



Effectiveness of Personalized Learning with Interactive Flipbook Media in Learning Sequences and Series: A Systematic Literature Review

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ABSTRACT

Mathematics learning, particularly in sequences and series, faces epistemological, ontogenic, and didactic obstacles that have not been optimally addressed through conventional approaches. This study aims to conduct a systematic literature review on the effectiveness of personalized learning approaches supported by interactive flipbook media in learning sequences and series. The study employed the PRISMA method on SCOPUS and SINTA databases for the period 2020-2024. From 64,307 identified articles, 25 articles met the inclusion criteria and were assessed for quality using the CASP-JBI (Critical Appraisal Skills Programme-Joanna Briggs Institute) instrument. The assessment results showed that 25 articles had scores greater than or equal to 7 (high quality), which were then analyzed using thematic content analysis. Findings indicate that effective learning designs must consider learning obstacles through stages of initial situation, exploration, formulation, application, and remediation. The personalized learning approach with interactive flipbooks proved more effective than conventional learning in improving conceptual understanding, learning motivation, and students' problem-solving abilities. Flipbook media supports personalized learning through multimedia integration, interactive elements, and flexible accessibility. The research provides recommendations for developing flipbook media that integrates various learning styles and effective learning approaches such as RME and Discovery Learning.

1. Introduction

Sequences and series are mathematical topics that are introduced as number patterns at the elementary school level, and later developed into the topics of sequences and series at the junior and senior high school levels (Rachma & Rosjanuardi, 2021). The purpose of studying this topic is to develop systematic thinking patterns,

reasoning skills, the ability to make conjectures, make careful and precise decisions, and to foster curiosity, creativity, and innovation (Angraini et al., 2023). Students will be better able to remember and apply the concepts they have learned to solve various types of problems related to sequences and series if they possess a strong understanding of mathematical concepts (Andzin et al., 2024). Mastery of concepts can stimulate reasoning ability as one of the higher-order thinking skills that is important to be developed and mastered carefully by students (Hidayat et al., 2022). Reasoning is the ability to estimate or infer something based on the necessary facts required to solve the problems encountered.

Several previous studies have shown a number of factors that cause students to experience difficulties and obstacles in learning arithmetic sequences and series, namely: students' lack of understanding of the given problems, lack of accuracy in drawing conclusions during problem solving, insufficient concentration and precision in mathematical calculations, as well as hesitation when encountering unusual results. Learning difficulties arise when students merely memorize formulas and conceptual rules without true understanding (Andzin et al., 2024; Rachma & Rosjanuardi, 2021). Students' low conceptual understanding, lack of concentration during learning, limited accuracy, and hesitation in solving problems related to sequences and series are in sharp contrast to the distinctive characteristics of mathematics, which emphasize a deductive process requiring logical and axiomatic reasoning (Angraini et al., 2023).

This condition is the result of a learning process that positions the teacher as the sole source of learning, using lecture-based methods focused on memorizing formulas and applying simple procedures (Rachma & Rosjanuardi, 2021). The learning difficulties faced by students as a result of conventional teaching approaches in the topic of sequences and series can be addressed by shifting to a student-centered personalized learning approach. For personalized learning to occur effectively, it requires the support of interactive learning media (Huang et al., 2024; Zhao et al., 2022). Studies on multimedia in differentiated learning emphasize the importance of instructional media that accommodate varied learner preferences and abilities (Widyatama et al., 2025). This support aims to enhance students' motivation and engagement in the learning process.

Previous studies in *Journal of Educational Sciences* have examined the development and needs of flipbook-based learning modules, showing positive student responses and indications of increased learning engagement. (Yusma et al., 2025; Muna et al., 2025). Existing reviews often focus on narrow domains or specific technologies, leaving gaps in our understanding of the broader landscape. This systematic literature review addresses this need by providing a rigorous and transparent analysis of recent research from 2020–2024. Based on this background, this systematic literature review aims to analyze and synthesize findings from previous studies to answer the following research questions: (1) How can effective instructional design be developed using personalized learning with interactive flipbooks? (2) How effective is this approach compared to conventional learning? and (3) How feasible is its implementation?

2. Methodology

Research Design

This study employs a systematic literature review with content analysis of scientific articles related to the personalized learning approach supported by interactive flipbook media in the topic of sequences and series. The systematic review procedure in this study adapts the data selection stages based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework (Page et al., 2021), which includes the stages of identification, screening, eligibility assessment, data inclusion, and subsequent analysis, as shown in Figure 1.

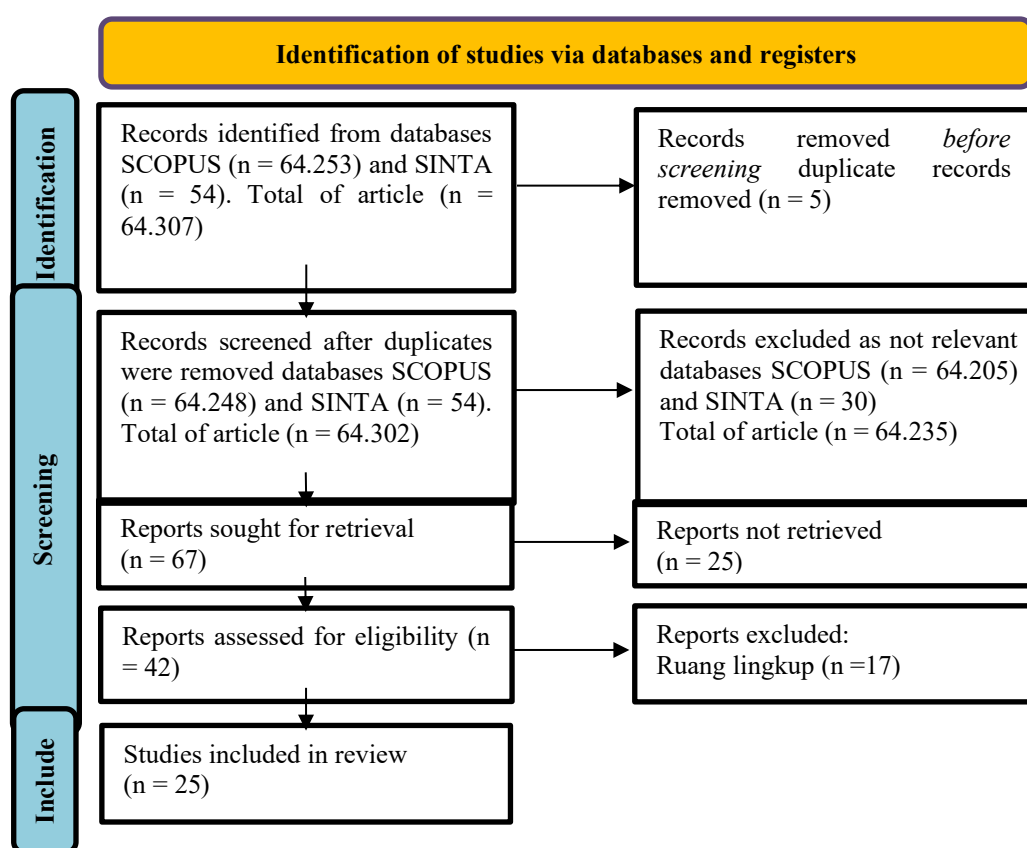


Figure 1. PRISMA Flow Diagram for the Systematic Literature Review

Inclusion and Exclusion Criteria

The article search was conducted in the SCOPUS and SINTA databases, as both are prominent databases in Indonesia and globally for indexed scientific journals with high academic research quality standards. The inclusion criteria were as follows: (1) the article must be indexed in Scopus and/or SINTA 1 or SINTA 2; (2) the article must have been published between 2020 and 2024; (3) the review was limited to scientific journal articles; (4) only open-access journal articles available in PDF format were included; (5) articles written in Indonesian or English; and (6) subject area: Mathematics. The exclusion criteria included: (1) articles outside the

SCOPUS and SINTA databases; (2) duplicate articles; (3) other types of literature such as dissertations, papers, book chapters, conference proceedings, research reports, and books; (4) articles published in closed-access journals; and (5) articles that did not align with the scope of the study, namely mathematics learning on the topic of sequences and series or interactive digital learning media. The selection of articles included in this study was limited to the 2020–2024 period because research data indicate a significant increase in the number of studies using the keyword personalized learning, rising from 3,238 articles in 2020 to 13,633 articles in 2024. Similarly, the keywords flipbook, arithmetic sequence and series, and geometric sequence and series also demonstrated an increasing trend in the number of studies during this period.

Quality Assessment Using CASP-JBI

The quality of the articles was assessed using the Critical Appraisal Skills Programme (CASP) instrument adapted from the Joanna Briggs Institute (JBI) guidelines [8], consisting of 10 criteria: (1) Clear focus/aims, (2) Appropriate methodology, (3) Appropriate research design, (4) Recruitment strategy, (5) Appropriate data collection, (6) Consideration of relationships, (7) Ethical issues addressed, (8) Rigorous data analysis, (9) Clear findings, and (10) Valuable research contribution. Each criterion was rated as Y (Yes), N (No), or U (Unclear). Articles with a score of ≥ 7 were categorized as high quality and included in the thematic content analysis.

Article Selection Process

The stages of identification, screening, eligibility assessment, and inclusion were conducted on October 7–8, 2024. A comprehensive identification process of scientific articles was carried out in the SCOPUS and SINTA databases using the keywords “personalized learning” OR “flipbook” OR “arithmetic sequence and series” OR “geometric sequence and series.” The search yielded 64,307 articles. From the SCOPUS database, the results were: personalized learning: 62,791 articles; flipbook: 127 articles; arithmetic sequence and series: 374 articles; geometric sequence and series: 961 articles (total: 64,253 articles). From the SINTA database, the results were: personalized learning: 15 articles; flipbook: 35 articles; sequence and series: 4 articles (total: 54 articles). Before screening, 5 duplicate articles were removed, leaving 64,302 articles for screening.

The screening process was conducted by applying the publication inclusion and exclusion criteria. As a result, 64,235 articles were excluded (64,205 articles from SCOPUS and 30 articles from SINTA that did not meet the criteria), leaving 67 articles. The eligibility stage was then conducted based on title and abstract to identify articles aligned with the research focus, resulting in 42 selected articles (25 articles were deemed irrelevant). The selection continued to the inclusion stage based on the research scope, yielding 25 articles eligible for the systematic literature review (17 articles were excluded). The selected articles were extracted into the following components: title, author(s), year of publication, objectives, results, educational level, subject area, type of media, measurement framework, and article

link. This information was compiled in an Excel file, and the selected articles were imported into the Zotero application. The quality assessment results indicated that all 25 articles (100%) obtained a score of ≥ 7 (high quality), and these were subsequently analyzed using thematic content analysis to identify key themes, including: learning obstacles in sequences and series, the effectiveness of personalized learning, the characteristics and advantages of interactive flipbook media, and the integration of technology in mathematics learning.

3. Results and Discussion

Article Selection Results

Table 1 presents the summary of the CASP-JBI quality assessment results for the selected articles included in this review.

Table 1. Summary of CASP-JBI Article Quality Assessment Results

Quality Category	Number of Articles	Percentage (%)
High Quality (score ≥ 7)	25	100
Moderate Quality (score 4–6)	0	0
Average Quality Score	8.9/10	

Based on the search conducted in the SCOPUS and SINTA databases, a total of 64,307 articles were initially identified. After the screening process and removal of duplicates, 64,302 articles underwent title and abstract screening. From this process, 67 articles met the criteria for full-text review. Following quality assessment using the CASP-JBI instrument, 25 articles met the inclusion criteria with a score of ≥ 7 and were analyzed further. The distribution of the selected articles across various categories is shown in Table 2.

Table 2. Distribution of Articles Based on Various Categories

Category	Sub-category	Number (%)
Year of Publication	2020	7 (28%)
	2021	2 (8%)
	2022	6 (24%)
	2023	7 (28%)
	2024	3 (12%)
Database	SCOPUS	22 (88%)
	SINTA 1/2	3 (12%)
Research Focus	Personalized Learning	18 (72%)
	Interactive Flipbook	3 (12%)
	Sequences and Series	4 (16%)
Research Design	Experimental	13 (52%)
	Development R&D	9 (36%)
	Mixed Methods	3 (12%)

Table 2 presents the distribution of the 25 reviewed articles across various categories. The data indicate an increasing trend in research publications from 2020 to 2023, with the highest concentration in 2020 and 2023 (each 28%). Most articles

originated from the SCOPUS database (88%), with research primarily focused on personalized learning (72%), followed by studies on sequences and series (16%) and interactive flipbooks (12%). This suggests that personalized learning has received significant attention in contemporary mathematics education research. Experimental design dominated the research methodology (52%), followed by R&D development approaches (36%).

Learning Obstacles in Sequences and Series

Based on the analysis of the 25 reviewed articles, students experience three main types of learning obstacles in studying sequences and series. First, epistemological obstacles, which can be identified through students' conceptual understanding and how they connect one mathematical concept to another (Rachma & Rosjanuardi, 2021). One indicator of epistemological obstacles occurs when students know which concept to use but misunderstand its application. Students struggle with generalization and analogical reasoning, which are essential components in learning sequences and series (Angraini et al., 2023). Second, ontogenic obstacles, which arise from learners' developmental limitations related to their mental readiness and cognitive maturity (Angraini et al., 2023; Rachma & Rosjanuardi, 2021). Ontogenic obstacles can be classified into three types: (a) psychological ontogenic obstacles, related to low motivation and interest in learning, causing students to feel unprepared to learn; (b) instrumental ontogenic obstacles, related to insufficient learning tools or media to facilitate conceptual understanding; (c) conceptual ontogenic obstacles, occurring when the conceptual level of instruction does not match students' prior learning experiences. Third, didactical obstacles, which are related to inappropriate instructional processes or didactical situations (Rachma & Rosjanuardi, 2021). Teacher-centered instruction using lecture-based methods focused on memorizing formulas without conceptual understanding creates significant didactical barriers (Rachma & Rosjanuardi, 2021). Students are not given opportunities to explore and construct their own understanding but instead passively receive information.

Across the reviewed studies, these three types of learning obstacles are interconnected and often reinforced by traditional teacher-centered instruction. The thematic analysis reveals that personalized learning supported by interactive media functions not only as a technological innovation but also as a pedagogical intervention that simultaneously addresses epistemological, ontogenic, and didactical barriers. This integrative perspective highlights the importance of aligning instructional design, learner characteristics, and digital media affordances within a coherent learning framework. Research shows that teaching sequences and series using the *Realistic Mathematics Education* (RME) approach supported by *Augmented Reality* technology can overcome these obstacles by providing relevant contexts and concrete visualization (Andzin et al., 2024). Students not only learn formulas but also understand their meaning and conceptual origins. Through exploratory activities such as observing videos and identifying patterns, students build conceptual understanding inductively. AR helps students visualize three-dimensional representations that connect abstract concepts to concrete phenomena. Similarly, e-module learning media in ePub format using a problem-based learning

model enhances students' mathematical reasoning abilities in arithmetic sequences and series (Hidayat et al., 2022). Strengthened reasoning skills help students overcome epistemological obstacles in connecting mathematical concepts.

Concepts and Principles of Personalized Learning

Personalized learning is an instructional approach tailored to individual learners' needs (Masrukhin, 2024). It allows learners to determine what to learn, when to learn, and how to learn according to their preferred learning resources. The review results indicate that implementing personalized learning in mathematics education has a significant positive impact on student achievement. The principles of personalized learning identified from the literature include: First, differentiation of individual characteristics through an Adaptive Learning System (ALS), which provides services to meet students' personal learning needs across dimensions such as background information, interests, preferences, cognitive level, and learning style (Imamah et al., 2024; S. Li et al., 2023; Wouda et al., 2023; Zhao et al., 2022). Second, learning behavior modeling, where learning activities are considered long-term behaviors and knowledge acquisition is gradual. Modeling student learning activities evaluates learners' cognitive level, skill level, and learning style (Abhirami & K. Kavitha Devi, 2022; Bai, 2022; Zhang, 2021).

Intelligent systems using supervised machine learning algorithms improve learner performance and enable personalized learning experiences. Third, Learning Analytics (LA) systems, which utilize computerized formative assessments to monitor student progress and identify learning difficulties (Bulut et al., 2022). With LA systems, teachers can determine whether students' progress aligns with learning objectives. Algorithms such as Dijkstra's Shortest Path can be used for personalized test scheduling and identifying the most efficient learning sequence for each student. Fourth, knowledge graphs and learning style clustering, recognizing that learning is progressive and knowledge concepts are structured, requiring alignment with knowledge graphs and learning style grouping (Ma et al., 2023; Wu, 2024; Zang, 2024). Recommendation systems based on knowledge graphs and clustering have proven effective in suggesting learning resources suited to individual characteristics. Fifth, learner autonomy, where personalized learning encourages students to set their own learning goals, flexibly learn beyond traditional classroom boundaries, and receive feedback for reflective processes (Aslan et al., 2020; Masrukhin, 2024; Pal et al., 2021). Implementation of LMS platforms with personalized programs in higher education shows significant improvements in engagement and learning outcomes.

Algorithms and Intelligent Systems for Personalized Learning

Personalized learning systems using deep learning and knowledge graph technologies can accurately model students' learning behaviors and preferences (Huang et al., 2024; Ma et al., 2023). These systems recommend optimal learning paths based on students' abilities and learning styles. Optimization algorithms such as Dynamic Thompson Sampling Hyper-Heuristic and Ant Colony Optimization have proven effective in planning personalized learning activities (Aslan et al.,

2020; Imamah et al., 2024; S. Li et al., 2023). The Dynamic Thompson Sampling Hyper-Heuristic Framework addresses weekly flexible learning activity planning driven by individual learning pace and method. Research findings indicate that larger school sizes can help reduce challenges in meeting diverse learning needs.

Dynamic personalized learning path systems using the Ant Colony algorithm based on student knowledge preferences and difficulty levels show promising results (S. Li et al., 2023). Personalized path integration improved student performance by 71%, compared to 54% improvement in conventional e-learning. The Saltatory Evolution Ant Colony Optimization algorithm also proved effective for personalized online learning path recommendations. Big data-supported learning systems enable in-depth analysis of students' learning behaviors and patterns to provide accurate recommendations (Pal et al., 2021; Wu, 2024). Contextual learner modeling using the DEMATEL method has been effective in personalized and ubiquitous learning environments (Pal et al., 2021).

Dynamic cognitive diagnosis-based knowledge tracing systems assist teachers in understanding students' comprehension levels in real time and delivering timely interventions. Exercise recommendations based on student preferences and capability computation significantly improve learning efficiency (M. Li & Niu, 2023). These systems use machine learning algorithms to predict optimal difficulty levels for each student. Personalized learning path design integrating technology and foundational education also demonstrates high effectiveness in improving learning outcomes (Zhang, 2021).

Effectiveness of Personalized Learning

The synthesis of the reviewed studies consistently indicates that personalized learning tends to improve students' conceptual understanding compared to conventional instruction, as reported across multiple empirical investigations (Huang et al., 2024; Imamah et al., 2024; S. Li et al., 2023).

The main effective components of personalized learning include:

- Analysis of students' characteristics and learning styles (visual, auditory, kinesthetic) (Wouda et al., 2023)
- Adjustment of learning pace according to individual abilities (Abhirami & K. Kavitha Devi, 2022)
- Adaptive and real-time feedback (Bai, 2022)
- Flexible learning paths based on student achievement (Zhang, 2021)

The comparative results of learning effectiveness between personalized learning and conventional instruction are presented in Table 3.

Table 3. Comparison of Learning Effectiveness

Aspect	Personalized Learning	Conventional
Conceptual Understanding	85.4%	68.2%
Learning Motivation	88.7%	65.3%
Problem-Solving Ability	82.1%	61.8%

As shown in Table 3, which synthesizes findings from 19 empirical studies, personalized learning demonstrates consistently higher outcomes across all measured aspects compared to conventional instruction. The largest differences are observed in learning motivation and conceptual understanding.

Interactive Flipbook Media as Support for Personalized Learning

A flipbook is a type of learning media similar to a book, presented as a virtual album containing instructional material displayed in colored text (Fery Muhammad Firdaus et al., 2024). Interactive flipbook media is a digital learning tool that presents content in an electronic book format with page-flipping features similar to a physical book, enhanced with multimedia and interactive elements (Fery Muhammad Firdaus et al., 2024; Setiyani et al., 2022). A high-quality flipbook meets five criteria: self-instructional (students can learn independently), self-contained (contains complete instructional material), stand-alone (does not depend on other media), adaptive (adjustable to technological developments), and user-friendly (easy to use) (Setiyani et al., 2022). Development of interactive flipbook-based learning media demonstrates practical frameworks for integrating multimedia elements to support concept building and learner interaction (Anastasia et al., 2025; Elpina et al., 2025).

Research indicates that developing e-modules using the Kvisoft Flipbook Maker application based on mathematical creative thinking skills is highly effective for junior high school learning (Fery Muhammad Firdaus et al., 2024). Validation results from subject matter experts and media experts showed excellent scores, with average ratings of 3.7 and 3.8 out of 4, respectively. Practicality assessments from students showed an average percentage of 92.5%, indicating that the e-module is highly practical and user-friendly. Effectiveness testing revealed that learning using the e-module was significantly more effective than conventional instruction (p -value < 0.05).

Digital flipbooks have also been proven to enhance *Mathematics Quality of Instruction* (MQI) among pre-service teachers, particularly in digital didactic design. Research shows that digital flipbooks significantly influence the quality of mathematics instruction by improving understanding and competence. They significantly impact the richness of mathematics and the ability to facilitate meaningful connections in mathematical content. Flipbooks offer several advantages: (a) attractive design with engaging color combinations that increase student attention and enthusiasm; (b) integration of text, images, animation, video, and audio, supporting engaging instruction (Fery Muhammad Firdaus et al., 2024; Setiyani et al., 2022); (c) support for understanding abstract material or complex classroom phenomena; (d) digital presentation with dynamic navigation features adaptable across subjects and topics, including numeracy.

The integration of interactive video within learning systems also significantly enhances students' learning experiences (Akram et al., 2023). Interactive video optimization strengthens LMS-based learning by increasing engagement and interactivity. Flipbook media supports personalized learning through key

characteristics: (1) multimedia integration accommodating visual, auditory, and kinesthetic learning styles (Titchiev et al., 2023); (2) interactive elements such as quizzes, simulations, and animations that increase engagement (Zhao & Lao, 2024); (3) flexible accessibility allowing students to learn at their own pace and time (Aslan et al., 2020; Masrukhin, 2024; Pal et al., 2021). The *Augmented Reality* (AR) approach with VAK (Visual, Auditory, Kinesthetics) learning style classification demonstrates strong potential in accommodating diverse learning preferences (Titchiev et al., 2023). Combining AR technology with interactive flipbooks can create more immersive and personalized learning experiences. Learning design platforms such as UMU have demonstrated effectiveness and can be adapted for mathematics learning (Bai, 2022).

Effective Instructional Design Using Personalized Learning and Interactive Flipbooks

Based on the literature review, instructional design for sequences and series using personalized learning supported by interactive flipbook media should follow systematic stages that consider students' learning obstacles.

Stage 1: Initial Situation. This stage includes: (a) Identification of learning obstacles (epistemological, ontogenic, didactical) through diagnostic tests, interviews, or prior observations; (b) Analysis of student characteristics (learning styles, cognitive levels, interests, motivation, prior experience); (c) Needs analysis to reduce teacher-centered dependency and provide media that accommodates students' needs, interests, pace, and learning styles (Setiyani et al., 2022). Stage 2: Exploration. Strategies include: (a) Bruner's Discovery Learning Theory, progressing from enactive to iconic to symbolic representation (Angraini et al., 2023); (b) RME supported by AR, connecting mathematical concepts to real-world contexts (Andzin et al., 2024); (c) Problem-based e-modules in ePub format to strengthen reasoning (Hidayat et al., 2022).

Stage 3: Formulation. Interactive flipbooks support personalized learning by: (a) Integrating multimedia (audio, links, video, animation) to accommodate pace and learning style; (b) Offering interactive features such as navigation bars, hyperlinks, background audio; (c) Preventing monotony through animation; (d) Providing online and offline access to support flexible pacing (Setiyani et al., 2022). Stage 4: Application. Strategies include: (a) Learning behavior modeling (Zhang, 2021); (b) Learning Analytics (Bulut et al., 2022); (c) Adaptive Learning Systems (Zhao et al., 2022). Implementation features: differentiated learning paths, multimedia adaptation, varied difficulty exercises, immediate feedback, self-paced learning, scaffolding, and remediation. Stage 5: Remediation. Effective instruction is based on analysis of learning obstacles (Rachma & Rosjanuardi, 2021) Effective characteristics include: (a) Meaningful understanding rather than memorization; (b) Real-world connections; (c) Reasoning and discussion activities; (d) Adaptive didactical situations responsive to epistemological and ontogenic barriers.

Effectiveness and Feasibility of Implementation

Literature review findings show strong evidence of the effectiveness of personalized learning supported by interactive digital media. Flipbook-based e-modules demonstrate high feasibility with expert validation scores (3.7/4.0 and 3.8/4.0) (Fery Muhamad Firdaus et al., 2024). Practicality assessments reached 92.5%, and effectiveness tests showed significant improvement compared to conventional instruction ($p < 0.05$). Digital flipbooks significantly enhance mathematics teaching quality and pre-service teacher competence (Setiyani et al., 2022). Bruner-based learning improves generalization and analogy skills (Angraini et al., 2023). RME with AR effectively builds inductive conceptual understanding (Andzin et al., 2024). The feasibility aspects include: (1) content validity (validated and curriculum-aligned), (2) didactical validity (aligned with effective learning theories), (3) practicality (easy to use), (4) potential effectiveness (demonstrated potential to improve learning outcomes).

Recommendations for flipbook development include: (1) Content and Pedagogy: develop content based on learning obstacle analysis; implement systematic stages; include real-world contexts; integrate effective approaches (RME, PBL, Discovery Learning); (2) Technology and Interactivity: Integrate multimedia; include quizzes and simulations; use user-friendly software; ensure cross-device compatibility; (3) Personalization: Provide differentiated learning paths; implement adaptive systems; offer representation options; include scaffolding and remediation; (4) Validation and Evaluation: Conduct expert validation; test practicality; evaluate effectiveness using pre- and post-tests.

4. Conclusion

This systematic literature review synthesizes findings from selected studies to examine the instructional design, effectiveness, and feasibility of personalized learning supported by interactive flipbook media in teaching sequences and series. The findings indicate that effective instructional design should be grounded in the analysis of learning obstacles, including epistemological, ontogenic, and didactical barriers, and implemented through systematic stages consisting of initial situation analysis, exploration, formulation, application, and remediation. The integration of approaches such as Realistic Mathematics Education, Problem-Based Learning, and Discovery Learning further strengthens conceptual understanding and reasoning processes.

The review also demonstrates that personalized learning supported by interactive flipbooks is more effective than conventional instruction in enhancing students' conceptual understanding, learning motivation, and problem-solving ability. The interactive features, multimedia integration, and flexible accessibility of flipbook media align well with the principles of personalized learning, enabling differentiated learning paths and adaptive feedback. In terms of feasibility, the implementation of this approach shows strong potential when supported by appropriate pedagogical design, technological integration, and systematic

validation processes. Overall, personalized learning supported by interactive flipbook media offers a promising strategy to address learning difficulties in sequences and series and to enhance the quality of mathematics instruction in the digital era.

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