Storyboarding in the Initial Design of Mobile Mathematics Educational Applications: A Systematic Review Using the PRISMA Framework

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ABSTRACT

The rapid growth of mobile learning has led to increased development of mobile educational applications, particularly in mathematics education. Effective design at the initial development stage is critical to ensure pedagogical alignment, usability, and learner engagement. Storyboarding has emerged as an instructional design technique for visualizing learning flows, interactions, and content sequencing before full application development. However, research examining the role of storyboarding in the early design of mobile mathematics educational applications remains fragmented. This study presents a systematic review of literature on storyboarding during the initial design phase of mobile mathematics educational applications, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework. Searches were conducted across Scopus, Web of Science and Google Scholar, with the final eligibility period restricted to publications from 2024 through 2025. A total of 612 records were identified, 148 duplicates were removed, 92 full texts were assessed, and 31 studies were included in the qualitative synthesis. The findings indicate that storyboarding is used to visualize learning flow, align pedagogical and interface decisions, support low-fidelity prototyping, and facilitate communication among stakeholders. Reported limitations include difficulty representing dynamic interactions, dependence on designer expertise, implementation ambiguity, and limited empirical validation. The review also identifies methodological inconsistency and a lack of comparative and outcome-focused studies as important research gaps.

Keywords: storyboarding, mobile learning, mathematics education, instructional design, educational applications, PRISMA, systematic review

INTRODUCTION

Mobile technologies have significantly transformed educational practices, enabling learners to access instructional content anytime and anywhere. In mathematics education, mobile applications offer interactive visualizations, adaptive feedback, and learner-centered experiences that can address long-standing challenges such as abstraction, motivation, and cognitive overload. However, the effectiveness of such applications depends heavily on sound instructional and interface design, particularly during the early stages of development.

The initial design phase plays a crucial role in aligning pedagogical goals, content structure, and user experience. Among various instructional design tools, storyboarding has gained prominence as a technique for planning screen-by-screen content, interactions, and navigation flows before programming begins. Storyboards allow

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designers to visualize learning sequences, anticipate user behavior, and communicate design intent to multidisciplinary teams.

Despite its widespread use in multimedia and e-learning development, the role of storyboarding specifically in mobile mathematics educational applications has not been systematically reviewed. Existing studies are scattered across fields such as educational technology, human–computer interaction, and instructional design, making it difficult to synthesize evidence and best practices.

Therefore, this study aims to systematically review the literature on storyboarding in the initial design of mobile mathematics educational applications using the PRISMA framework. The review seeks to answer the following research questions:

1. How is storyboarding used in the initial design of mobile mathematics educational applications?
2. What benefits and challenges are associated with storyboarding in this context?
3. What research gaps exist in current studies on storyboarding for mobile mathematics learning?

METHODOLOGY

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency, rigor, and replicability.

Review Protocol

The review was conducted using the PRISMA framework to systematically identify and analyze studies related to storyboarding, mobile learning, digital storytelling, and interactive mathematics learning. Studies published mainly during 2024–2025 were considered using keywords such as *storyboarding*, *mobile learning*, *mathematics education*, *digital storytelling*, *interactive mathematics learning*, and *Articulate Storyline*. Relevant peer-reviewed articles were selected based on predefined inclusion and exclusion criteria. The studies were screened through their titles, abstracts, and full texts. Data such as author, year, educational level, mathematical topic, methodology, purpose, outcomes, benefits, challenges, and research gaps were extracted. The findings were analyzed thematically and grouped into three major themes: Use of Storyboarding in Initial Design, Benefits and Challenges of Storyboarding, and Research Gaps. The results were then presented using thematic descriptions, article codes, and the number of studies contributing to each category.

Data Sources and Search Strategy

- Scopus
- Web of Science
- Google Scholar

Inclusion and Exclusion Criteria

Inclusion criteria:

- Published between 2024 and 2025
- Peer-reviewed journal articles or conference papers
- Focused on mobile or tablet-based educational applications
- Included mathematics or numeracy learning contexts
- Explicitly discussed storyboarding or early-stage design visualization

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Exclusion criteria:

- Studies unrelated to education or mathematics
- Applications designed for desktop-only platforms
- Papers lacking discussion of design methodology
- Non-English publications

Study Selection

The selection process followed PRISMA's four stages: identification, screening, eligibility, and inclusion. Titles and abstracts were screened after duplicate removal, followed by full-text assessment against the predefined criteria. The manuscript currently does not document whether screening and eligibility assessment were conducted independently by two or more reviewers or how disagreements were resolved.

Data Extraction and Analysis

Data extracted from the selected studies included author(s) and year, educational level and mathematical topic, purpose of storyboarding, design methodology, and reported outcomes and limitations. A thematic analysis approach was used to synthesize findings across studies.

PRISMA Flow Diagram

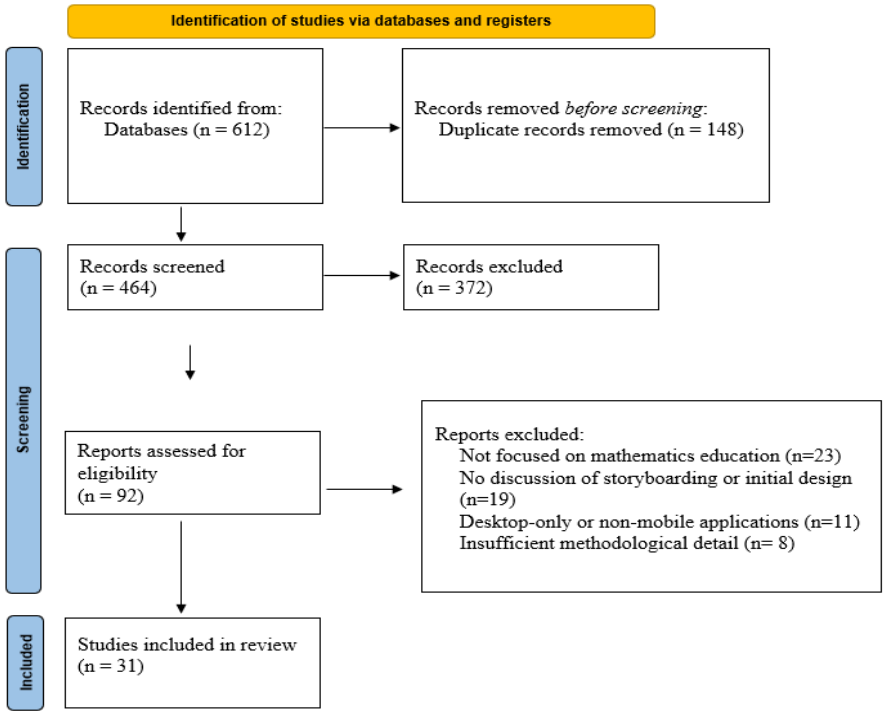


Figure 1. PRISMA 2020-style flow diagram showing the identification, screening, eligibility, and inclusion counts reported in this review.

The study selection process followed the PRISMA framework and consisted of four stages: identification, screening, eligibility, and inclusion.

During the identification stage, a total of 612 records were retrieved from three electronic databases, including Scopus, Web of Science and Google Scholar. After removing 148 duplicate records, 464 unique studies remained for screening.

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In the screening stage, titles and abstracts were reviewed to assess relevance. A total of 372 records were excluded because they were unrelated to mobile learning, mathematics education, or instructional design, or did not mention storyboarding or early-stage design methods. This resulted in 92 studies being retained for full-text assessment.

During the eligibility stage, the full texts of the 92 studies were evaluated against the predefined inclusion and exclusion criteria. of these, 61 studies were excluded for reasons such as lack of focus on mathematics education, absence of discussion on storyboarding or initial design processes, desktop-only application design, or insufficient methodological detail.

Finally, 31 studies met all eligibility criteria and were included in the qualitative synthesis of this systematic review.

PRISMA Flow Summary

Table: 1- PRISMA-Aligned Synthesis of How Storyboarding Is Used in the Initial Design of Mobile Mathematics Educational Applications

PRISMA Stage	Description	Number of Records
Identification	Records identified through database searching	612
	Duplicate records removed	148
	Records after duplicates removed	464
Screening	Records screened (title and abstract)	464
	Records excluded	372
Eligibility	Full-text articles assessed for eligibility	92
	Full-text articles excluded	61
	– Not focused on mathematics education	23
	– No discussion of storyboarding or initial design	19
	– Desktop-only or non-mobile applications	11
	– Insufficient methodological detail	8
Included	Studies included in qualitative synthesis	31

Results

1. How is storyboarding used in the initial design of mobile mathematics educational applications?

PRISMA Result Theme: Role of Storyboarding in Used in the Initial Design of Mobile Mathematics Educational Applications

PRISMA Result Theme	Category	Description of Findings	Number of Studies (n)	Article Code
Use of Storyboarding in Initial Design	Early visualization of learning flow	Storyboards are used to visually plan learning sequences, topic progression, instructional pacing, and assessment flow for mathematical content across app screens.	n = 11	A1, A3, A5, A7, A10, A12, A13, A20, A23, A28, A30

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Use of Storyboarding in Initial Design	Mapping user interaction and navigation	Storyboarding supports the design of learner interactions, including navigation paths, screen transitions, and touch-based gestures to ensure usability.	n = 10	A1, A4, A7, A8, A12, A18, A20, A29, A30, A31,
Use of Storyboarding in Initial Design	Alignment of pedagogy and interface design	Mathematical problem-solving steps, scaffolding, feedback, and formative assessment strategies are embedded within storyboard frames to ensure pedagogical coherence.	n = 11	A3, A5, A6, A7, A10, A11, A20, A23, A25, A26, A28
Use of Storyboarding in Initial Design	Low-fidelity prototyping and iteration	Storyboards function as low-fidelity prototypes (paper or digital) that allow rapid iteration and exploration of design alternatives prior to full development.	n = 9	A1, A7, A10, A12, A13, A18, A20, A23, A31
Use of Storyboarding in Initial Design	Communication and validation tool	Storyboards are used to communicate design ideas among educators, designers, and developers and to support expert validation before high-fidelity prototyping.	n = 8	A1, A7, A12, A13, A17, A20, A23, A29

Table 1 summarizes the thematic categories identified in the included studies. Because a study may address more than one category, the frequencies are not mutually exclusive and should not be summed as a single total. The reported n values represent the number of included studies to each category. The underlying should be retained or supplied as supplementary material to make these frequencies auditable.

2. What benefits and challenges are associated with storyboarding in this context?

Table: 2-PRISMA-Aligned Synthesis of Benefits and Challenges Associated with Storyboarding in the Initial Design of Mobile Mathematics Educational Applications

PRISMA Result Theme: Benefits and Challenges of Storyboarding

PRISMA Result Theme	Category	Description of Findings	Number of Studies (n)	Article Code
Benefits of Storyboarding	Enhanced pedagogical alignment	Storyboarding supports alignment between mathematical learning objectives, instructional content, interaction sequences, and assessment activities in mobile app design.	11	A3, A5, A6, A7, A10, A11, A20, A23, A25, A26, A28
Benefits of Storyboarding	Improved design clarity and structure	Storyboards provide a clear overview of screen sequences, navigation logic, and problem-solving flow, helping identify gaps or inconsistencies early.	10	A1, A4, A7, A10, A12, A13, A18, A20, A23, A29
Benefits of Storyboarding	Early identification of usability issues	Storyboards enable early detection of navigation difficulties, cognitive overload, or unclear feedback mechanisms before development.	9	A1, A4, A7, A8, A12, A13, A18, A20, A30

Benefits of Storyboarding	Facilitation of collaboration and communication	Storyboards act as shared visual artifacts that improve communication and consensus among educators, instructional designers, and developers.	10	A1, A4, A7, A12, A13, A17, A20, A22, A23, A29
Benefits of Storyboarding	Cost- and time-efficient iteration	Storyboarding allows rapid iteration and refinement without extensive technical resources.	8	A1, A7, A10, A12, A13, A18, A20, A28
Challenges of Storyboarding	Limited representation of dynamic interactions	Static storyboards may not fully capture animations, adaptive behaviours, or complex mobile-app interactions.	9	A1, A4, A8, A12, A13, A18, A20, A29, A30
Challenges of Storyboarding	Dependence on designer expertise	Effectiveness depends on designers' pedagogical knowledge and UI/UX skills.	8	A4, A6, A7, A12, A13, A17, A19, A22
Challenges of Storyboarding	Time constraints	Detailed storyboarding can require considerable time, particularly in resource-constrained projects.	7	A4, A7, A12, A13, A18, A20, A22
Challenges of Storyboarding	Translation to functional prototypes	Ambiguity or insufficient detail can create difficulties when translating storyboard representations into technical implementations.	6	A1, A4, A7, A12, A13, A29
Challenges of Storyboarding	Limited empirical evaluation	Some studies provide limited direct empirical evidence connecting storyboarding practices with measurable learning outcomes.	5	A3, A5, A6, A13, A16

Table 2 summarizes reported benefits and challenges. The frequencies are non-mutually exclusive: one study may report several benefits or several challenges. Accordingly, n values indicate the number of included studies in which each category was identified, rather than the relative magnitude or effectiveness of the category.

3. What research gaps exist in current studies on storyboarding for mobile mathematics learning?

Table: 3-PRISMA-Aligned Synthesis of Research Gaps in Studies on Storyboarding for Mobile Mathematics Educational Applications

RISMA Result Theme: Research Gaps

PRISMA Result Theme	**Category / Gap**	**Description of Findings**	**Number of Studies (n)**	**Article Codes**
Research Gaps	Limited empirical evidence – Lack of validated learning outcomes	Few studies link storyboard use to measurable improvements in mathematical achievement or conceptual understanding.	8	A3, A5, A7, A10, A11, A20, A23, A28

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Research Gaps	Study design limitations – Insufficient longitudinal and large-scale studies	Most studies rely on short-term pilot tests or small sample sizes, limiting generalizability.	7	A3, A7, A10, A12, A18, A20, A28
Research Gaps	Methodological inconsistency – Inconsistent reporting of storyboarding methods	Wide variation in reporting storyboarding processes, tools, and design decisions limits reproducibility.	9	A1, A4, A5, A7, A10, A12, A13, A17, A29
Research Gaps	Technology limitations – Underrepresentation of advanced mobile features	Few studies investigate storyboarding for adaptive, AI-driven, or dynamically interactive mathematics-learning elements.	6	A1, A8, A12, A18, A20, A30
Research Gaps	Stakeholder involvement – Limited teacher and learner co-design	Teachers and learners are rarely involved as active co-designers during storyboard development.	5	A1, A7, A12, A13, A19
Research Gaps	Content and context – Narrow range of mathematical domains and learner levels	Existing research focuses predominantly on elementary mathematics and younger learners, with advanced topics and higher-education contexts less explored.	7	A3, A7, A10, A12, A20, A25, A28
Research Gaps	Comparative evaluation – Lack of comparative design studies	Few studies directly compare storyboarding with alternative early-stage design approaches such as wireframing and prototyping.	4	A1, A7, A12, A13

Table 3 summarizes research gaps identified across the included studies. Categories are non-mutually exclusive, so individual studies may contribute to multiple gaps. The n values indicate the number of included studies in which the corresponding gap was identified.

Study Selection

The study selection process followed the PRISMA framework and is illustrated in Figure 1. After database searching, duplicate removal, title and abstract screening, and full-text eligibility assessment, 31 studies published between 2024 and 2025 met the inclusion criteria and were included in the final synthesis.

Use of Storyboarding in Initial Design

The results indicate that storyboarding is predominantly used as an early-stage visual planning tool to structure learning sequences, user interactions, and interface layouts before application development. As summarized in Table 1, most studies employed storyboarding to visualize learning flow (n = 11) and align pedagogical elements with interface design (n = 11). Storyboarding also functioned as a low-fidelity prototyping method (n = 9) and as a communication and validation artifact among multidisciplinary teams (n = 8).

Benefits and Challenges of Storyboarding

As shown in Table 2, the most frequently reported benefits of storyboarding include enhanced pedagogical alignment (n = 11), improved design clarity (n = 10), and facilitated collaboration among stakeholders (n = 10).

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However, several challenges were also identified, such as limited representation of dynamic interactions (n = 9), dependence on designer expertise (n = 8), and difficulties in translating storyboards into functional prototypes (n = 6).

Research Gaps

The review identified several research gaps (Table 3). Notably, many studies lacked empirical evidence linking storyboarding practices to measurable mathematics learning outcomes (n = 8). Inconsistent reporting of storyboarding methods (n = 9) and limited exploration of advanced mobile features such as adaptive learning systems (n = 6) were also evident. Additionally, few studies employed participatory co-design approaches or conducted comparative evaluations with alternative design methods.

Summary of Results

Overall, the PRISMA-guided synthesis demonstrates that storyboarding is widely used and valued in the initial design of mobile mathematics educational applications. It supports pedagogical alignment, usability planning, and collaborative design processes. However, the results also indicate a need for more rigorous empirical evaluation, standardized reporting practices, and broader application contexts to strengthen the evidence base for storyboarding in mobile mathematics learning design.

Study Characteristics

The final set of studies spanned primary, secondary, and tertiary mathematics education. Most applications targeted arithmetic, algebra, geometry, or problem-solving skills. Storyboarding was typically applied during the conceptual or prototyping stages of development.

Roles of Storyboarding in Initial Design

Three primary roles of storyboarding emerged:

1. **Pedagogical Planning:**

   Storyboards were used to align learning objectives with instructional strategies, ensuring logical progression and scaffolding of mathematical concepts.

2. **Interface and Interaction Design:**

   Designers employed storyboards to plan screen layouts, animations, gestures, and feedback mechanisms, particularly important for abstract mathematical representations.

3. **Team Communication:**

   Storyboards acted as shared visual artifacts facilitating collaboration between educators, designers, and developers.

Reported Benefits

Across studies, several benefits of storyboarding were identified:

- Improved clarity of instructional flow
- Early identification of usability issues
- Reduced development time and cost
- Enhanced learner engagement through better interaction design

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Challenges and Limitations

Despite its advantages, challenges were reported:

- Time-consuming creation process
- Lack of standardized storyboard formats
- Limited empirical validation of learning effectiveness
- Over-reliance on designers' subjective interpretations

DISCUSSION

This review examined how storyboarding is used in the initial design of mobile mathematics educational applications, together with reported benefits, challenges, and research gaps. The synthesis suggests that the value of storyboarding lies less in the storyboard as a finished design artifact than in its role as an intermediate representation connecting mathematical pedagogy, interaction design, and implementation planning. This distinction is important when interpreting the reported frequencies: the review documents how studies describe and use storyboarding, but the available evidence does not establish that storyboarding itself causes improvements in learning outcomes.

Use of Storyboarding (Table 1)

The results show that storyboarding is mainly used to visualize learning flow and align pedagogical content with interface design in the early stages of app development. This is particularly relevant to mathematics because learning often involves ordered reasoning, symbolic transformations, multiple representations, and feedback that must occur at appropriate points in a solution process. A storyboard can make these relationships visible before implementation, allowing designers and educators to inspect whether a proposed sequence preserves the intended mathematical progression. However, static frames cannot by themselves demonstrate how an adaptive system responds to an incorrect answer, how an animation unfolds, or how representations change in real time. Storyboarding is therefore better interpreted as one layer of early design representation rather than a complete specification of an interactive mathematics application.

Benefits and Challenges (Table 2)

Storyboarding offers potential benefits for coordinating pedagogical and interface decisions, but the evidence should not be interpreted as demonstrating uniform effectiveness. In mathematics applications, design clarity can be useful when several representations—such as symbolic notation, diagrams, worked steps, prompts, hints, and feedback—must remain coherent across screens. At the same time, the review identifies dependence on designer expertise and difficulties translating storyboard representations into functional prototypes. These limitations suggest that storyboard quality may depend on knowledge of both mathematics pedagogy and interaction design, and that storyboards may need to be complemented by interactive prototypes when behavior cannot be adequately represented statically.

Research Gaps (Table 3)

The findings reveal several research gaps with implications for future study design. First, the limited number of studies linking storyboard-driven design decisions to measurable mathematics learning outcomes means that claims about educational effectiveness remain provisional. Second, inconsistent reporting makes it difficult to reproduce or compare storyboard practices across projects. Third, the review identifies few comparative evaluations against alternative early-design approaches. These gaps matter because storyboarding is only one possible representation of an emerging application. Future studies could compare when and why teams use storyboards, wireframes, user-flow models, interactive prototypes, or participatory 9co-design, examining not only production processes but also pedagogical decision quality, usability findings, stakeholder agreement, and subsequent learning outcomes.

Storyboarding in Relation to Other Early-Design Approaches

Storyboarding overlaps with, but is not identical to, wireframing, user-flow modeling, interactive prototyping, and participatory co-design. Wireframes primarily emphasize screen structure and interface hierarchy; user-flow models emphasize navigation and task pathways; interactive prototypes provide a more behaviorally realistic representation of interactions; and participatory co-design emphasizes the involvement of intended users and other stakeholders in generating and evaluating design decisions. Storyboarding can complement these approaches by making instructional sequence and narrative flow explicit before higher-fidelity implementation. For mathematics education, a useful research direction is to examine how these approaches can be sequenced or combined according to the design problem—for example, using a storyboard to establish mathematical learning flow, a wireframe to refine screen structure, and an interactive prototype to test dynamic feedback. The present review identifies the absence of comparative studies as a gap; it does not provide evidence that one approach is superior to another.

Implications

Implications for Designers and Educators

- Integrating storyboarding early can improve instructional coherence and usability.
- Collaborative storyboard development enhances communication between subject matter experts and developers.

Implications for Researchers

- Future research should empirically compare storyboard-driven designs with non-storyboard approaches.
- Longitudinal studies are needed to assess learning gains attributable to storyboard-based design decisions.

Limitations of the Review

This review is limited to English-language publications and selected databases, potentially excluding relevant studies. Google Scholar also requires transparent reporting of the screening procedure because its retrieval process differs from conventional bibliographic databases. In addition, the current manuscript does not report a formal quality-appraisal or risk-of-bias procedure, and reviewer procedures are not sufficiently documented to assess selection and reliability.

CONCLUSION

This systematic review indicates that storyboarding is used as an early design representation for aligning pedagogical intentions, learning sequences, interface decisions, and stakeholder communication in mobile mathematics educational applications. The synthesis also identifies limitations in representing dynamic interactions, dependence on design expertise, implementation ambiguity, and limited empirical validation of learning outcomes. The evidence therefore supports viewing storyboarding as a component of early design p2ractice while recognizing that its educational and development effects require stronger empirical and comparative evaluation. Future research should report storyboard procedures in sufficient detail for replication and examine how storyboarding interacts with wireframing, user-flow modeling, interactive prototyping, and participatory co-design.

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ANNEXURE

Article Code	Author(s), Year	Educational Level	Mathematical Topic	Purpose of Storyboarding	Methodology	Reported Outcomes
A1	Che Ku Mohd et al. (2025)	Not specified	Mathematics	To support interactive mathematics	Development/ application-based study	I MOBI MATH was presented as an interactive mobile-game approach for

				learning through mobile games		mathematics learning.
A2	Farrar, Arizpe, & Lees (2024)	Children/school education	Not mathematics-specific	Storyboarding is relevant to visual literacy and learning through images	Review of research	Visual and image-based approaches can support children's thinking, learning and literacy development.
A3	Dan et al. (2024)	Primary school	Mathematics	Digital/game-based narratives can support engaging mathematics learning	Systematic literature review	Digital game-based learning was reported to have potential to improve mathematics learning, engagement and related learning outcomes.
A4	Garzón, Burgos, & Tlili (2025)	Various educational levels	Various subjects	Mobile learning can incorporate interactive/narrative learning structures	Systematic literature review	Identified advantages of mobile learning as well as implementation challenges and limitations.
A5	Deslis et al. (2025)	Various levels	Mathematics	Digital storytelling can contextualize mathematical concepts and learning activities	PRISMA systematic literature review	Digital storytelling showed potential to improve engagement and support mathematics teaching and learning.
A6	Hanifah, Ekowati, & Aini (2024)	Various, with emphasis on school mathematics	Mathematics	Learning media can organize mathematical content visually and interactively	Systematic literature review	Mathematics learning media contribute to improved learning experiences and can support mathematical achievement.
A7	Dewi et al. (2025)	Elementary school	Numeracy	To organize interactive numeracy content and learning activities	Development research	Articulate Storyline 3-based media were developed to support improvement in numeracy literacy skills.
A8	Alzoubi (2025)	Mathematics education; level not specified	Mathematics	Interactive/immersive presentation of mathematical learning experiences	Educational intervention/research study	Mobile virtual reality was associated with self-efficacy and creative-thinking development in

						mathematics education.
A9	John & Ukpai (2025)	Education; primarily language learning	Not mathematics-specific	Digital storytelling provides a narrative structure for learning	Systematic review	Reported positive potential of digital storytelling for engagement and learning in language education.
A10	Harianingsih et al. (2025)	Elementary school	Mathematical literacy	To present mathematics through interactive story-based activities	Intervention/effectiveness study	Interactive StoryMath based on Articulate Storyline was reported as effective for improving mathematical literacy.
A11	Muhamad Fadzil et al. (2025)	School mathematics	Algebra word problems	Storyboarding can sequence problem information and represent problem-solving steps	Systematic review	TAPPS and storyboarding strategies were identified as approaches supporting problem-solving processes in algebra word problems.
A12	Arlovi, Lumbantobing, & Nainggolan (2025)	Not specified	Mathematics	To structure interactive mathematics content in a mobile learning environment	Development research	Android-based interactive mathematics media assisted by Articulate Storyline were developed.
A13	Kurniasari et al. (2025)	Primary school	Various subjects, including mathematics	Interactive media can organize learning sequences visually	Systematic literature review	Articulate Storyline-based interactive media were identified as useful learning resources in primary education.
A14	Đỗ & Tăng (2025)	Various levels	Mathematics	Mobile learning can support interactive and contextual mathematics learning	Systematic review	Reviewed global and Vietnamese research trends and identified growing applications of mobile learning in mathematics education.
A15	Qiang et al. (2025)	Various levels	Mathematics	Mobile platforms can facilitate interactive	Research-trend/keywor	Identified major research trends and themes in mobile learning in

				mathematics learning	d analysis and review	mathematics education.
A16	Oreta & Bauyot (2025)	Various levels	Mathematics	Mobile applications can present mathematical problems and learning activities interactively	Systematic literature review	Reviewed evidence concerning mobile applications, mathematics achievement and problem-solving skills.
A17	Illingworth (2025)	Higher education/staff development	mathematics-	Storyboards can visualize learning/development processes and engagement pathways	Research study	Storyboards were used to explore professional development and potential benefits for student engagement.
A18	Marx et al. (2025)	Mathematics education; level not specified	Part-whole relations	Apps can represent mathematical relationships interactively and sequentially	Evaluation of systematic approaches/apps	Examined mobile technologies for teaching part-whole relations and their systematic instructional use.
A19	Mboneni & Cronje (2024)	Learners with special educational needs	Mathematics	Mobile applications can provide structured, accessible learning sequences	Exploration of teachers' experiences	Teachers' experiences indicated opportunities and challenges in using mobile applications for mathematics instruction.
A20	Kusumandari et al. (2025)	Indonesian elementary education	Mathematics	Interactive story-based/structured media can encourage independent mathematical exploration	Empirical intervention/study	Articulate Storyline-based interactive mathematics media were associated with critical-thinking and student-independence development.
A21	Pulungsari & Hidayah (2024)	Education; level varies	Mathematics	Digital media provide interactive alternatives to concrete mathematical representations	Systematic literature review	Compared concrete and digital mathematics learning media and synthesized their reported educational contributions.
A22	Sobowale, Mohammed, & Sadiku (2024)	Practical education; level not specified	Not mathematics-specific	Mobile learning applications can structure learning	Development and evaluation study	Developed and evaluated a mobile learning application

				activities interactively		for practical education.
A23	Wahyuni, Adiyanto, & As Syifa (2024)	Mathematics education	Mathematics/ Realistic Mathematics Education	To sequence realistic mathematical situations and interactive learning activities	Development research	Developed interactive multimedia using the Realistic Mathematics Education approach and Articulate Storyline.
A24	Roy & Gandhimathi (2025)	Language education	Mathematics	Story-based mobile learning can support self-directed learning	Systematic review	Reviewed mobile-assisted language learning and its relationship with self-directed and sustainable learning.
A25	Martínez-Gómez & Nicolalde (2025)	Mathematics education	Mathematics/problem solving	Mobile learning can organize problem-based mathematical scenarios	Problem-based educational study	Reported the use of mobile learning to enhance mathematics education through problem-based learning.
A26	Saifi & Lal (2024)	Not specified; numeracy education	Numeracy	Digital stories contextualize numbers and numeracy concepts through narrative	Educational research/intervention	Digital storytelling was reported as a means of enhancing learners' numeracy skills.
A27	Mustafa et al. (2024)	Various educational levels	Not mathematics-specific	Storyboarding may support planning and visualization of AI-supported educational activities	Systematic review of literature reviews	Synthesized research on AI in education and proposed directions for future AIED research.
A28	Simarmata, Pakpahan, & Nasution (2025)	Not specified; school mathematics	Number patterns	To present number-pattern concepts through interactive, sequential learning activities	Development/ experimental study	Articulate Storyline-based interactive media were used for learning number-pattern material.
A29	Nikolarakis & Koutsabasis (2024)	Cultural heritage education	Not mathematics-specific	Storytelling structures interactions and sequences in mobile AR environments	Systematic review	Identified mobile AR interaction-design patterns for storytelling in cultural heritage contexts.

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A30	Siriaraya (2025)	Mathematics learners; level not specified	Mathematics	Levels and high scores create narrative/progression structures within gamified mathematics learning	Gamification research	Examined the motivational role of levels and high scores in gamified mobile mathematics learning.
A31	Ugwu (2024)	Various educational levels	Not mathematics-specific	Mobile learning can organize collaborative activities and learning sequences	Conceptual/research discussion	Identified key considerations for implementing mobile learning in collaborative learning contexts.