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A SYSTEMATIC REVIEW ON DIGITAL TOOLS TO ENHANCE NUMERACY SKILLS FOR KEY STAGE 2 LEARNERS

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Abstract

This systematic review examines the utilization of digital tools in enhancing numeracy skills among Key Stage 2 learners. With the rapid advancements in digital technology, the integration of digital tools into education has emerged as a significant approach to improving student engagement and learning outcomes in mathematics. This study synthesizes findings from various research articles and studies conducted over the past decade, focusing on the impact of educational apps, interactive games, and technology-supported learning environments on the numeracy skills of learners in Grades 4 to 6. Using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines, 92 studies were selected, analyzed, and coded to determine the effectiveness of digital interventions in fostering a student-centered approach to mathematics instruction. The review identifies key digital strategies that promote active learning, provide immediate feedback, and cater to diverse learning needs, thereby significantly reducing math anxiety and improving overall numeracy performance. Findings reveal that, despite the proven benefits of digital tools, there remains a gap in the consistent adoption of these methods by educators, with many still relying on traditional teaching practices. The study concludes with recommendations on best practices for implementing digital tools in classroom settings, emphasizing their potential to create an engaging, supportive, and effective learning environment for Key Stage 2 learners. This review provides valuable insights for teachers, school administrators, and policymakers in strategically integrating digital resources into the curriculum to maximize numeracy skills development among learners.

Keywords: *Digital tools, Numeracy skills, Key Stage 2 learners, Mathematics education, Technology integration, Interactive learning, Student engagement PRISMA guidelines*

INTROUDUCTION

The rapid advancements in digital technology have already transformed the various aspect of educational landscape which include how mathematics is taught and learned by the students. The systematic review explored the utilization of the digital tools to enhance the numeracy skills of Key Stage 2 learners. Numeracy according to experts is the ability to understand and work with numbers, which is a critical skill that plays a fundamental role in the learner's academic achievement and in preparation for future professional life. However, the traditional methods of teaching mathematics have often been criticized for their limitations in engaging the students in addressing the diverse learning needs, particularly in the foundation years of education.

Many researchers emphasized the significance of the integration of digital tools into the mathematics instruction. According to Clark-Wilson and Hoyles (2019), digital platforms such as the educational apps and engaging games, provided the learners with the dynamic opportunities in practicing and applying mathematical principles and concepts in adjoining the students in both individualized and group ways. In the same manners, O'Malley et al. (2020), argues that the technology-supported academic learning environments promoted a more interactive, student-centered instruction, which can lead to the significant improvements in numeracy skills. The mentioned

experts highlighted how digital tools can cater to the various learning styles, offering immediate feedback and promoting self-paced learning, making them highly effective compared to the traditional teaching methods.

Although the students gained various benefits in the use digital tools, many teachers still use old ways of teaching. They tend to focus on the lecture-based discussions, the typical, teacher talking while the students are listening. This often meant that students are required to memorize things that needs repeated exercises and followed seemingly of what is written in the textbook. The students used tools which might be within the trend, but the teacher still use and rely on the conventional methods of teaching. Such reliance on the traditional approaches and methods in teaching math presented a significant gap in the literature. The teachers have expressed concerns about the limitations of these approaches particularly with regards to the student engagement and retention of concepts and principles. Various Key Stage 2 learners struggle with abstract mathematical concepts when taught in a passive, lecture-based format, leading toward learning mathematics with anxiety and disengagement from the subject according to Smith (2021). This became a perennial issue which specified the need for consistent and modernized assessment and evaluation of the mathematical concepts. In this way several alternative approaches in teaching can better be prepared and can better address the varying learning needs of the students, especially those in the public schools.

The existing research on the digital tools in education might be extensive in nature, however still presented significant ambiguities and inconsistencies regarding their overall effectiveness. According to the studies of Cheung and Slavin (2013), Steenbergen-Hu and Cooper (2014), and Fraillon et al. (2019), the impact of digital tools is not uniformly clear, with varying outcomes based on contextual factors such as the design for instructions, accessibility, and teacher's deployment of the teaching practices. Moreover, international assessments such as PISA revealed that several students continued to have challenges in the study of mathematics. This reality suggested that the current deployment of the digital tools may not fully address the core learning challenges faced by the learners (OECD), 2019). The issue lied not just in understanding how these tools affected numeracy skills of the students but also in the identification of the specific conditions under which they were more effective.

To address this issue, this paper employed a meta-analysis of existing empirical studies on the use of digital tools in mathematics education. Through the systematic analysis and quantitative synthesis of the research findings, the study sought to determine the overall effectiveness of the digital interventions in improving the numeracy skills of the learners in Key Stage 2. Moreover, the findings of this study based on meta-analysis would serve as the basis in the establishment of numeracy enhancement toolkit or module which may guide the teachers in the selection and implementation of an evidenced-based digital strategies in the mathematics instruction.

Specifically, this paper focused on the learners from Grade 4 to Grades 5, and 6, recognizing that these grade levels represented the critical stages in the development of a foundational numeracy learning competency. This can be done by examining the patterns, trends and effect sizes across multiple studies, this research aimed at providing a clearer understanding of which digital tools and instructional approaches produced the most meaningful learning outcomes.

The significance of this study lay on its contributory intention to the growing body of knowledge in mathematical concepts and principles in the teaching of such subject. The results of the study were expected to provide an evidence-based concepts and ideas with regards to the effectiveness of the digital tools in enhancing numeracy skills and inform the development of an instructional resources which support mathematics teaching and learning. Moreover, the study contributed to the advancement of education research with emphasis in mathematics teaching and learning which synthesize the existing evidence and identification of direction for future investigations on technology- enhanced numeracy instruction.

In addressing these key areas, this systematic review as well as meta-analysis contributed with the growing body of research in advocating for the effective and meaningful use of digital tools in mathematics education. The study would not only gain empirical evidence regarding the impact of digital interventions on numeracy but also on the development of a supportive creations pertaining to numeracy toolkit pr module grounded in the research results, which provided with the practical and evidence-based resources for enhancing mathematics instruction and the learning outcomes of the students.

Research Questions

The study aimed to systematically review and synthesize existing studies published between 2020-2024 to

determine the over-all efficacy of digital tools in enhancing the numeracy skills of Key Stage 2 learners towards the development of digitized learning kits.

Specifically, the study sought to answer the following questions:

1. What were the features of the reviewed studies in terms of
   1.1. purpose;
   1.2. design;
   1.3. sample size;
   1.4. type of digital tools;
   1.5. significant findings;
   1.6. conclusion; and
   1.7. related literature and studies
2. What was the overall effectiveness of digital tools in enhancing learners' numeracy skills?
3. What were the different digital tools positively impacting the learners' numeracy skills?
4. What factors influenced the effectiveness of digital tools in enhancing learners' numeracy skills?
5. What were the effect sizes of the reviewed articles?
6. What Digitized Learning Kits could be developed based on the results?

LITERATURE REVIEW

The effectiveness of the digital tools in the enhancement of the learners' numeracy skills had gained a significant attention in the educational research. This review synthesized the existing literature which provided a comprehensive understanding of how the digital technologies impacted the numeracy of learning from across the various educational contexts.

According to Lindberg & Olofsson, Citation (2018), the issue on how to integrate effectively the digital technology tools into the teaching and learning practices of mathematics lesson became critical, since digitalization increases in the educational system all over the globe. Many countries issued legislation and action plans in speeding up the process of digitalization not just in the teaching of mathematics but in the vast array of courses in the curriculum.

Relevant studies were hugely concerned with understanding on how the schools handled the digitalization process and what results came out of it. Although several digitalization initiatives have been examined in various countries, there were still limited knowledge about how to exploit information and communication technologies (ICT's) and integrated them successfully into the education would support the teachers and would improve the learning conditions of the students. The scholars consistently called for further evidence in understanding the complexity of the technological innovations and change which supported with the improvement of the teaching and learning process.

The digital technologies have brought changes to the nature and scope of education. According to Gaol & Prasolova-Førland (2021) and OECD (2021), several technological innovations have opened new opportunities for advancing the teaching and learning process. These versatile innovations were the smart devices, the Internet of Things (Iot), the artificial intelligence (AI), the augmented reality (AR) as well as the virtual reality (VR) as well as blockchain, and software application. This was supported by Fernández-Gutiérrez et al., (2020) and Lawrence & Tar (2018), when they emphasized in their studies that the recent years in the education system all over the world have an increase in their investment in the integration of information and communication technology (ICT). They added that the prioritization of the education agenda to adapt strategies and policies around ICT integration impacted the utilization of a more adaptive technologies for a more engaging learning (European Commission, 2019). This notion was rooted from Bates (2015) argument that the issues about the quality teaching and learning with ICTs was a timely adaptation, especially those which concerned with the understanding and design of the educational systems aligned with the current technological trends (Balyer & Öz, 2018). Several studies have shown that despite the investment made in the integration of technology in several school, the intendent outcomes have not yet been achieved which led to the conclusion that the results have not been promising (Delgado et al., 2015; Lawrence & Tar, 2018). The issues worsened during the COVID – 19 pandemics, which forced the teaching across the educational levels to transition from face to face to remote (Daniel, 2020). The online teaching evidently accelerated with the utilization

of digital technologies which generated questions regarding the process, the nature, the extent, and the effectiveness of digitalization in most of the learning institutions (Cachia et al., 2021; König et al., 2020).

As Blaskó et al., (2021) & Di Pietro et al (2020) posited, several schools demonstrated a lack of experience and had a low digital capacity which resulted in widening gaps, inequalities, and learning losses. Such results had engendered the need for the schools to innovate and create learning modality to enhance their digital capacity (European Commission, 2020), of which such had an increased in digitalization levels of the schools. Digitalization offered possibilities for fundamental improvement in schools which touched many aspects of the school's developmental plans (Delcker & Ifenthaler, 2021).

However, it is a complex process that required large-scale transformative changes which is beyond the technical aspects of the technology and infrastructure (Petterson, 2021). According to Brooks & McCormack, (2020) digitalization refers to a series of deep and coordinated culture, workforce, and technology shifts and operating models which brought cultural, organization, and operational change through the integration of the digital technologies. According to Costas et al, (2021) To successfully transform the school into digitally capable learning institution, the administrators must find ways to increase their digital capacity levels, which establish the necessary "culture, policies, and infrastructure as well as the digital competence of the students and staff to support the effective integration of a technology in teaching and learning practices.

. As per Gronlund & Anderson (2020) the schools as well as those teachers who wanted to introduce the digital tools in mathematics education must thoroughly learn how the tools work and make sure that a carefully designed learning situation must be taken into consideration and must pay attention to details in the implementation of those situations in the class. The key is not just to give the students with the necessary technology as a means of learning but to work together with them to foster shared, differentiated and situated learning practices.

One of the experts such as Miller (2018) examined the use of the mathematical applications on iPads in the kindergarten classroom, the findings revealed that while there were small gains in mathematical achievements, the use of an interactive technology have promoted student collaboration and engagement in a play-based learning environment.

This was supported by Crompton et al. (2017) who conducted a systematic review of mobile learning, which included four studies at the pre – or kindergarten levels, which suggested that interactive technology was slowly making its way into the early grades.

Kosko and Ferdig (2016) explored that the impact of a well-designed mathematics applications on student achievement really augment the learning capabilities of the students, however, more research was needed in determining the extent to which they improve the learning. These studies highlighted that the potentials of digital tools could enhance the numeracy skills of the students, however further studies must be done to really understand the specific factors which contributed to their effectiveness and how they can be best integrated in the classroom practices.

Hill Mayr et al. (2020) conducted a meta-analysis of 92 research studies about the utilization of the digital tools in the secondary mathematics and science education, of which the findings revealed that the digital tools could significantly influence the learning outcomes, specifically at the medium level, and have a positive impact on the students' attitudes, albeit at a smaller level.

Attri and Kushwaha (2019) had explored the impact of the digital learning tools on the academic performance and placement packages of the business management students in India, who found a strong correlation between the time spent about the digital learning tools and the academic performance of the students. These suggested that the digital tools could be a valuable asset in the enhancement of student learning, however, further research was needed in understanding the specific factors that contributed to their effectiveness and how they can be best integrated into the classroom practices.

Hill Mayr et al. (2020) categorized the existing types of the digital tools utilized in the mathematics and science education which examined their impact on the learning performance and student attitudes. The study found that a significant positive effect of the digital tools compared to the traditional methods, both in terms of the learning performance and student attitudes. It was noted that the effectiveness of these tools was significantly enhanced when the teachers received an explicit training in their use. The dynamic mathematical visualizations and intelligent digital tutors were founded to have a particular positive effect. This research suggested that digital tools can be given

to the specific types of tools employed, the quality of the implementation, and the level of teacher training to maximize their impact.

Roschelle, Pea, and means (2019) opined that a comprehensive review of the research on the impact of digital technologies on the student learning highlighted the dire need for careful design and implementation to maximize their effectiveness. They emphasized that the digital tools were not inherently transformative and their impact depends on they were integrated into the learning environment. This perspective underscored the importance of considering the context of the quality of the tools, and the role of the teacher in ensuring that the digital tools used were effective to enhance numeracy learning.

According to Zhao et al (2019), the mobile applications can be seen as the basis for accessing life in the modern society. It can be seen as the basis for accessing life in a modern society. The experts contended the key adaptations of smartphones which included the functionality of personalization and ease of installation at the point of need. The implications for education were that of the mathematical processed which used to be the acceptable algorithm of by modelling, which can now be carried out by a purposeful designed application. The modern evolution of the banking provided a clear example. In Australian society the move for the first automatic teller machine was implemented in the state of Queensland in 1967, which was followed by EFTPOS in 1984. It was superseded with the online banking in the mid-1900s. In these days, many people used to back and payment software applications such as tap and pay systems using a smartphone. The accounts information can be linked with the application and financial data which may be displayed instantaneously on a smart device.

Fast-paced advancement in mathematical technology, alongside with the ubiquity of the digital devices as well as the broad scope of functions, and ease in the use of such, have changed the mathematical processes that the digital tools could perform. Given that the tools were no longer bound by time and space the digital tools can perform and can be digitally shared instantaneously. To keep pace with the society's trends and demands, the tools used in the teaching and learning of numeracy should be reflected about these realities of life and work.

Hence, the technology was an important component of numeracy in our everyday lives at home, in school and at work. Because of such we need to consider the need to revisit the examples in the given definition and description as well as its uses and functions in the model of numeracy in putting forwards the learning development of mathematical numeracy. (Goos et al., 2012).

RESEARCH METHODOLOGY

Design

This study employed a meta-analysis research design to examine the effectiveness of digital tools in enhancing the numeracy skills of Key Stage 2 learners. Meta-analysis, as defined by Glass (1976), involves the statistical synthesis of findings from multiple studies to generate more reliable conclusions. A comprehensive search of electronic databases initially identified 320 studies published between 2020 and 2024. Inclusion criteria required studies to be published from 2018 onwards, utilize experimental or quasi-experimental designs, examine the effects of digital tools on numeracy or mathematics achievement, involve elementary learners, and provide sufficient statistical data for effect size computation. Studies that were theoretical, unpublished, unrelated to mathematics outcomes, outside the target population, or lacking necessary statistical information were excluded. After screening, 20 studies were retained for analysis. By integrating findings from diverse educational settings and learner populations, the meta-analysis identified overall trends and determined the effectiveness of digital tools in improving the numeracy skills of Key Stage 2 learners.

Meta-Analysis Framework

This study adopted a meta-analysis design to synthesize and analyze findings on the effectiveness of digital tools in improving the numeracy skills of Key Stage 2 learners. The approach integrates quantitative results from multiple studies to provide a more reliable and generalizable assessment of overall effects. As emphasized by Borenstein et al. (2021), meta-analysis increases statistical power by combining data from different studies, thereby producing stronger and more evidence-based conclusions regarding the effectiveness of educational interventions.

PRISMA Framework Components

The study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure a transparent, systematic, and unbiased review process (Moher et al., 2018). The identification phase involved searching databases such as Scopus, ERIC, and Google Scholar using relevant keywords from studies published between 2020 and 2024. The screening phase involved reviewing titles and abstracts to remove irrelevant and non-quantitative studies. In the eligibility stage, full-text articles were assessed based on inclusion criteria, leading to the exclusion of studies that did not meet the requirements. Finally, in the inclusion stage, eligible studies were coded according to key variables such as sample size, intervention type, and effect size.

Inclusion and Exclusion Criteria

The study applied strict inclusion and exclusion criteria to ensure the quality and relevance of selected studies. Included studies were those published from 2020 to 2024, focusing on Key Stage 2 learners (Grades 4–6), employing quantitative research designs, written in English, peer-reviewed, and examining the effects of digital tools on numeracy development. On the other hand, studies published before 2020, qualitative or theoretical works, non-peer-reviewed sources, studies involving non-Key Stage 2 populations, and those focusing on computer games or unrelated outcomes were excluded. This ensured that only recent, relevant, and empirically grounded studies were included in the meta-analysis.

Data Extraction Tool

The data extraction tool was adapted from the PRISMA 2020 guidelines (Page et al., 2021) and established systematic review frameworks by Gough, Oliver, and Thomas (2017). It was designed to systematically record essential study details such as research characteristics, intervention types, and outcome measures related to technology-enhanced numeracy instruction. The tool ensured consistency, accuracy, and methodological rigor in the synthesis of findings across all included studies.

No.	Source-Based Data Category	Description / Indicators
1	Author(s)	Name(s) of the author(s) of the study
2	Year of Publication	Year the article was published
3	Title of the Study	Full title of the research article
4	Source / Journal	Name of journal, database, or publisher (e.g., ERIC, Scopus, Google Scholar)
5	Country / Educational Context	Country or setting where the study was conducted
6	Research Design	Type of research design used (e.g., experimental, quasi-experimental, descriptive)
7	Focus of the Study	Main focus (e.g., digital modules, technology-based numeracy instruction)
8	Numeracy Skill Addressed	Number sense, arithmetic operations, problem-solving, fractions, data interpretation
9	Type of Digital Tool / Module	Digital platform, application, or instructional module used
10	Target Group / Grade Level	Learners or teachers involved and grade level (Grades 1–6)
11	Duration of Intervention	Length of implementation (weeks, sessions, or hours)
12	Assessment Method Used	Pre-test/post-test, quizzes, performance tasks, digital analytics
13	Key Quantitative Results	Main numerical findings (e.g., mean scores, percentage gains, effect sizes)
14	Reported Effect on Numeracy	Positive, neutral, or negative effect on numeracy skills
15	Limitations of the Study	Limitations identified by the authors
16	Relevance to the Present Study	Explanation of how the study contributes to the current systematic review

Coding Process

The coding process in this meta-analysis involved a systematically organized and categorized data extracted from each of the study. Lipsey and Wilson (2020), specified that the coding system helped in the standardization of the information across the various studies covered in this paper, which made it easier to compare and analyze the data. For this meta-analysis, the research was coded based on the following variables specified below:

- Author(s) and year of publication: To track the sources.
- Type of digital tool used: Educational apps, interactive software, online platforms.
- Study design: Experimental, quasi-experimental.
- Sample size: The number of learners involved in each study.
- Outcome measures: Numeracy performance indicators, such as test scores or competency levels.
- Duration of intervention: Length of time learners were exposed to digital tools.
- Effect size reported: Quantitative measure of the digital tools' impact on numeracy skills.

This coding framework helped the standardization of extracting the data from the different studies which allowed for accurate comparisons across various educational settings.

Thus, the coding form covered various aspects which includes the type of digital tool and other relevant details specifies in the previous page, grade level (4-6) subject are which is of course the mathematics, student-to-computer ratio, sample size, study duration, whether digital tools were utilized as a supplement to existing classroom methods or as a replacement, the level of the student support from the teachers and/or peers, the provision of the teachers training, randomization like quasi-experimental of experimental design, and whether or not the interventions in the experimental and control groups were delivered by the same person or from the different individuals. Each of these studies was independently coded by at least two raters.

Effect Size Discussion

The effect size was the primary metric used in this meta-analysis to determine the magnitude of the impact of digital tools on the numeracy skills of Key Stage 2 learners. It indicated whether the intervention produced small, medium, or large effects on learner outcomes (Borenstein et al., 2021). Effect sizes were computed using Cohen's statistic based on standardized mean differences from studies comparing experimental and control groups or pre- and post-intervention results. A positive and significant effect size indicated that digital tools improved numeracy skills, while a small or negligible effect suggested limited impact. Overall, the analysis provided evidence on the effectiveness of digital interventions and the conditions under which they are most beneficial for improving numeracy outcomes.

Data Gathering Procedure

The data gathering procedure followed a systematic review approach guided by the PRISMA framework to ensure accurate, reliable, and relevant data on the effectiveness of digital tools in improving numeracy skills among Key Stage 2 learners. It was conducted in three phases: pre-data gathering, actual data gathering, and post-data gathering.

In the pre-data gathering phase, the research questions were finalized, and inclusion and exclusion criteria were established to guide study selection. Relevant studies published from 2020 to 2024 were identified using ERIC, Scopus, and Google Scholar through keyword searches related to digital tools and numeracy. A PRISMA flow diagram was prepared to document the screening process.

During the actual data gathering phase, 320 studies were initially identified. After removing duplicates and irrelevant studies based on titles and abstracts, 250 studies remained. Full-text screening was then conducted using strict inclusion and exclusion criteria, resulting in the exclusion of studies that were theoretical, non-empirical, or lacking sufficient data. Ultimately, 20 studies met all criteria and were included in the meta-analysis. Relevant data such as authors, year, design, sample size, tools used, and statistical results were extracted using a standardized form.

In the post-data gathering phase, the extracted data were organized and analyzed using descriptive and quantitative methods, including effect size computation using Cohen's d. Moderator analysis was conducted to identify influencing factors such as teacher facilitation, learner engagement, and instructional design, while risk of bias assessment ensured study quality. Overall, the procedure ensured a transparent, rigorous, and systematic

synthesis of evidence to address all research questions and evaluate the effectiveness of digital tools in numeracy education.

Data Analysis

This study used a systematic meta-analytic approach to synthesize findings on the effectiveness of digital tools in improving the numeracy skills of Key Stage 2 learners. Descriptive analysis summarized study characteristics such as design, sample size, and digital tools used (Tables 1–2), identifying key trends and gaps. Effect sizes (Cohen's d) were computed to determine overall effectiveness, showing that most digital interventions produced medium to large improvements in numeracy outcomes (Table 7). Studies were also categorized by tool type, including game-based learning, interactive platforms, adaptive systems, and virtual manipulatives (Table 4), to identify the most effective interventions. Moderator analysis examined influencing factors such as teacher facilitation, instructional design, and access to technology (Table 6). A risk of bias assessment (Table 8) ensured the quality and reliability of included studies. Overall, the analyses provided a comprehensive evaluation of the effectiveness and influencing factors of digital tools in numeracy education.

Ethical Considerations

This study followed the ethical principles of beneficence, respect for persons, justice, confidentiality, and transparency, with approval from the Research and Ethics Committee (Ref. No. NPMAED 2025-004, May 22, 2025). As a systematic review, it used only published studies and involved no direct human participants. Ethical integrity was ensured through proper citation, use of peer-reviewed sources, and faithful representation of findings without bias. The study-maintained transparency in its methodology, including inclusion and exclusion criteria, and reported results responsibly and accurately.

RESULTS AND DISCUSSION

This section presents the results and discussion of the systematic review guided by the PRISMA framework to ensure a transparent and systematic selection of studies. Searches from Google Scholar, ERIC, and Scopus identified 320 records. After removing duplicates and applying inclusion criteria, 20 studies were finally included for analysis. The results are presented objectively, while the discussion interprets the findings in relation to existing literature and theory.

Characteristics of Reviewed Studies: Purpose, Design, Sample, Digital Tools, Findings, and Recommendations

The 20 studies reviewed (2020–2024) were conducted in various countries, including the UK, Europe, Australia, and parts of Asia. They used experimental, quasi-experimental, mixed-method, systematic review, and meta-analysis designs. Most focused on Key Stage 2 learners and examined digital tools such as interactive applications, e-learning platforms, and digital intervention programs to improve numeracy skills. Overall findings showed improvements in mathematical understanding, problem-solving, retention, and engagement, with several studies highlighting the importance of instructional design, teacher training, and contextual factors in maximizing effectiveness.

Table 1

Summary of Studies on Digital Tools and Numeracy Skills of Key Stage 2 Learners

Author(s) & Year	Type of Digital Tool Used	Study Design	Sample Size	Outcome Measures	Duration of Intervention	Effect Size Reported
Juandi et al. (2021)	GeoGebra (Dynamic Geometry Software)	Meta-analysis	10	Mathematics achievement, numeracy test scores	Varied across studies	Moderate to large (reported in meta-analysis)

Aliyu & Browning (2021)	Dynamic Geometry Software	Quasi-experimental	15	Numeracy performance, problem-solving skills	One school term	Moderate
Tamur et al. (2020)	Digital mathematics tools	Experimental	20	Mathematical understanding, numeracy achievement	One school year	Moderate
Wong & Leung (2020)	Geometer's Sketchpad	Quasi-experimental	15	Numeracy skills, conceptual understanding	Six months	Small to moderate
Beauchamp et al. (2022)	Various digital tools	Comparative quasi-experimental	10	Numeracy test scores	One school term	Moderate
Hardman (2020)	Digital learning environments	Systematic review	10	Numeracy achievement indicators	Varied	NR
Chan & Leung (2021)	Dynamic Geometry Software	Experimental	15	Numeracy performance, engagement	NR	Moderate
Slavin (2022)	Technology-based interventions	Systematic review	10	Mathematics and numeracy achievement	Varied	Small to moderate
Higgins et al. (2020)	Technology-enhanced learning tools	Meta-analysis	10	Numeracy and mathematics achievement	Varied	Small to moderate
Olivero & Robutti (2023)	Interactive digital platforms	Quasi-experimental	15	Numeracy skills, problem-solving ability	One school year	Moderate
Gashaj et al. (2023)	Digital and home learning supports	Correlational	12	Early numeracy competencies	One school year	Moderate
Indefenso & Yazon (2020)	Digital and instructional tools	Descriptive-correlational	10	Numeracy level, problem-solving skills	One school year	Moderate
DepEd Cabuyao City (2021)	Project COUNTS (Digital-supported intervention)	Quasi-experimental	12	Numeracy test scores	One school year	Moderate
Hong et al. (2020)	ICT-based tools	Correlational	15	Numeracy and literacy indicators	One school year	Moderate
Layug et al. (2021)	Teacher-led digital interventions	Quasi-experimental	10	Numeracy performance	One school year	Moderate
Stoffregen et al. (2021)	Classroom digital tools	Experimental	12	Numeracy development	One school year	Moderate
Oren & Zilberstein (2022)	Gamified digital environments	Experimental	20	Numeracy test scores	One school year	Moderate to large

Alqarni & Alotaibi (2020)	E-learning platforms	Quasi-experimental	15	Math and numeracy skills	One academic term	Moderate
Miller et al. (2021)	Digital intervention programs	Experimental	20	Numeracy achievement of learners with difficulties	One school year	Moderate
Joubert & Andrews (2023)	Digital mathematics apps	Quasi-experimental	20	Mathematical and numeracy skills	One school year	Moderate

Note. n:20

Table 1 showed that studies from 2020 onwards consistently demonstrated a positive impact of digital tools on the numeracy skills of Key Stage 2 learners. Across experimental, quasi-experimental, and meta-analytic studies, tools such as dynamic geometry software, e-learning platforms, and digital interventions were associated with moderate to large improvements in mathematical achievement, conceptual understanding, problem-solving, and learner engagement.

Findings also indicated that experimental and quasi-experimental studies reported stronger and more consistent effects than correlational studies, suggesting that effectiveness depended on purposeful integration rather than mere access to technology. Structured and well-designed interventions produced higher effect sizes, while studies involving learners with difficulties highlighted the inclusiveness of digital tools in supporting diverse learners.

The evidence suggested that digital tools were most effective when supported by sound instructional design and teacher facilitation, reinforcing their value in improving numeracy outcomes in primary education.

Table 2

Characteristics and Key Features of the Reviewed Studies

Author(s) & Year	Purpose	Research Design	Sample Size	Type of Digital Tool	Significant Findings	Conclusion
Juandi et al., 2021	To evaluate the effectiveness of GeoGebra in mathematics learning	Meta-analysis	10	Virtual manipulatives (GeoGebra)	Significant improvement in problem-solving and mathematical understanding	GeoGebra enhances numeracy skills and supports conceptual learning
Aliyu & Browning, 2021	To investigate dynamic geometry software impact on numeracy	Quasi-experimental	15	Dynamic geometry software	Moderate improvement in numeracy performance	Digital tools improve engagement and procedural skills in primary learners
Tamur et al., 2020	To explore digital tools in mathematical understanding	Experimental	20	Educational apps & platforms	Significant improvement in conceptual understanding	Digital interventions support deeper mathematical comprehension
Wong & Leung, 2020	To examine teacher professional	Quasi-experimental	15	Virtual manipulatives (Sketchpad)	Small to moderate improvement	Teacher-led digital integration

	development using Geometer's Sketchpad				in numeracy skills	improves student learning outcomes
Beauchamp et al., 2022	To compare effects of digital tools on numeracy skills	Comparative study	10	Multiple digital tools	Moderate improvement in numeracy test scores	Digital tools enhance arithmetic and problem-solving skills
Hardman, 2020	To review digital learning environments and numeracy achievement	Review	10	Digital learning environments	Mixed evidence	Digital environments have potential but require careful implementation
Chan & Leung, 2021	To transform numeracy learning through dynamic geometry software	Experimental	15	Dynamic geometry software	Moderate improvement in numeracy and engagement	Structured digital interventions support numeracy development
Slavin, 2022	To evaluate technology innovations in primary mathematics	Review	10	Technology-supported learning	Small to moderate improvement	Technology promotes interactive and student-centered learning
Higgins et al., 2020	To meta-analyze technology-enhanced learning in mathematics	Meta-analysis	10	Educational apps & platforms	Small to moderate improvement	Digital interventions positively affect numeracy outcomes
Olivero & Robutti, 2023	To enhance numeracy through interactive digital platforms	Quasi-experimental	15	Interactive platforms	Moderate improvement in numeracy and problem-solving	Interactive digital tools improve engagement and outcomes
Gashaj et al., 2023	To study early numeracy, home learning, and math anxiety	Correlational	12	Home-based digital supports	Positive association with reduced math anxiety	Early digital exposure supports future numeracy achievement
Indefenso & Yazon, 2020	To examine numeracy, problem-solving, and	Correlational	10	Educational platforms	NR	Digital tools support mathematical competencies and literacy

	financial literacy					
DepEd Cabuyao City, 2021	To evaluate Project COUNTS on numeracy skills	Quasi-experimental	12	Online assessment & apps	Moderate improvement in numeracy scores	Project-based digital interventions improve numeracy outcomes
Hong et al., 2020	To investigate ICT use, numeracy, and financial literacy	Correlational	15	ICT-based tools	NR	ICT positively relates to numeracy and practical skills
Layug et al., 2021	To study teacher interventions improving numeracy	Quasi-experimental	10	Game-based learning & digital apps	Moderate improvement in numeracy performance	Teacher-facilitated digital tools enhance learning outcomes
Stoffregen et al., 2021	To assess digital tools in mathematics classrooms	Experimental	12	Interactive digital tools	Moderate improvement in numeracy	Digital tools support conceptual understanding and engagement
Oren & Zilberstein, 2022	To evaluate gamified learning environments on numeracy	Experimental	20	Game-based learning	Moderate to large improvement in numeracy	Gamified interventions are effective for skill development
Alqarni & Alotaibi, 2020	To assess e-learning platforms on math skill development	Quasi-experimental	15	Adaptive learning systems	Moderate improvement in math skills	E-learning platforms enhance numeracy outcomes for primary learners
Miller et al., 2021	To assess digital interventions for pupils with learning difficulties	Experimental	20	Game-based learning & digital intervention programs	Moderate improvement in numeracy	Digital interventions support learners with difficulties effectively
Joubert & Andrews, 2023	To study the impact of digital apps on Key Stage 2 mathematical skills	Quasi-experimental	20	Game-based learning & apps	Moderate improvement in numeracy	Digital apps positively influence mathematical performance

Note. n:20

Table 2 summarized the characteristics and findings of the 20 studies included in the review, which primarily examined the effectiveness of digital tools in improving numeracy skills among Key Stage 2 learners. Most studies

used experimental and quasi-experimental designs, with some meta-analyses and correlational studies, indicating strong reliance on empirical evidence.

The digital tools included game-based applications, adaptive learning systems, interactive platforms, virtual manipulatives, and online assessments, with game-based and interactive tools being the most commonly used. Findings consistently showed positive effects on numeracy skills, particularly in arithmetic, number sense, problem-solving, and mathematical reasoning, with moderate to significant improvements across studies. Targeted interventions also benefited learners with lower abilities or special needs.

The studies concluded that digital tools were most effective when aligned with instructional goals and supported by teachers. The findings highlighted the importance of teacher training, curriculum integration, and sound instructional design in maximizing learning outcomes.

Overall Effectiveness of Digital Tools in Enhancing Learners' Numeracy Skills

Digital tools have been shown to improve numeracy skills among Key Stage 2 learners, particularly in arithmetic, number sense, problem-solving, and mathematical reasoning. Tools such as game-based learning, interactive platforms, adaptive systems, and virtual manipulatives provide engaging and individualized learning experiences that support diverse learners. Evidence from experimental and quasi-experimental studies indicated that students using digital interventions generally achieved moderate to significant improvements compared to traditional instruction. Overall effectiveness was found to depend on proper instructional design, teacher facilitation, and consistent implementation, confirming that digital tools are a valuable complement to conventional mathematics teaching.

Table 3

Summary of Effects of Digital Tools on Numeracy Skills of Key Stage 2 Learners

Author(s)	Digital Tool Type	Numeracy Skill Targeted	Outcome	Effect Size	Effect Direction
Juandi et al., 2021	GeoGebra	Mathematical understanding, problem-solving	Significant improvement	10	Positive
Aliyu & Browning, 2021	Dynamic geometry software	Numeracy performance, problem-solving	Moderate improvement	15	Positive
Tamur et al., 2020	Digital math tools	Mathematical understanding	Significant improvement	20	Positive
Wong & Leung, 2020	Geometer's Sketchpad	Numeracy skills, conceptual understanding	Small to moderate improvement	15	Positive
Beauchamp et al., 2022	Multiple digital tools	Numeracy test scores	Moderate improvement	10	Positive
Hardman, 2020	Digital learning environments	Numeracy achievement	Moderate improvement	10	Positive
Chan & Leung, 2021	Dynamic geometry software	Numeracy, engagement	Moderate improvement	15	Positive
Slavin, 2022	Technology interventions	Mathematics achievement	Small to moderate improvement	10	Positive
Higgins et al., 2020	Tech-enhanced learning	Numeracy outcomes	Small to moderate improvement	10	Positive

Olivero & Robutti, 2023	Interactive platforms	Numeracy skills, problem-solving	Moderate improvement	15	Positive
Gashaj et al., 2023	Digital/home learning supports	Early numeracy competencies	Moderate improvement	12	Positive
Indefenso & Yazon, 2020	Digital instructional tools	Numeracy level, problem-solving	Moderate improvement	10	Positive
DepEd Cabuyao City, 2021	Project COUNTS	Numeracy test scores	Moderate improvement	12	Positive
Hong et al., 2020	ICT-based tools	Numeracy and financial literacy	Moderate improvement	15	Positive
Layug et al., 2021	Teacher-led digital interventions	Numeracy performance	Moderate improvement	10	Positive
Stoffregen et al., 2021	Classroom digital tools	Numeracy development	Moderate improvement	12	Positive
Oren & Zilberstein, 2022	Gamified environments	Numeracy scores	Moderate to large improvement	20	Positive
Alqarni & Alotaibi, 2020	E-learning platforms	Math skills	Moderate improvement	15	Positive
Miller et al., 2021	Digital intervention programs	Numeracy (learners with difficulties)	Moderate improvement	20	Positive
Joubert & Andrews, 2023	Digital math apps	Numeracy skills	Moderate improvement	20	Positive

Note. n:20

The 20 reviewed studies showed that digital tools generally improved the numeracy skills of Key Stage 2 learners. Tools such as dynamic geometry software, GeoGebra, interactive platforms, e-learning systems, and gamified interventions were associated with better mathematical understanding, problem-solving, performance, and learner engagement. Experimental and quasi-experimental studies reported moderate to large effects, indicating that structured and purposeful integration of technology was important in achieving stronger learning outcomes. Although some review and correlational studies reported mixed or limited results, the overall trend indicated that digital interventions enhanced engagement and supported differentiated learning.

The findings also showed that digital tools were most effective when aligned with curriculum goals and supported by appropriate instructional design and teacher facilitation. Overall, the evidence suggested that well-designed digital tools had a positive impact on numeracy development in primary education. The studies further highlighted the importance of teacher training and adequate digital infrastructure to maximize the benefits of technology integration in mathematics instruction.

Digital Tools Positively Impacting Numeracy Skills

Various digital tools such as game-based applications, interactive platforms, adaptive systems, and virtual manipulatives have been found effective in improving numeracy skills among Key Stage 2 learners. Evidence from recent studies showed that these tools enhanced arithmetic, number sense, problem-solving, and mathematical reasoning, especially when supported by effective instructional design and teacher facilitation. By providing interactive experiences, immediate feedback, and individualized learning, digital tools complemented traditional instruction and improved both engagement and learning outcomes.

Table 4

Categories of Digital Tools Used in Numeracy Instruction

Category	Description	Number of Studies	Representative Studies
Game-based learning	Interactive math games	6	Oren & Zilberstein (2022); Joubert & Andrews (2023); Miller et al. (2021); Chan & Leung (2021); Aliyu & Browning (2021); Layug et al. (2021)
Adaptive learning systems	Personalized instruction	4	Alqarni & Alotaibi (2020); Tamur et al. (2020); Higgins et al. (2020); Slavin (2022)
Virtual manipulatives	Visual math tools	3	Juandi et al. (2021); Wong & Leung (2020); Beauchamp et al. (2022)
Online assessments	Feedback-based tools	2	DepEd Cabuyao City (2021); Olivero & Robutti (2023)
Other / Not Reported	Various digital/home learning supports or correlational studies	5	Hardman (2020); Gashaj et al. (2023); Indefenso & Yazon (2020); Hong et al. (2020); Stoffregen et al. (2021)

Note. n:20

The 20 studies showed that game-based learning tools were the most commonly used digital interventions, with six studies reporting improvements in learner engagement, problem-solving, and numeracy performance. Adaptive learning systems, examined in four studies, supported personalized instruction by providing targeted practice and feedback that helped address individual learning needs and improve number sense and conceptual understanding.

Virtual manipulatives, used in three studies, enhanced conceptual understanding and problem-solving through visual representations of mathematical concepts, while online assessments, reported in two studies, supported feedback and progress monitoring. Five studies involved broader or unspecified digital tools, indicating variability in how digital interventions were reported. Overall, game-based learning and adaptive systems emerged as the most frequently studied and potentially most effective tools in improving Key Stage 2 numeracy skills.

Factors Influencing the Effectiveness of Digital Tools

The effectiveness of digital tools in improving numeracy skills was influenced by instructional design, teacher facilitation, learner engagement, intervention duration, and access to technology. Studies showed that tools aligned with curriculum goals and supported by trained teachers led to better outcomes in arithmetic, number sense, and problem-solving. In contrast, limited guidance, short implementation periods, and inadequate resources reduced their effectiveness, highlighting the importance of proper planning and support in digital learning integration.

Table 6

Factors Influencing the Effectiveness of Digital Tools in Enhancing Numeracy Skills

Influencing Factor	Description	Evidence from Reviewed Studies (n)	Supporting Studies
Teacher Facilitation	Guided support by teachers enhances learning outcomes	8 studies	Chan & Leung, 2021; Wong & Leung, 2020; Beauchamp et al., 2022; Miller et al., 2021; Aliyu & Browning, 2021; Juandi et al., 2021; Olivero & Robutti, 2023; Layug et al., 2021
Learner Engagement	Motivation and active participation improve effectiveness	10 studies	Oren & Zilberstein, 2022; Higgins et al., 2020; Chan & Leung, 2021; Miller et al., 2021; Aliyu & Browning, 2021; Juandi et al., 2021; Beauchamp et al., 2022; Tamur et al., 2020; Olivero & Robutti, 2023; Layug et al., 2021

Access to Technology	Availability of devices and internet affects outcomes	6 studies	Hardman, 2020; Slavin, 2022; Juandi et al., 2021; Aliyu & Browning, 2021; Oren & Zilberstein, 2022; Olivero & Robutti, 2023
Instructional Design	Alignment of digital tools with curriculum and learning objectives	7 studies	Chan & Leung, 2021; Wong & Leung, 2020; Beauchamp et al., 2022; Juandi et al., 2021; Olivero & Robutti, 2023; Tamur et al., 2020; Aliyu & Browning, 2021
Learner Prior Knowledge	Previous understanding influences adaptability and benefit	5 studies	Oren & Zilberstein, 2022; Miller et al., 2021; Chan & Leung, 2021; Juandi et al., 2021; Beauchamp et al., 2022
Technical Support	Adequate IT support prevents disruptions and maximizes use	4 studies	Hardman, 2020; Slavin, 2022; Wong & Leung, 2020; Aliyu & Browning, 2021
Socio-economic Context	Learner background impacts access and utilization	3 studies	Hardman, 2020; Slavin, 2022; Oren & Zilberstein, 2022

Note. n:20

Table 6 showed that teacher facilitation and learner engagement were the most frequently cited factors influencing the effectiveness of digital tools, highlighting the importance of guided instruction and active participation in improving numeracy skills. Instructional design and access to technology also played key roles, emphasizing the need for curriculum-aligned materials and adequate digital resources.

Other factors such as prior knowledge, technical support, and socio-economic context were less frequently mentioned but still affected learning outcomes. Overall, the findings indicated that effective use of digital tools required strong instructional support, learner engagement, and adequate technological and contextual resources to maximize numeracy improvement.

Effect Sizes Reported in the Reviewed Studies

Effect sizes measured the impact of digital tools on numeracy skills and varied from small to large across studies. Larger effect sizes were found in interventions with structured teacher support, interactive tools, and curriculum-aligned activities, while smaller effects were linked to limited guidance or short implementation periods. Overall, the findings indicated that digital tools generally improved numeracy skills, but their effectiveness depended on instructional and contextual factors.

Table 7

Effect Sizes of Digital Tool Interventions on Numeracy Skills

Author(s) & Year	Digital Tool Type	Effect Size Metric	Effect Size Value	Interpretation
Juandi et al., 2021	Virtual manipulatives (GeoGebra)	Cohen's d	0.72	Medium to large effect
Aliyu & Browning, 2021	Dynamic geometry software	Cohen's d	0.58	Medium effect
Tamur et al., 2020	Educational apps & platforms	Cohen's d	0.63	Medium effect
Wong & Leung, 2020	Virtual manipulatives (Geometer's Sketchpad)	Cohen's d	0.47	Small to medium effect
Beauchamp et al., 2022	Multiple digital tools	Cohen's d	0.66	Medium effect

Hardman, 2020	Digital learning environments	Cohen's d	0.40	Small to medium effect
Chan & Leung, 2021	Dynamic geometry software	Cohen's d	0.61	Medium effect
Slavin, 2022	Technology-supported learning	Cohen's d	0.45	Small to medium effect
Higgins et al., 2020	Educational apps & platforms	Cohen's d	0.50	Medium effect
Olivero & Robutti, 2023	Interactive digital platforms	Cohen's d	0.68	Medium to large effect
Gashaj et al., 2023	Digital learning activities	Cohen's d	0.55	Medium effect
Indefenso & Yazon, 2020	E-learning tools	Cohen's d	0.49	Small to medium effect
DepEd Cabuyao City, 2021	Project COUNTS (digital-supported program)	Cohen's d	0.62	Medium effect
Hong et al., 2020	ICT-based interventions	Cohen's d	0.41	Small to medium effect
Layug et al., 2021	Teacher-guided digital tools	Cohen's d	0.57	Medium effect
Stoffregen et al., 2021	Digital classroom tools	Cohen's d	0.60	Medium effect
Oren & Zilberstein, 2022	Gamified learning environments	Cohen's d	0.69	Medium to large effect
Alqarni & Alotaibi, 2020	E-learning platforms	Cohen's d	0.53	Medium effect
Miller et al., 2021	Digital intervention programs	Cohen's d	0.65	Medium effect
Joubert & Andrews, 2023	Educational apps	Cohen's d	0.67	Medium to large effect

N. 20: 0.00 – 0.19 Negligible; 0.20-0.49 Small; 0.50-0.69 Medium; 0.70 – 0.89 Medium to Large; 0.90 and above Large

Table 7 showed that effect sizes ranged from 0.40 to 0.72, indicating small to large effects of digital tools on Key Stage 2 numeracy skills. Most studies reported medium effects (0.50–0.69), suggesting consistent moderate improvements in numeracy outcomes. Higher effects (0.68–0.72) were found in studies using virtual manipulatives and gamified learning, while lower effects (0.40–0.49) were linked to variations in tool design, implementation, and learner engagement.

The results indicated that digital tools were generally effective in improving numeracy skills, with stronger impacts observed when tools were interactive, well-integrated into instruction, and supported by teachers.

Table 8

Risk of Bias Assessment of Included Studies

Study	Design	Sample Adequacy	Measurement Validity	Score (0–6)	Overall Risk	Interpretation
Juandi et al., 2021	Meta-analysis	Adequate	Valid	6	Low Risk	High-quality meta-analysis
Aliyu & Browning, 2021	Quasi-experimental	Adequate	Valid	6	Low Risk	Sample and instruments reliable
Tamur et al., 2020	Experimental	Adequate	Valid	6	Low Risk	Strong design and measurement
Wong & Leung, 2020	Quasi-experimental	Adequate	Valid	6	Low Risk	Proper controls used

Beauchamp et al., 2022	Comparative	Adequate	Valid	6	Low Risk	Measurement tools validated
Hardman, 2020	Review	Adequate	Valid	2	Moderate Risk	Sample and measurement not reported
Chan & Leung, 2021	Experimental	Adequate	Valid	6	Low Risk	Strong study design
Slavin, 2022	Review	Adequate	Valid	2	Moderate Risk	No original data, unclear measures
Gashaj et al., 2023	Correlational	Adequate	Valid	4	Moderate Risk	Measurement validity not reported
Indefenso & Yazon, 2020	Correlational	Adequate	Valid	2	Moderate Risk	Sample & measurement not reported
DepEd Cabuyao City, 2021	Quasi-experimental	Adequate	Valid	6	Low Risk	Clear methodology
Hong et al., 2020	Correlational	Adequate	Valid	2	Moderate Risk	Weak reporting

Note. n:20; 5-6, Low Risk; 3-4, Moderate Risk; 0 – 2 High Risk

Table 8 presented the risk of bias assessment of the 20 included studies based on PRISMA guidelines, considering study design, sample adequacy, and measurement validity. Most experimental and quasi-experimental studies were rated as low risk, indicating strong and reliable evidence supporting the positive effects of digital tools on numeracy skills.

In contrast, review and correlational studies were rated as moderate risk due to reliance on secondary data and limited reporting of methodological details. Overall, the assessment showed that most evidence was methodologically sound, strengthening confidence in the finding that digital tools positively influenced Key Stage 2 numeracy outcomes, while also highlighting areas for improvement in future research quality.

CONCLUSION

This systematic review, guided by the PRISMA framework, evaluated studies from 2020 to 2024 on the effectiveness of digital tools in enhancing numeracy skills among Key Stage 2 learners. Analysis of 20 studies showed that gamified applications, interactive platforms, adaptive learning systems, and virtual manipulatives consistently improved arithmetic, number sense, problem-solving, and mathematical reasoning. Effect sizes ranging from small to large indicated stronger outcomes when interventions were supported by effective teacher facilitation and well-designed instructional strategies.

The findings further showed that effectiveness depended not only on the availability of digital tools but also on instructional alignment, learner engagement, access to technology, and intervention duration. Teacher guidance and curriculum integration were identified as key factors in maximizing learning outcomes. Based on these results, digitized learning kits may be developed to support numeracy instruction. Overall, the study confirmed that well-integrated digital tools can significantly enhance numeracy skills, providing strong support for their adoption in primary mathematics education.

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