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A Systematic Literature Review: The Effectiveness of Interactive E-Modules in Numeracy Learning on Students' Concept Understanding

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Abstract: This study systematically reviews the effectiveness of interactive e-modules in Numeracy learning to improve students' concept understanding. The study employed a Systematic Literature Review (SLR) method using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach. Data were collected from 12 articles published in SINTA-indexed journals between 2021–2025. Analysis identified publication trends, educational levels, and e-module effectiveness on concept understanding. Results indicate interactive e-modules effectively improve Numeracy concept understanding, marked by significant N-Gain score improvements and learning completeness. Publication trends increased rapidly (2021–2025), dominated by Junior High School (50%), Senior High School (33%), and Elementary School (17%). The study concludes further research is needed at the Elementary level, adjusting learning models to students' developmental stages.

Keywords: Concept understanding; Interactive E-module; Numeracy; Systematic Literature Review

Introduction

Numeracy education plays a strategic role in developing logical, systematic, and creative thinking skills among students (Imjai et al., 2024; Szörényi et al., 2026; Xu et al., 2025). The primary goal of Numeracy learning is not only oriented toward academic achievement but also toward building deep concept understanding as a foundation for solving complex problems (Chen et al., 2025; Keadkraichaiwat et al., 2026; Talkhan et al., 2025). Concept understanding is a hierarchical competence; failure to grasp basic concepts will hinder mastery of advanced concepts. Therefore, educational standards emphasize the importance of students being able to demonstrate, explain relationships between concepts, and apply algorithms accurately (Permendiknas No. 22 Year 2006) (Alashwal & Barham, 2025; Funa, 2026; Martínez-Martín et al., 2024). However, classroom realities indicate that Numeracy concept understanding remains a major challenge. Many students experience difficulties in constructing new knowledge due to cognitive conflicts between preconceptions and new information, leading to low motivation and learning outcomes (Aleni et al., 2026; Ernstsen et al., 2025; Offerman et al., 2025).

This gap between curriculum demands and learning realities necessitates innovation in learning media. In the digital era, technology integration in education offers potential solutions to visualize abstract concepts more concretely (Chen et al., 2024; Chenge et al., 2026; Sun et al., 2026). Although various digital platforms are available, their utilization is often sporadic and not systematically integrated into independent learning materials (Lee, 2025; Ofem et al., 2026; Stigberg et al., 2024). Students need media that is not only informative but also interactive and capable of providing immediate feedback. In this context, Interactive E-Modules emerge as an alternative solution. Unlike printed modules, E-Modules allow multimedia integration (images, audio, video, animations) and

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flexible navigation, which are believed to facilitate diverse student learning styles and increase their engagement in learning (Hajek Gross et al., 2026; Kikas et al., 2025; Marques et al., 2024).

Several empirical studies have tested the effectiveness of Interactive E-Modules in Numeracy learning. Previous studies generally show positive results on motivation and concept understanding (Li et al., 2024; Rajaguru, 2025; Shin et al., 2025). However, existing literature remains scattered across different educational levels, Numeracy concept variables, and development tools. To date, no systematic review has comprehensively mapped the effectiveness trends of Interactive E-Modules, particularly regarding the most frequently used software applications and the educational levels that benefit most from this intervention in recent years (2021–2025). The absence of this evidence-based synthesis makes it difficult for educators and developers to determine the most effective E-Module development standards.

Based on this urgency, this study aims to systematically review the effectiveness of Interactive E-Module use in Numeracy learning to improve students' concept understanding. Through the Systematic Literature Review (SLR) method with PRISMA protocol, this study not only measures the effectiveness of learning impacts but also maps current research trends. The findings are expected to contribute theoretically regarding digital media effectiveness patterns in Numeracy, as well as provide practical contributions in the form of E-Module development recommendations suitable for educational level characteristics and student needs in the digital era.

Method

This study employs a Systematic Literature Review (SLR) design to comprehensively examine the effectiveness of interactive e-modules in Numeracy learning. The review adheres to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol to ensure transparency and reproducibility in the selection and analysis of literature (Fütterer et al., 2026; Otalike et al., 2026). The primary objective is to synthesize empirical evidence regarding the impact of interactive e-modules on students' Numeracy concept understanding.

Data Sources and Search Strategy

Data were collected from peer-reviewed articles published in national journals indexed by SINTA (Science and Technology Index). The search was conducted using the Publish or Perish 8 (PoP) software, utilizing Google Scholar as the primary database. The search strategy employed specific keywords: "*e-modul interaktif*", "*pemahaman konsep*", and "*pembelajaran matematika*" (and their English equivalents). The publication timeframe was restricted to 2021–2025 to ensure the relevance and currency of the data.

Selection Criteria

Article selection was based on predefined inclusion and exclusion criteria to ensure the quality and relevance of the reviewed literature. The criteria are detailed in Table 1.

Table 1. Inclusion and Exclusion Criteria

Criteria	Inclusion	Exclusion
Topic	Articles specifically discussing the effectiveness of interactive e-modules on Numeracy concept understanding	Articles not focusing on interactive e-modules or concept understanding (e.g., general media, other subjects)
Publication Year	Published between 2021 and 2025	Published before 2021
Journal Index	Published in journals indexed by SINTA (minimum SINTA 5)	Non-indexed journals, proceedings, or unpublished manuscripts
Language	Indonesian or English	Other languages
Accessibility	Full-text available	Full-text unavailable

Study Selection Process

The selection process followed the four stages of the PRISMA flow diagram: Identification, Screening, Eligibility, and Inclusion.

Data Analysis

Data extraction focused on publication trends, educational levels, software tools used, and learning outcomes (specifically N-Gain scores and concept understanding indicators). The analysis was conducted in two phases: descriptive analysis, to map publication trends and demographic characteristics (educational levels); and content analysis: to synthesize findings on the effectiveness of e-modules, identifying patterns in learning outcomes and implementation strategies. This mixed analytical approach allows for a comprehensive understanding of both the quantitative impact and qualitative implementation of interactive e-modules in Numeracy education.

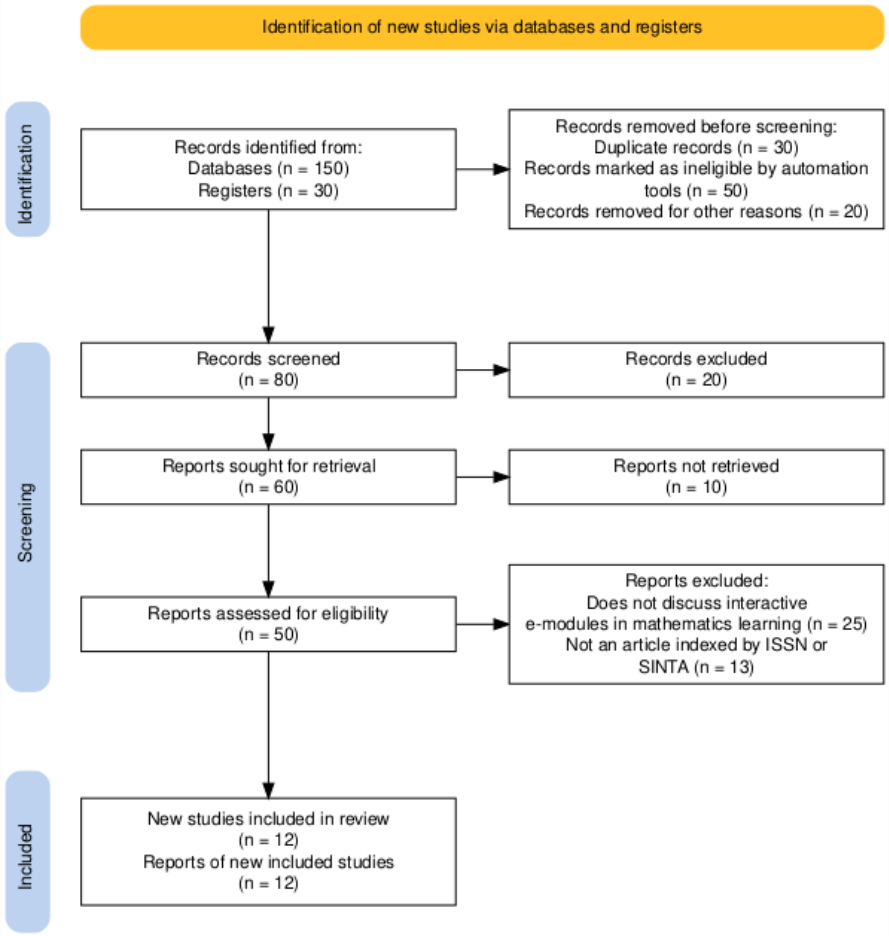

Figure 1. Document Search Process for Articles using the PRISMA method

Result and Discussion

Relevan Results of the Analysis of Relevant Articles

A search with the keyword "interactive e-modules to improve concept understanding" on the PoP 8 application yielded 12 literatures that met the inclusion criteria as SLR research data. The data obtained in this SLR method research consisted of an analysis and summary of 12 articles, focusing on the effectiveness of using interactive e-modules to improve concept understanding. The analysis results, including the identities of the 12 articles obtained, are presented in the Table 2.

Table 2. The data obtained in this SLR method research

Code	Author(s)	Title	Publishing Journal	Research Type
A1	Hastiyani & Muliawan	Development of Contextual E-Modules with FlipPDF to Improve Mathematical Concept Understanding of High School Students	ULIL ALBAB: Jurnal Ilmiah Multidisiplin (SINTA 2)	Research and Development (R&D)
A2	Taufik et al.	Interactive E-Modules to Facilitate Students' Concept Understanding	Majamath: Jurnal Matematika dan Pendidikan Matematika (SINTA 4)	Research and Development (R&D)
A3	Izwita Dewi et al.	Improving Concept Understanding of Grade VIII Students Through Guided Discovery Model Assisted by Interactive E-Modules	Jurnal Pendidikan Amarta (SINTA 5)	Classroom Action Research (CAR)
A4	Nunik Ardiana et al.	Development of Flipbook Maker-Assisted E-Modules to Build Students' Concept Understanding at SMK Negeri 4 Padangsidimpuan	JURNAL MathEdu (Mathematic Education Journal) (SINTA 5)	Research and Development (R&D)

Code	Author(s)	Title	Publishing Journal	Research Type
A5	Ratu Syifa Fauziyah et al.	Junior High School Students' Mathematical Concept Understanding Using Kodular-Assisted E-Modules on Smartphones	WILANGAN: Jurnal Inovasi dan Riset Pendidikan Matematika (SINTA 5)	Quantitative Descriptive Research
A6	Enggar Tri Aulia et al.	Developing interactive e-module based on realistic Numeracy education approach and mathematical literacy ability	Jurnal Elemen (SINTA 2)	Research and Development (R&D)
A7	Makmun Murod et al.	Effectiveness of Android-Based Interactive E-Module Teaching Materials to Improve Understanding of Circle Concepts for Grade VI Elementary School Students	FENOMENA (SINTA 3)	Experimental Research
A8	Alawiyah Mahfudhah et al.	Lectora Inspire Interactive E-Module with a Realistic Approach to Facilitate Understanding of Mathematical Concepts	Al-Khwarizmi: Jurnal Pendidikan Matematika dan Ilmu Pengetahuan Alam (SINTA 3)	Research and Development (R&D)
A9	Isna Hamida Maghfirana & Jumatin	Application of Problem-Based Learning Assisted by Interactive E-Modules to Improve Mathematical Understanding of Geometric Solid Volumes	Jurnal Didaktika Pendidikan Dasar (SINTA 3)	Classroom Action Research (CAR)
A10	N.P. Supawidhiasih et al.	Development of Undagi Bali-Oriented E-Modules to Improve Concept Understanding of Number Patterns in Grade VIII Junior High School Students	Jurnal Pendidikan dan Pembelajaran Matematika Indonesia (SINTA 4)	Research and Development (R&D)
A11	R. Susmawathi, et al.	Development of GeoGebra-Assisted E-Modules in Improving Mathematical Concept Understanding and Learning Motivation of Junior High School Students	Jurnal Pendidikan dan Pembelajaran Matematika Indonesia (SINTA 4)	Research and Development (R&D)
A12	Agnes Katrina et al.	The Effect of Desmos-Based Interactive E-Module Assisted Deep Learning Approach on Understanding Derivative Concepts	Jurnal Pendidikan MIPA (SINTA 4)	Experimental Research

Based on the data above, 4 out of 12 analyzed articles were published in SINTA 4 journals, 2 articles originated from SINTA 2 indexed journals, 3 articles were each published in SINTA 3 and SINTA 5 journals. Thus, the use of interactive e-modules in enhancing conceptual understanding becomes a topic worthy of analysis and summarization in the SLR.

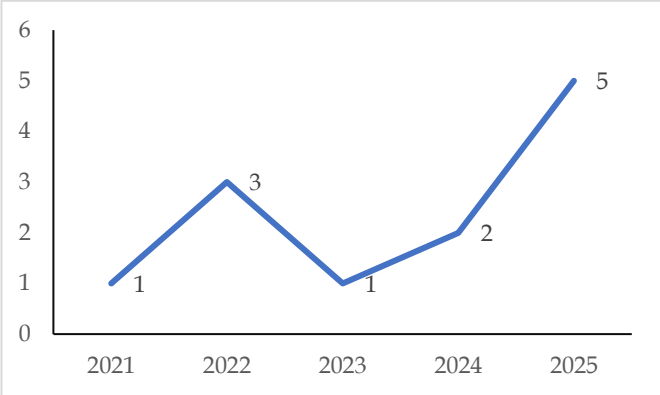

Figure 2. Trends in the Publication of Interactive E-Modules for Enhancing Conceptual Understanding from 2021 to 2025

Based on Figure 2, the article with code A7 is the literature published in 2021. In 2022, there were 3 articles published, namely the articles with codes A5, A6, and A8. From 2021 to 2022, which was a transition period of learning methods from blended learning to face-to-face, there was an increase in the number of published articles. The trend then shows a decline in 2023, where only 1 article discussing the use of interactive e-modules to enhance conceptual understanding was published, namely the article with code A9. The number of articles published in SINTA-indexed journals (minimum SINTA 5) significantly increased, especially in 2025, where there were 5 articles on related topics, namely articles with codes A3, A4, A10, A11, and A12.

Articles with codes A1 and A2 in 2024 explained that interactive e-modules were chosen because they contained materials, limitations, methods, and evaluation techniques that were systematically and attractively arranged to achieve the desired competencies according to the level of complexity interactively. Thus, the development of interactive e-modules was used to measure how conceptual understanding improved during the learning process, whether thru group or independent study, and with or without teacher assistance. Overall, this data shows a significant increase in the number of publications from 2021 to 2025, followed by only a slight decrease in 2023 where there was only 1 publication after there were 3

publications in 2022. The highest number of publications was in 2025 with 5 articles published by July, marking a significant surge after only 2 journals were published in 2024.

Educational Levels That Most Frequently Use Interactive E-Modules to Enhance Conceptual Understanding

Based on Figure 3, out of 12 articles, 6 were conducted at the junior high school level with a percentage of 50%. 2 articles were conducted at the elementary school level with a percentage of 17%, namely articles with codes A7 and A9. Meanwhile, 4 other articles were conducted at the senior high school level, namely articles with codes A1, A2, A4, and A12. The results of this analysis indicate that there are still not many published studies that can serve as sources or provide information regarding the effectiveness of using e-modules in enhancing conceptual understanding. If we consider Jean Piaget's theory of cognitive development, then the development of interactive e-module products is still needed to help improve conceptual understanding in Numeracy learning at the elementary school level (Fredy et al., 2025; Iqbal et al., 2025; Melani et al., 2025).

At this age, students are at the Concrete Operational stage (7-12 years), where they are mature enough to use logical thinking or operations, but only for physical objects that are present at the moment (Abdennaji et al., 2026; Tang & Geng, 2025; Tïmurlenk et al., 2026). At this stage, children have lost the tendency toward animism and artificialism. Their egocentrism decreases and their ability in conservation tasks improves. However, without physical objects in front of them, children at the concrete operational stage still face significant difficulties in completing logical tasks, so the use of interactive e-modules in Numeracy learning can help in their learning progress, thereby meeting the three indicators of conceptual understanding (Pishchukhina et al., 2024; Xia et al., 2026; Yang, 2025).

Meanwhile, 33% at the high school level found that the use of interactive e-modules emphasized how students could adjust to their learning needs and pace, learn independently anywhere and anytime, and help in understanding more complex material by systematically compiling the material and problems that students need to solve in understanding the subject matter. Interactive e-modules that have been widely used at the junior high school level to enhance students' conceptual understanding demonstrate that interactive e-modules are one of the vital instruments in building the foundation of students' mathematical concepts from an early age, which is crucial for students' readiness at the next level of education (Igarashi & Suryadarma, 2023; Kong & Hou, 2025; Prediger et al., 2025).

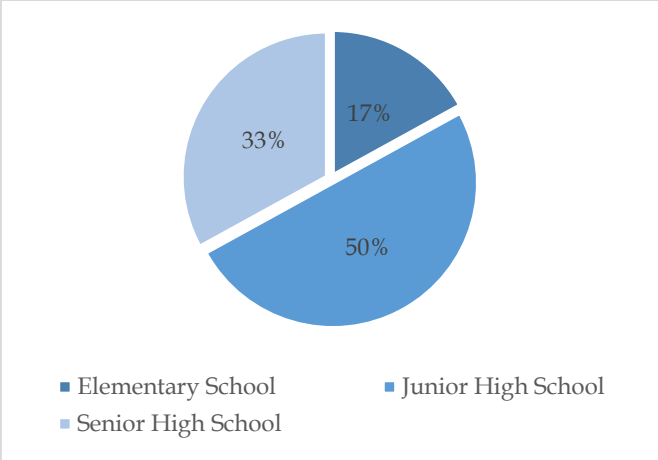

Figure 3. Distribution of educational levels in the analyzed article sample

The Effectiveness of Interactive E-Modules to Improve Conceptual Understanding

The research article with code A1 involved 30 samples. The research results obtained indicate that the contextual-based e-module product using Flip PDF developed is declared effective in improving conceptual understanding abilities based on an N-Gain value of 0.65 with a moderate improvement category. The research in the article with code A2 was conducted with a sample of 35 students. The interactive e-module has proven successful in facilitating the understanding of mathematical concepts, as evidenced by a high level of conceptual understanding ability at 90%.

The research results in the article with code A3 show that the level of students' conceptual understanding ability is in the poor category with an average of 57.93, and 5 students (15.15%) achieved the learning completeness level after the implementation of cycle I. In the implementation of cycle II, the level of students' conceptual understanding ability is in the very good category with an average of 87.31, and 30 students (90.90%) achieved the completeness criteria. The G value on the gain index is 0.70035, categorized as high, and all criteria for the concept understanding indicators and observations fall into the good category (61-80%).

Meanwhile, the research results in the article coded A9, which is also a type of classroom action research, show an increase in mathematical understanding with a completion percentage of 58% in cycle 1, rising to 71% in cycle 2, and reaching 79% in cycle 3. With a sample of 17 students, the article coded A4 received validation results from three validators amounting to 90.5, categorized as "very valid," while the effectiveness of the module usage was obtained from the analysis of students' concept understanding test data with a classical completion percentage of 94%. The practicality of the product was obtained from positive student responses, evidenced by

questionnaire completion with a percentage of 95%, also categorized as "very valid."

Based on the research results in the article coded A5, it was found that the use of an e-module assisted by Kodular on smartphones resulted in an increase in concept understanding ability by 0.57, which falls into the moderate category. The article with code A6 provides effectiveness test results using a paired sample t-test, which shows a significant difference between pretest and posttest scores, as well as n gain to observe the improvement in conceptual understanding ability with an average of 0.32 (moderate category).

The interactive Android-based Math e-module teaching material in the article with code A7 is quite effective in improving the understanding of the circle concept for sixth-grade elementary school students. This is evidenced by the N-Gain values from both limited and extensive trials, which are interpreted as quite effective, meaning there is a significant improvement in sixth-grade students' understanding of the circle concept due to the use of the interactive Android-based Math e-module teaching material. The research results in the article with code A12, which is of the same type, indicate that there is a significant difference between the pretest and posttest in both groups.

Furthermore, the Mann–Whitney U test showed a highly significant difference between the post-test results of both groups, indicating that the deep learning approach supported by the Desmos-based interactive e-module is more effective in enhancing the understanding of derivative concepts. The research results in article code A8 show that the e-Module is valid and can facilitate students' understanding of mathematical concepts. The percentage of validation results by content experts, media experts, and learning experts were 84%, 83%, and 88%, respectively. The average score of the students' concept understanding test was 71.5, which falls into the moderate category of students' concept understanding.

The assessment results from the validators showed that the use of the e-module received an average score of 3.6 and 3.72, categorized as very good. In the article with code A10, the final average score of the concept understanding test was 75 in the first field trial and 80 in the second field trial, categorized as complete because it met the Minimum Completeness Criteria (KKM) of 70. Meanwhile, in the article with code A11, the average score of the Numeracy concept understanding test on the topic of linear equations for eighth-grade students was 71.21 in the first field trial and 72.06 in the second field trial, with a completeness level of 80%. Thus, the use of e-modules is said to be effective in improving students' conceptual understanding.

Flipbook Maker, Flip PDF, Geogebra, Desmos, Lectora Inspire 17 Flash Player 8.0 are the main software and applications used in creating interactive e-modules. Some interactive e-modules that include learning videos use videos already available on YouTube, such as the interactive e-module products in articles with codes A2 and A5, or create them with the Kinemaster application, like the interactive e-module products in article code A8. The learning model used is adjusted according to the material and grade level. In article code A12, a deep learning approach assisted by interactive e-modules based on Desmos is used for the 12th-grade derivative material. For article A3 at the elementary school level, the Problem Based Learning model is applied for the 5th-grade spatial building material.

Conclusion

This systematic literature review confirms that interactive e-modules are effective in enhancing students' Numeracy concept understanding across various educational levels. The synthesis of 12 empirical studies (2021–2025) demonstrates consistent positive outcomes, evidenced by moderate to high N-Gain scores (0.32–0.70), improved classical completeness percentages (up to 94%), and statistically significant differences in pretest-posttest comparisons. Publication trends indicate growing researcher interest in digital media integration, with a notable surge in 2025. However, research distribution remains uneven, with Junior High School dominating (50%), followed by Senior High School (33%), and Elementary School significantly underrepresented (17%). Software tools such as FlipPDF, Geogebra, Desmos, and Lectora Inspire are most frequently utilized, with dynamic visualization tools showing superior effectiveness for complex mathematical concepts. Despite the demonstrated effectiveness, critical gaps remain that warrant attention. The limited focus on Elementary School is concerning, given that students in the Concrete Operational Stage (ages 7–12) require visual and interactive media to bridge concrete and abstract thinking. Additionally, most studies prioritize cognitive outcomes while neglecting affective domains such as character development and social-emotional learning. Future research should prioritize elementary-level development with age-appropriate interactivity, incorporate character-building variables (responsibility, independence, collaboration), and adopt Deep Learning and Social-Emotional Learning (SEL) approaches. Furthermore, subsequent studies should explore Artificial Intelligence (AI) integration for personalized learning pathways and investigate long-term retention

effects of e-module-based learning to ensure technology fosters both cognitive and affective development.

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