additional-support populations are eligible
Intervention	Structured digital instruction, practice, feedback, or content interaction	Tablets, applications, computers, games, e-readers, and adaptive platforms
Outcomes	Mathematics, numeracy, reading, literacy, language, or broad achievement	Attitudes or engagement alone were insufficient
Eligible designs	Randomized, cluster-randomized, quasi-experimental, longitudinal comparison, mixed-method effectiveness	A comparison, control, baseline, or credible counterfactual was required.
Synthesis	Thematic and mechanism-based	No pooled meta-analysis because interventions and measures were heterogeneous

4. Results

4.1 Study selection

Database search yielded 1,006 documents and citations, and supplementary search yielded 33 documents, resulting in 1039 documents. A total of 765 titles and abstracts were screened after removal of 241 duplicates, with 601 of those excluded due to non-eligibility criteria. 164 database records and

33 additional records were retrieved, resulting in 197 full-texts assessed. 175 of these were ineligible for inclusion because the population was ineligible (48), the study failed to have an achievement outcome (35), was not empirical or a review (29), had no substantive intervention (25), had no credible comparison or insufficient data (23), or duplicated a sample and/or finding (15). A total of 22 studies made it into the synthesis.

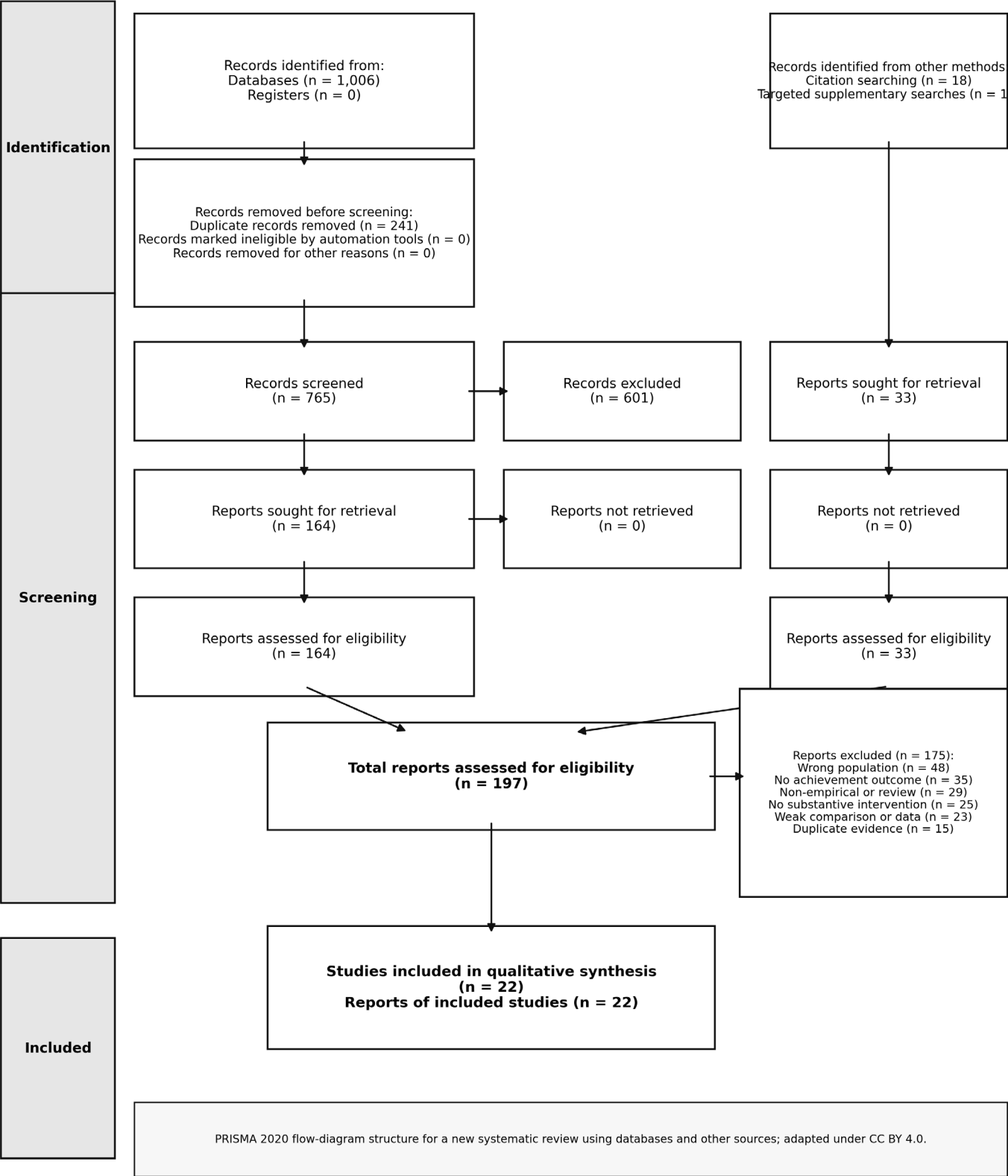


Figure 1. PRISMA 2020 flow diagram for study identification and selection; adapted under CC BY 4.0.

4.2 Characteristics of the evidence base

All 22 studies were conducted in 2015–23 and included those in Malawi, the United States, Kenya, Northern Ireland, England, Australia, Greece, Norway, Scotland, Tanzania, Brazil, Zambia, the Netherlands, and Belgium. The majority of assessed children are being judged in mathematics (numeracy), reading or emergent literacy. Intervention program length varied from 6 weeks to an entire school year and included tablet use, computer-based reading instruction, e-Readers, digital games, individualised print–app–based interventions, and district-wide one-to-one tablet initiatives (Muhaimin & Juandi, 2023).

Randomized or cluster randomized designs were the main type of designs in the evidence, but a few large-scale implementation studies were of quasi-experimental or mixed methods nature. The number of pupils sampled varied from less than a hundred to over 15,000 (Namoun & Alshanqiti, 2020). This involved standardized tests, testing based on the curriculum used, phonological tests, knowledge of letters, knowledge of numbers, reasoning and results from a national test.

There was a geographical spread, although the major focus of the evidence was in early primary education. Numerous studies focused on the following children: children at risk from low attainment, children in low-resource schools, or children who needed extra support for reading. This emphasis gave greater policy significance, but seemed to lessen the ability to apply to all primary learners.

4.3 Mathematics and numeracy outcomes

The richest and most consistent impact was seen with planned early math interventions. Standard interventions or different uses of tablets often yielded bigger gains than tablet programs which were sequenced in learning numbers, quantity discrimination, addition, subtraction, and reasoning. Reports of benefits in the United States, United Kingdom, Greece, Tanzania and Malawi in early years' settings.

There were some characteristics found in more programs that were successful. Explicit links were made to progressions of learning. Activities provided regular repetition, prompt feedback and correction. It was an evolutionary process to make things harder,

and interfaces were made to reduce the need for text or navigation. Children spent individual times (often supervised by the teacher or facilitator) working with the software. These conditions resulted in more active learning time and less whole-class pacing (Nurajizah et al., 2026).

Sometimes the effects were greater for the low-attainment children or children with poor memory. One presentation had an indication that perhaps structured applications could reduce the number of cognitive requirements; displaying one step at a time, repeating concepts, and being able to make mistakes without it showing on the outside. Some reported transfer to application-based format or paper and pencil tasks, as well as more complex reasoning, suggesting some learning was not limited to practised formats.

But not all results in mathematics were favourable. Mobile Math trial (collaborative/ contextual math activities) showed no significant overall post-test difference, yet increased positive student perception and increased student performance on some misconception items. A district-wide rollout of kindergarten tablets and digital math support did not impact mathematics-specific outcomes, partly due to their limited use. Limited and mixed or subgroup results of large-scale Norwegian implementations. The results of these studies showed that the predictors of success at a low level were provision of devices and overall level of classroom integration, whereas the predictors of success at a high level were curriculum quality and actual dosage.

4.4 Reading and literacy outcomes

The impacts of the digital literacy interventions were more differentiated. In some studies, computer-based reading programs resulted in growth in specific phonological skills, non-word reading, letter knowledge, print concepts, emergent writing, comprehension, or standardized reading scores. Development of emergent literacy was also enhanced with early childhood education programs at school or home for young children from low-income families. For the programs to be more effective, there needed to be a specific component skill targeted, and there needed to be repeated guided practice. Sequencing and immediate feedback resulted in gains in letter-

sound association, blending, decoding, vocabulary and comprehension. The Digital game-based literacy training resulted in improvements in letter knowledge and improvements (albeit small) in reading fluency; stronger initial phonological awareness affected response (Panagouli et al., 2021).

The distinction between narrow and broad outcomes was also demonstrated in the reading evidence. One program enhanced a standard reading assessment for students with language- or reading-based disabilities, but failed to increase the oral reading fluency. Another early reading trial showed that continuing implementation support had a greater impact than just initial training and technical support services. The suggested outcomes from these findings were that software might enable reinforcement of certain reading processes to remain unaffected.

Across Zambia, e-readers, as part of a wider safe space and community programme, helped enhance the basic literacy and non-verbal reasoning of girls in Grade 7. However, a trial in Kenya did not conclude that the e-readers given to students or the tablets given to teachers led to a significant improvement over an effective non-digital teaching programme in schools, which could justify the extra expense. The level of added value was lower when the teaching in the comparison condition was coherent and evidence-based.

4.5 Adaptivity, personalization, and feedback

While generally strong outcomes were found with adaptive and personalized features, the effectiveness was related to implementation. Programs which differentiated for learner performance prevented pupils from being subjected to tasks constantly and repeatedly at a level that was too easy or too difficult. Individualised pathways have also helped to escalate opportunities for mastery before moving on.

Sequential adaptive literacy trial indicated that enhanced follow-up, gamification, and parent messaging were associated with increased comprehension for those children who did not have initial responses to the adaptive program. However, less than half of the parents used the application that comes with it. This gap represented a common issue: the theory of the intervention and the actual intervention were different. The use of all the planned

elements would allow for personalization only where learners and families were using them (Parandrengi et al., 2026).

Quality of feedback, rather than visual richness, mattered more. Successful applications related to specific corrections, demonstrations or next steps. Trivia and generic rewards may distract people without furthering learning. Programs with sequential play activities and those that integrated explicit instruction with play activities were more likely to have higher reported achievement than popular but not validated collections of activities.

4.6 Teacher mediation and implementation support

Even when the company provided the core content, teachers had an influence on the effectiveness. Teachers planned sessions, kept procedures, translated information, boosted students' perseverance, linked online activities to ideas within the classroom and addressed technical issues. Programs which seemed to be independent still utilized organizational work.

Especially clear evidence comes from the Head Sprout Implementation Trial. Ongoing support to schools led to better reading outcomes than schools that were provided with initial training and technical assistance only. Whilst this was echoed at a whole-school level, studies of tablets revealed that higher levels of digital competence among teachers led to more positive effects (Parandrengi et al., 2026). These findings questioned the belief of de-professionalization of the role of teachers that is inherent in the application of technology in education.

Frequencies of sessions, completion rates, availability of devices, connectivity, completion of login and classroom management, and staff confidence were latencies that varied in implementation fidelity. Several initiatives were hampered by their low usage. If digital resources were an alternative to or in conflict with other activities, the targeted dosage was not met. So, achievement outcomes demonstrated both programme effectiveness and consistency of programme delivery.

4.7 Equity and learner heterogeneity

Digital interventions based on an opportunity for inclusion, but were not inclusive for all learners. Structured mathematics application was very

beneficial for pupils who were underachieving. Children with reading or language-based disabilities' performances increased on the selected standardized assessments. Malawi girls and boys learned mathematics at similar rates when provided effective interactive applications that they could access, indicating that mathematical learning-rate gaps could be lessened or eliminated in the way the design of instructional applications is designed.

Concurrently, responsiveness was expressed in terms of working memory, baseline phonological awareness, previous levels of achievement and digital confidence. There was a lack of progression for some pupils despite the good provision of programmes. Household-based interventions required parents to be involved, have access to equipment and have routines. However, there was no consistency across the studies in the moderators of language, socioeconomic status or gender.

Equity needed to go beyond an equal distribution of devices. Schools had to track users of the intervention, schools had to track people who made it through the intended number of sessions, schools had to track whether additional adult support was needed, and schools had to track whether there was transfer to conventional assessment. Differentiated support is needed to ensure that the variations in individual

needs will not be reproduced in the amounts and kinds of engagement in universal access.

4.8 Overall pattern of effectiveness

The number and range of the positive achievement effects across the range of studies were variable, with the majority of studies demonstrating at least one positive achievement effect. Targeted applications that are aligned to the curriculum received the greatest support with regard to early mathematics and the foundations of literacy. Experience mixed results with broad transformations and with low use and/or with voluntary use, as well as with strong instructional alternatives.

There was no evidence of the effect of the mere presence of a tablet or computer on achievement. Technology was a delivery or interaction, system, and human-to-human transmission was rare. That system, which led to greater productive learning time, more individual challenge, extended feedback and continued to be in support of teacher-led instruction, improved achievement. Thus, the explanatory model proposed for the analysis of these studies placed digital design on an equal footing with implementation fidelity, the mediation of the teacher, and also the disposition of the learner, all determining achievement.

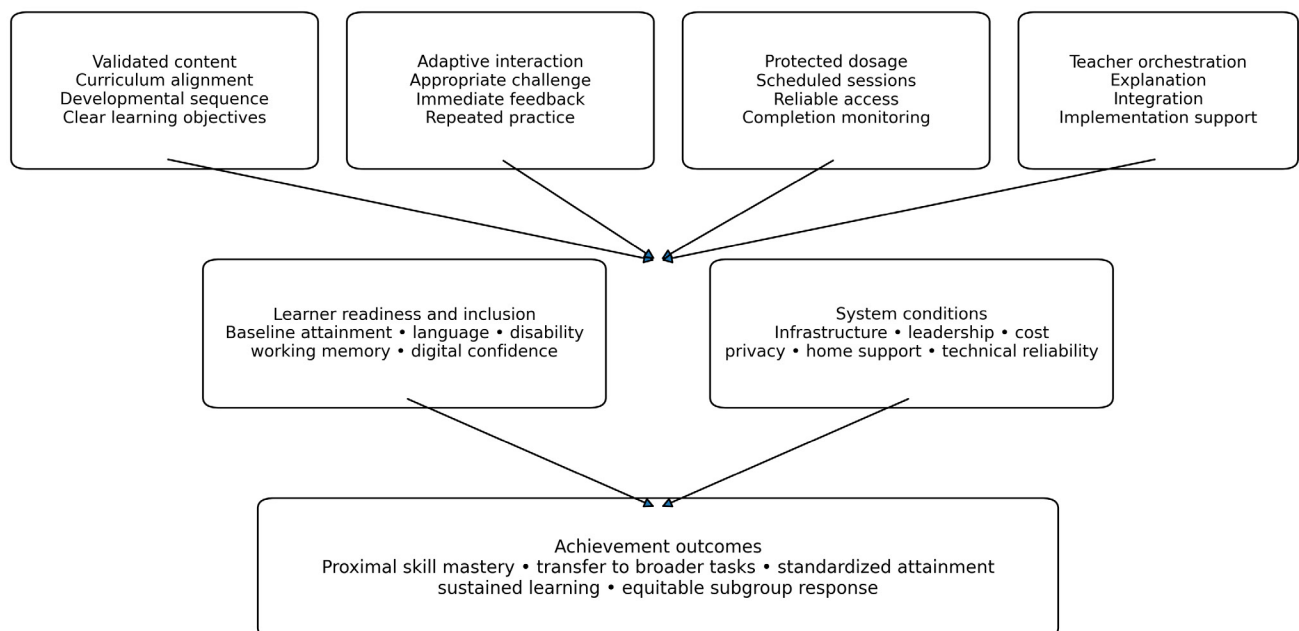
Table 2. Characteristics and achievement findings of the 22 included studies

Study	Context and sample	Digital intervention	Achievement domain	Principal finding
Pitchford, 2015	Malawi; 318 Standards 1-3 pupils	Tablet mathematics application; 8 weeks	Mathematics knowledge	Positive in Standards 2-3; transfer to paper assessment
Schacter et al., 2016	United States; 100 low-income prekindergarten pupils	Math Shelf tablet curriculum; 6 weeks	Number sense and mathematics	Positive relative to comparison mathematics applications
Piper et al., 2016	Kenya; early-grade primary pupils	E-readers, teacher tablets, and supervisor tablets	Early-grade reading	Digital additions did not outperform strong non-digital instruction cost-effectively
O'Callaghan et al., 2016	Northern Ireland; 98 pupils aged 4-6	Lexia Reading Core5; 8 weeks	Blending and non-word reading	Small positive gains; varied individual response
Outhwaite et al., 2017	United Kingdom; 133 pupils aged 4-7	Interactive tablet mathematics software	Early mathematics	Immediate and sustained gains, strongest for low achievers

Schacter and Jo, 2017	United States; 433 pre-school pupils	Math Shelf tablet program; 22 weeks	Mathematics achievement	Large positive effect, especially for low achievers
Neumann, 2017	Australia; 48 children aged 2-5	iPad literacy applications; 9 weeks	Emergent literacy	Positive letter, print-concept, and name-writing outcomes
Papadakis et al., 2018	Greece; 365 kindergarten pupils	Computer and tablet number-learning programs	Understanding of numbers	Both positive; tablets outperformed computers
Outhwaite et al., 2018	United Kingdom; 389 pupils aged 4-5	Interactive mathematics applications; 12 weeks	Early mathematics and reasoning	Positive gains in trained skills and higher-level reasoning
Krumsvik et al., 2018	Norway; district cohort within 15,708 pupils	Whole-school tablet implementation	Reading, arithmetic, and English tests	Mixed, limited, and subgroup-specific effects
Fabian and Topping, 2019	Scotland; 74 Grade 5-6 pupils	Tablet-supported contextual mathematics; 6 weeks	Mathematics achievement	No overall post-test difference; selected misconception benefits
Pitchford et al., 2019	Malawi; early primary pupils	Interactive mathematics and reading applications	Early mathematics and reading	Comparable learning across genders; reduced mathematics disparity
Kim et al., 2019	United States; 273 K-2 pupils	Personalized texts plus app-based activities	Reading comprehension	Adaptive intensification helped initial nonresponders
Lee and Choi, 2020	Tanzania; 122 Standard 1 pupils	Tablet mathematics games; 46 days	Early numeracy	Positive quantity, addition, and subtraction gains
Parks and Tortorelli, 2020	United States; district kindergarten classrooms	One-to-one tablets with mathematics resources	Mathematics and literacy	No targeted mathematics gain; low use, limited impact
Arnold et al., 2021	United States; low-income 4-5-year-olds	Khan Academy Kids home application; 10 weeks	Emergent literacy	Positive relative to non-literacy applications
Nogueira et al., 2021	Brazil, rural Grade 5 pupils	Digital literacy and computational-thinking course; 16 hours	Logic and mathematics	Positive achievement and digital competence effects
Mensch et al., 2021	Zambia, nearly 1,200 Grade 7 girls	Take-home e-readers within the safe-space program	Literacy, numeracy, reasoning	Positive literacy and non-verbal reasoning outcomes
Krumsvik et al., 2021	Norway; second district implementation cohort	Whole-school tablet implementation	National reading, arithmetic, and English outcomes	Limited, mixed, and gender-differentiated effects

Hurwitz and Vanacore, 2022	United States; 115 K-5 pupils with disabilities	Lexia Core5 supplementary reading	Standardized reading and oral fluency	Positive standardized reading; null oral-fluency difference
Glatz et al., 2023	Netherlands and Belgium; 247 first graders	Digital literacy game; up to 7 weeks	Letter knowledge and reading fluency	Positive letter knowledge; small fluency benefit
Roberts-Tyler et al., 2023	United Kingdom; 269 pupils in 22 schools	Headsprout with differing implementation support	Reading achievement	Ongoing support produced better outcomes

Digital Intervention Effectiveness Framework for Primary Achievement



Effectiveness emerged from alignment across technology, pedagogy, implementation, learner needs, and system capacity.

Table 3. Cross-study synthesis of effects, mechanisms, and boundary conditions

Intervention category	Overall evidence pattern	Mechanisms supporting achievement	Boundary conditions and risks
Targeted early mathematics applications	Mostly positive and sometimes large	Developmental sequence, immediate feedback, repeated practice, individualized pacing	Effects weakened with low use, unstable technology, or weak curricular fit.
Foundational literacy and reading software	Positive for selected component skills; broader effects varied	Explicit decoding, phonological practice, adaptive feedback, structured dosage	One reading component could improve while fluency or comprehension remained unchanged

Digital games and interactive applications	Positive when instructional mechanics were embedded	Active response, feedback, gradual challenge, purposeful gamification	Decorative rewards and novelty did not guarantee learning
E-readers and home-supported learning	Positive in some low-resource settings; context dependent	Access to texts, practice time, parent or community support	Uptake, home routines, and comparison quality moderated effects
Whole-school or one-to-one device initiatives	Mixed, null, negative, or subgroup-specific	Teacher competence and meaningful classroom integration	Hardware access without validated content or protected dosage was insufficient
Learners requiring additional support	Promising but heterogeneous	Individual pacing, privacy of practice, accessible repetition	Working memory, baseline skills, disability, and adult support shaped the response

5. Discussion

The review concluded that while digital learning interventions have the potential to increase achievement in primary schools, they are not guaranteed to be effective. The most obvious benefits happened when technology provided a well-defined sequence of instruction, meshed with developmental needs, and kept in mind curriculum goals. Not all of these interventions simply “tech-enhanced” old worksheets. Increased pacing and feedback, representation, and practice opportunities all changed.

The findings indicated an interpretation in terms of the quality of instruction. A technology could be helpful when it makes it possible for a child to work at a suitable level, get instant feedback about his/her mistakes, go over some of the basics, and work through a planned set of exercises. Convenience and interactivity of the device itself, and pedagogical learning mechanisms. This helped in explaining the superior performance of validated mathematics applications as compared to popular apps, which are gathered together in one assortment without any structure, and the inconsistent results of whole device approaches (Polater & Çelik, 2026).

Also important were the subject differences. There were often large gains for early mathematics applications, where the scope of the mathematics and knowledge progressions was bounded. These components represented in reading include reading

phonological awareness, decoding, fluency, reading vocabulary and reading comprehension. A program might enhance an aspect without impacting reading on the whole. Therefore, evaluations must not consider the achievement of one reading outcome as sufficient to communicate “literacy development.

The evidence also showed that there was no sideline support in the process of implementation. Digital programmes were occasionally touted as being scalable due to their ability to do away with specialist delivery. Schools still required training and schedules, monitoring, technical support and instructional integration in practice. The low usage meant the work was an ineffective waste of potentially effective resources. Scaling sustainably was a combination of humans, organization and, licenses and devices (Rahayu et al., 2025).

Interpretation was influenced by comparisons. Where the control groups’ interventions were of a good standard in terms of structured teaching and learning, there was not a great deal of technology that was an extra influence. This does not imply that the effectiveness of the program was not demonstrated; it means that the program did not appear to convey much benefit beyond an effective non-digital approach. Thus, cost, teacher time, infrastructure, accessibility and scalability were also factors to take into consideration with achievement.

The review also suggested that there should be three levels of evaluating the effects of digital interventions. Mastery of directly trained skills was

measured as a proximal outcome. Transfer outcomes focused on extending to other reasoning, on paper-based activities or on standardized testing. Sustained outcomes were implemented for 12 months and identified if gains were maintained at a 12-month follow-up. Results showed that there was much more evidence for proximal improvement and less evidence for transfer, and follow-up evidence was limited. So assertions of ongoing change have to be made with some caution (Sidik et al., 2025).

A comprehensive effectiveness system has been developed. The first component was validated, the content of the programs required learning outcomes to be clearly stated, and the programs should be nurtured sequentially. The second was adaptive interaction: complexity, feedback required for a meaningful response to performance. The third of these was a protected dosage – pupils needed some time to use them. The fourth was teacher orchestration – staff had to link up digital and classroom learning. Active management of the fifth was inclusive implementation: access, support, language, disability and learner variability had to be actively managed. The sixth was assessment integrity; it was important to assess transfer and sustained achievement, not software familiarity only.

The impact of this Schema on procurement. A school's choice of programs should outweigh the interface, the brand name, and personalization message. They should include evidence from similar learners, conduct an evaluation of curriculum mapping, review data and privacy practices and test the accessibility as well as setting implementation requirements. Small-scale use/learning pilots should measure actual usage prior to large-scale purchasing (Valverde-Berrocso et al., 2022).

The research also raised questions about the replacement narrative. Digital learning was most convincing when used as a part of a blended learning system. Applications could offer individualized practice and feedback, and teaching support can be offered for individual explanation, dialogue, motivation and transfer. Counting on the likelihood of allocating tasks based on comparative performance, instead of displacing teachers by software, was a good indicator of a high-performing system.

An additional implication has been on the maturity

of evidence. Numerous research studies have investigated proprietary programs in researcher-supported settings, while numerous schools may have an unknown level of access to and variability in technology implementation. External validity, therefore, should be considered a specific issue. The evaluation should include who chose the system used, teacher support for program delivery, what transpired when the program was not as intended, and whether any alterations of the intended program occurred. Average dosage as reported was not a good indicator, as pupils might be exposed to very different dosages (Wewe et al., 2026). Distributional measures for differences, completion trajectories and for non-use and reasons would help to discern if it was a difference in instructional quality or access to implementation. Independent replication was of keen importance in the cases where commercial claims relied on small trials or outcomes developed by program developers. The evidence should be linked to evidence at the system level relating to staffing, procurement, data governance and opportunity cost. The time assigned to an application ineluctably implemented another focus. Future assessment should determine what was substituted and if the substitution would have provided for a similar gain. Such a wider gaze would do more to enable decision makers to differentiate out and valorize what is promisingly effective from what is effective, and would cut down on the danger of vice versa becoming the case. It would also enhance long-term public investments' accountability.

6. Implications for Practice and Policy

School leaders must start with a learning problem that is well formulated. The decision to use technology to enhance number sense, phonological blending or reading comprehension offers more clarity over the selection of the technology. Content validity, age appropriateness, accessibility, feedback design and proof of achievement must then be assessed in the evaluation of the program.

Implementation plans should include the frequency, duration, group size, staffing, managing use of devices, and response to missed sessions. What you see in

the Usage data should also be applied in context with what you see in the Assessment data; otherwise, low usage numbers might lead you to assume a program failure. Preparation for teachers should be on how to operate and on teacher pedagogical integration. Continual coaching is better than a one-off training. Digital activities need to be clearly related to in-class activities. Teachers can talk about strategies they've seen in applications, utilize errors for small group teaching, and not let the use of the technology replace the use of oral language, manipulatives, collaboration and reasoning, and extended reading. The Transfer is protected with a balanced design.

For equity, shared-device strategies, offline options, accessible interfaces and language support, accommodations, and increased adult supervision should be considered. Home interventions must not rely on a steady parent presence or level of parental connectivity. Alternatives that maintain the learning objectives should be made available in the school.

The total cost (not the particular acquisition cost) should be considered for policymakers. Costs are related to the infrastructure, the maintenance, replacement, training, support, data protection, and the time of the instruction. Investment to be linked to the evidence and an independent evaluation. Staged implementation, comparison (where possible), groups and open reporting of negative results should be done with large-scale rollouts.

Likewise, proximal, transfer and follow-up outcomes should be measured to monitor achievement. The schools also need to review the results for subgroups and the burden of implementation. Raising average scores without addressing pupils who are hard to reach and overburdening our teaching workforce should not be regarded as an effective programme.

7. Limitations and Future Research

Evidence from the region may have been missed due to the language restrictions of the review on English-language publications only. The included studies were heterogeneous, and due to the lack of any meta-analysis, no estimation of any pooled effect. Learners at the extremity of the primary education were included in several of the interventions, which

included pre-school or kindergarten students. There were incomplete fidelity, follow-up or cost data for some publications.

In future studies, outcomes should be preregistered, standardized measures and transfer measures should be used, usage distributions should be reported, and there is a need to see pupils beyond immediate post-testing. There is a need for further research into Science, writing and across-curricular achievement. Comparative trials need to compare digital programs with effective forms of non-digital instruction and should not only compare them with business-as-usual practices. Consideration of economic evaluation and environmental costs should be included with the outcomes of learning. There is also a need for the investigation of the impact of artificial intelligence, speech recognition and adaptive analyses on teacher decision making, privacy, and equity within primary classrooms.

8. Conclusion

Results of this systematic review (22 included from 1,039 initial records) indicated that digital learning interventions often yielded higher levels of achievement in the primary school context, in particular when focused on early mathematics and foundational literacy. This was particularly true for programs that were related to the curriculum, interactive, adaptive, used often, and received teacher support.

Access to technology alone was not enough to equal learning. The results of broad tablet initiatives, of low usage resources and of poorly integrated programs were mixed and null. Four of these factors - content of the instructional materials, protected dosage, support for implementation, and readiness of learners and assessment alignment - were found to influence achievement.

Digital learning must then be approached as an intervention to learning, and not as a hardware project. Content, teacher capacity, key delivery of the content to students, and stringent monitoring of the above must be the focus of schools and policymakers. In the context of meaningful pedagogical setups, the digital tools can be utilized for the extension of individual practice and feedback. If not used with those systems in place, however, they are a potential

source of cost and additional complexity with no guarantee of enhanced achievement.

Declarations

Author contribution

Liam Biggart :

Conceptualization, Methodology, Investigation, Data Curation.

Renee Paguirigan B. Osorio :

Formal Analysis, Visualization, Writing – Original Draft, and Writing – Review & Editing.

Acknowledgement:

The author acknowledges educators and researchers whose documented evidence supported this systematic secondary analysis work.

Funding statement:

This study received no external funding and used only publicly available secondary research evidence sources.

Competing interests:

The author declares no competing interests affecting the review design, synthesis, interpretation, or conclusions reported.

Ethics approval:

Not applicable because the study analyzed published, non-identifiable secondary evidence.

Data availability:

The included study evidence and selection decisions are reported within the manuscript and its tables.

References

- Al-Zu'bi, M. A. A., Sharadgah, M. T., Al Shaar, M. S., Alkouri, Z., Dawoud, M., Al-Mseidin, K. I. M., Yaakob, M. F. M., Fauzee, M. S. B. O., Al-Mawadieh, R. S., & Jdaitawi, M. (2026). Impact of iPad based learning on preschool education and sustainable development goals from 2010 to 2020 a systematic review and meta-analysis. *Discover Sustainability*, 7(1), 306. <https://doi.org/10.1007/s43621-026-02733-9>
- Alam, S. S., & Ansari, D. (2026). How Are Educational Technologies Evaluated for Elementary Students' Math and Literacy Learning: A Systematic Review. *Journal of Research in Childhood Education*, 1-35. <https://doi.org/10.1080/02568543.2026.2657313>
- Albreiki, B., Zaki, N., & Alashwal, H. (2021). A systematic literature review of student performance prediction using machine learning techniques. *Education Sciences*, 11(9), 552. <https://doi.org/10.3390/educsci11090552>
- Bagdonaite, J., & Dagiene, V. (2025). Artificial Intelligence in Primary Education: A Systematic Literature Review 2020-2025. *Informatics in Education*, 24(4), 697-736. <https://doi.org/10.15388/infedu.2025.24>
- Dahalan, F., Alias, N., & Shaharom, M. S. N. (2024). Gamification and game based learning for vocational education and training: A systematic literature review. *Education and information technologies*, 29(2), 1279-1317. <https://doi.org/10.1007/s10639-022-11548-w>
- Dorris, C., Winter, K., O'Hare, L., & Lwoga, E. T. (2024). Mobile device use in the primary school classroom and impact on pupil literacy and numeracy attainment: A systematic review. *Campbell Systematic Reviews*, 20(2), e1417. <https://doi.org/10.1002/cl2.1417>
- Guan, X., Sun, C., Hwang, G.-j., Xue, K., & Wang, Z. (2024). Applying game-based learning in primary education: A systematic review of journal publications from 2010 to 2020. *Interactive Learning Environments*, 32(2), 534-556. <https://doi.org/10.1080/10494820.2022.2091611>
- Hammerstein, S., König, C., Dreisörner, T., & Frey, A. (2021). Effects of COVID-19-related school closures on student achievement-a systematic review. *Frontiers in psychology*, 12, 746289. <https://doi.org/10.3389/fpsyg.2021.746289>

- Hardiyana, M. R., & Dewanti, S. S. Teachers' Strategies in Enhancing Numeracy Skills in Elementary Schools. *International Journal of Basic Educational Research*, 3(1), 49-59. <https://doi.org/https://doi.org/10.14421/7vz0ec45>
- Husriawati, W., & Ubaidah, N. (2026). Project-Based Learning and Numeracy Literacy in Vocational Education: A Systematic Review of Their Impact on Critical Thinking. *Jurnal Didactical Mathematics*, 8(1), 171-186. <https://doi.org/https://doi.org/10.31949/dm.v8i1.17987>
- Jannah, M., Nuraeni, E., Kusumastuti, M. N., Murae, F., & Rachman, I. (2026). Numeracy Literacy and Quantitative Literacy in Biology Education: A Systematic Literature Review. *Jurnal Pendidikan Sains Indonesia*, 14(2), 390-402. <https://doi.org/https://doi.org/10.24815/jpsi.v14i2.688>
- Muhaimin, L. H., & Juandi, D. (2023). The role of learning media in learning mathematics: A systematic literature review. *Journal of Mathematics and Mathematics Education*, 13(1), 85-107. <https://doi.org/http://dx.doi.org/10.20961/jmme.v13i1.74425>
- Namoun, A., & Alshanqiti, A. (2020). Predicting student performance using data mining and learning analytics techniques: A systematic literature review. *Applied Sciences*, 11(1), 237. <https://doi.org/https://doi.org/10.3390/app11010237>
- Nurajizah, N., Solihat, K., Supriyanto, S., & Kusuma, J. W. (2026). OPTIMIZING AUDIO-VISUAL MEDIA, NUMERACY, AND DIGITAL LITERACY. *International Conference on Artificial Intelligence and the Digital Commons*,
- Panagouli, E., Stavridou, A., Savvidi, C., Kourti, A., Psaltopoulou, T., Sergentanis, T. N., & Tsitsika, A. (2021). School performance among children and adolescents during COVID-19 pandemic: A systematic review. *Children*, 8(12), 1134. <https://doi.org/https://doi.org/10.3390/children8121134>
- Parandrenge, M. J., Nusantara, D. S., Rohati, R., Nguyen, D. T., & Maphutha, K. (2026). Contextual Design of Literacy and Numeracy-Based Assessments: A Systematic Literature Review. *Journal of General Education and Humanities*, 5(3), 3231-3248-3231-3248. <https://doi.org/https://doi.org/10.58421/gehu.v5i3.1114>
- Polater, C., & Çelik, S. (2026). The Use of Intelligent Tutoring Systems in Primary School Mathematics Education: A Systematic Literature Review. *Indexing/Abstracting: 1. HW Wilson (Education Full Text)*, 22(1), 14.
- Rahayu, I., Salim, H., & Munandar, A. (2025). Enhancing Elementary Students' Numeracy Skills through Ethnomathematics in Geometry Learning: A Systematic Literature Review. *International Conference on Elementary Education*,
- Sidik, D. P., Irawijayanti, F., & Fatqurhohman, F. (2025). The role of artificial intelligence in enhancing digital and data literacy among secondary school students: A systematic literature review. *JINEA: Journal of Innovation in Education and Learning*, 1(3), 173-188. <https://doi.org/https://doi.org/10.66031/jinea.132025.38>
- Valverde-Berrocso, J., Acevedo-Borrega, J., & Cerezo-Pizarro, M. (2022). Educational technology and student performance: A systematic review. *Frontiers in Education*,
- Wewe, M., Parwata, I. G. L., Budhhyani, I. D. A., & Ratnya, I. G. (2026). Reconceptualizing Assessment For Learning In Mathematics Education: A Systematic Literature Review Of Digital, Formative, And Student-Centered Practices. *Jurnal Ilmiah Profesi Pendidikan*, 11(2), 1861-1874. <https://doi.org/https://doi.org/10.1007/s43621-026-02733-9>