

The Effectiveness of Using Escape Room-Based Interactive Media to Enhance Elementary School Students' Numeracy Literacy

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Abstract: This study aimed to analyze the effectiveness of using interactive *escape room*-based media in improving elementary school students' numeracy literacy and identify the most effective *escape room* design characteristics for mathematics learning. This research applied a Systematic Literature Review (SLR) with the PRISMA framework including four stages, namely: identification, screening, eligibility, and inclusion. A total of 20 scientific articles published between 2020 and 2025 that are relevant to the topic of educational *escape rooms* and numeracy literacy were analyzed systematically. Data collection techniques were carried out by identifying source *databases*, determining keywords, applying inclusion and exclusion criteria, screening and selection, and documentation. Data analysis techniques were carried out using thematic descriptive analysis. The results of the study indicated that interactive *escape room*-based media is proven effective in improving elementary school students' numeracy literacy through a learning approach that emphasizes collaborative problem solving, critical thinking, and the application of mathematical concepts in real contexts. The most effective *escape room* characteristics include multilevel numeracy-based puzzle designs, motivating gamification elements, group collaboration, and direct constructive feedback. The main challenges identified were limited implementation time, the complexity of the puzzle design, and the need for teacher training in designing and facilitating *escape room* activities. This study proposes that future development of educational *escape rooms* should be carried out by increasing the integration of digital technology, strengthening empirical validation of learning impacts, and providing practical guidance for teachers to implement *escape rooms* sustainably in numeracy literacy learning in elementary schools.

Keywords: educational *escape room*, interactive media, numeracy literacy, mathematics learning, elementary school students

Abstrak : Penelitian ini bertujuan untuk menganalisis efektivitas penggunaan media interaktif berbasis *escape room* dalam meningkatkan literasi numerasi siswa sekolah dasar dan mengidentifikasi karakteristik desain *escape room* yang paling efektif untuk pembelajaran matematika. Pendekatan penelitian menerapkan Systematic Literature Review (SLR) dengan kerangka PRISMA yang meliputi empat tahapan, yaitu: identification, screening, eligibility, dan included. Sebanyak 20 artikel ilmiah dengan tahun terbit 2020-2025 yang relevan dengan topik *escape room* edukatif dan literasi numerasi dianalisis secara sistematis. Teknik pengumpulan data dilakukan dengan identifikasi *database* sumber, penentuan kata kunci, penerapan kriteria inklusi dan eksklusi, penyaringan dan seleksi serta dokumentasi. Teknik analisis data dilakukan dengan analisis deskriptif tematik. Hasil penelitian menunjukkan bahwa media interaktif berbasis *escape room* terbukti efektif dalam meningkatkan literasi numerasi siswa sekolah dasar melalui pendekatan pembelajaran yang menekankan pemecahan masalah kolaboratif, berpikir kritis, dan penerapan konsep matematika dalam konteks nyata. Karakteristik *escape room* yang paling efektif mencakup

desain teka-teki berbasis numerasi bertingkat, elemen gamifikasi yang memotivasi, kerja sama kelompok, serta umpan balik langsung yang konstruktif. Tantangan utama yang ditemukan adalah keterbatasan waktu implementasi, kompleksitas desain teka-teki, serta kebutuhan pelatihan guru dalam merancang dan memfasilitasi aktivitas *escape room*. Penelitian ini mengusulkan agar pengembangan *escape room* edukatif ke depan dilakukan dengan meningkatkan integrasi teknologi digital, memperkuat validasi empiris terhadap dampak pembelajaran, serta menyediakan panduan praktis bagi guru untuk mengimplementasikan *escape room* secara berkelanjutan dalam pembelajaran literasi numerasi di sekolah dasar.

Kata Kunci: *escape room* edukatif, media interaktif, literasi numerasi, pembelajaran matematika, siswa sekolah dasar

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INTRODUCTION

The low level of numeracy literacy among elementary school students in Indonesia represents a systemic challenge rooted in the dominance of monotonous conventional teaching approaches. Such methods often fail to facilitate the internalization of mathematical concepts because they focus primarily on procedural memorization, which significantly reduces students' motivation and triggers anxiety.¹ To address these challenges, a transition toward more interactive and contextualized learning strategies is required. Escape room–based interactive media have emerged as a complementary solution that integrates elements of gamification, authentic problem-solving, and team collaboration. Unlike traditional methods, escape rooms create learning environments in which students must apply numeracy concepts to solve puzzles in challenging situations, which has been shown to correlate positively with increased students' cognitive and emotional engagement.²

The urgent need for innovative learning strategies to enhance numeracy literacy in elementary schools has encouraged the exploration of more interactive and contextualized instructional approaches. The dominance of conventional teaching methods often fails to stimulate students' interest in mathematics due to the lack of engaging challenges and collaborative elements. Escape room–based interactive media offer a learning experience

¹ Veldkamp, A., van de Grint, L., Knippels, M. C. P. J., & van Joelingen, W. R. (2020). Escape education: A systematic review on escape rooms in education. *Educational Research Review*, 31, 100364.

² Huang, S. Y., Kuo, Y. H., & Chen, H. C. (2020). Applying digital escape rooms infused with science teaching in elementary school: Learning performance, learning motivation, RetryMAContinue and problem-solving ability. *Thinking Skills and Creativity*, 37, 100681.

that integrates elements of gameplay, problem-solving, teamwork, and the application of mathematical concepts in challenging yet enjoyable situations. Empirical studies indicate that both digital and physical escape rooms can improve elementary school students’ learning motivation, critical thinking skills, and numeracy competencies.³ Other studies have reported that the implementation of escape rooms in science and mathematics learning significantly improves students’ academic performance and problem-solving skills.⁴ Therefore, the implementation of escape room–based interactive media is recommended as an instructional strategy capable of improving elementary school students’ numeracy literacy, supported by well-structured instructional design and adequate teacher training.

This study aims to analyze and describe the effectiveness of using escape room–based interactive media in improving elementary school students’ numeracy literacy. A previous study revealed that low numeracy literacy in elementary schools is also caused by learning media that are insufficiently capable of presenting mathematical concepts in a clear and engaging manner. Interactive media, such as augmented reality, have been proven to provide more concrete visualizations, thereby enhancing students’ understanding of two-dimensional and three-dimensional geometric concepts. Therefore, this study has a strategic objective to strengthen empirical evidence regarding the effectiveness of escape room approaches in the context of numeracy literacy and to provide practical recommendations for their sustainable implementation in Indonesian elementary schools.

The main argument of this study emphasizes that technology-based escape rooms are capable of creating holistic learning experiences that extend beyond mere computational skills. Through time pressure and narrative-based challenges, students are encouraged to develop logical thinking, creativity, and social skills simultaneously. The high level of cognitive activation within this learning ecosystem has been shown to improve knowledge retention and foster positive dispositions toward mathematics. Thus, the implementation of well-structured escape room–based interactive media represents a highly relevant innovative strategy for reforming numeracy literacy and preparing elementary school students to face more complex learning challenges in the future with greater confidence.

METHOD

This study employed a Systematic Literature Review (SLR) approach using the PRISMA 2020 framework to address the issue of the effectiveness of educational escape rooms in improving elementary school students’ numeracy literacy. This method was selected because SLR enables researchers to synthesize findings from previous studies in a systematic, transparent, and replicable manner, thereby ensuring that the review results are grounded in strong empirical evidence.⁵ The research process was conducted through four main stages in accordance with the PRISMA flow, namely identification, screening, eligibility, and inclusion. In the identification stage, article searches were carried out

³ Vidergor, H. E. (2021). Effects of digital escape room on gameful experience, collaboration, and motivation of elementary school students. *Computers & Education*, 166, 104156.

⁴ Huang, S. Y., Kuo, Y. H., & Chen, H. C. (2020). Applying digital escape rooms infused with science teaching in elementary school: Learning performance, learning motivation, RetryMAContinue and problem-solving ability. *Thinking Skills and Creativity*, 37, 100681.

⁵ Gusenbauer, M. (2020). Which academic search systems are suitable for systematic reviews? *International Journal of Educational Research*, 103, 101595.

through databases such as Google Scholar, Scopus, ERIC, and ScienceDirect using a combination of keywords, including “educational escape room,” “numeracy literacy,” “mathematics,” and “elementary/primary school.” This search strategy was designed to capture relevant and comprehensive studies aligned with the focus of the research. The entire search process was reported transparently to ensure it can be replicated by other researchers.⁶ Other studies have also shown that the use of the PRISMA 2020 checklist assists researchers in documenting each stage of the article selection process in a detailed and transparent manner.

The data and information sources in this study were obtained from Google Scholar, Scopus, ERIC, and ScienceDirect databases. The selection of multiple databases was necessary to ensure comprehensive literature coverage, both from national and international publications, as well as to minimize publication bias from a single source. These databases were chosen because they provide access to reputable, peer-reviewed journal articles and include empirical studies on educational escape rooms and numeracy literacy. This study indicates that the use of multiple databases in an SLR enhances the quality of literature search and the validity of findings by accommodating variations in terminology and a broader scope of publications.⁷ A study on escape rooms in education conducted by Veldkamp employed a combination of databases such as Scopus, Web of Science, and ERIC to ensure comprehensive and representative results.⁸ Data analysis was conducted using a descriptive–thematic approach to describe article characteristics and synthesize findings related to the effectiveness of escape rooms in improving students’ numeracy literacy. This approach was chosen because the primary aim of an SLR is not to produce a single quantitative effect size, but rather to understand patterns, trends, and implementation characteristics of escape rooms in the context of numeracy learning. Descriptive analysis enables researchers to identify relationships among variables such as types of escape rooms, implementation contexts, puzzle design, and their impacts on students’ numeracy literacy. SLR studies employing thematic analysis are used to identify key design elements of escape rooms that contribute to effective learning across different educational levels.⁹ A descriptive analysis was applied to categorize the types of escape rooms, learning objectives, and learning outcomes reported across the 89 studies analyzed. Therefore, this study employed a descriptive–thematic analysis by grouping the types of escape rooms, design characteristics, impacts on numeracy literacy, implementation challenges, and optimization strategies, which were then presented in a comprehensive and systematic manner.

The following presents the PRISMA framework generated in this study:

⁶ Grepperud, G. (2025). Educational escape games: A systematic literature review. *Education Sciences*, 15(1), 89.

⁷ Heath, A., Lefmann, T., & McDonald, S. (2021). Literature searching methods and their reporting: A scoping review of guidance and best practice. *Research Synthesis Methods*, 12(1), 1-20.

⁸ Veldkamp, A., van de Grint, L., Knippels, M. C. P. J., & van Joolingen, W. R. (2020). Escape education: A systematic review on escape rooms in education. *Educational Research Review*, 31, 100364.

⁹ Veldkamp, A., van de Grint, L., Knippels, M. C. P. J., & van Joolingen, W. R. (2020). Escape education: A systematic review on escape rooms in education. *Educational Research Review*, 31, 100364.

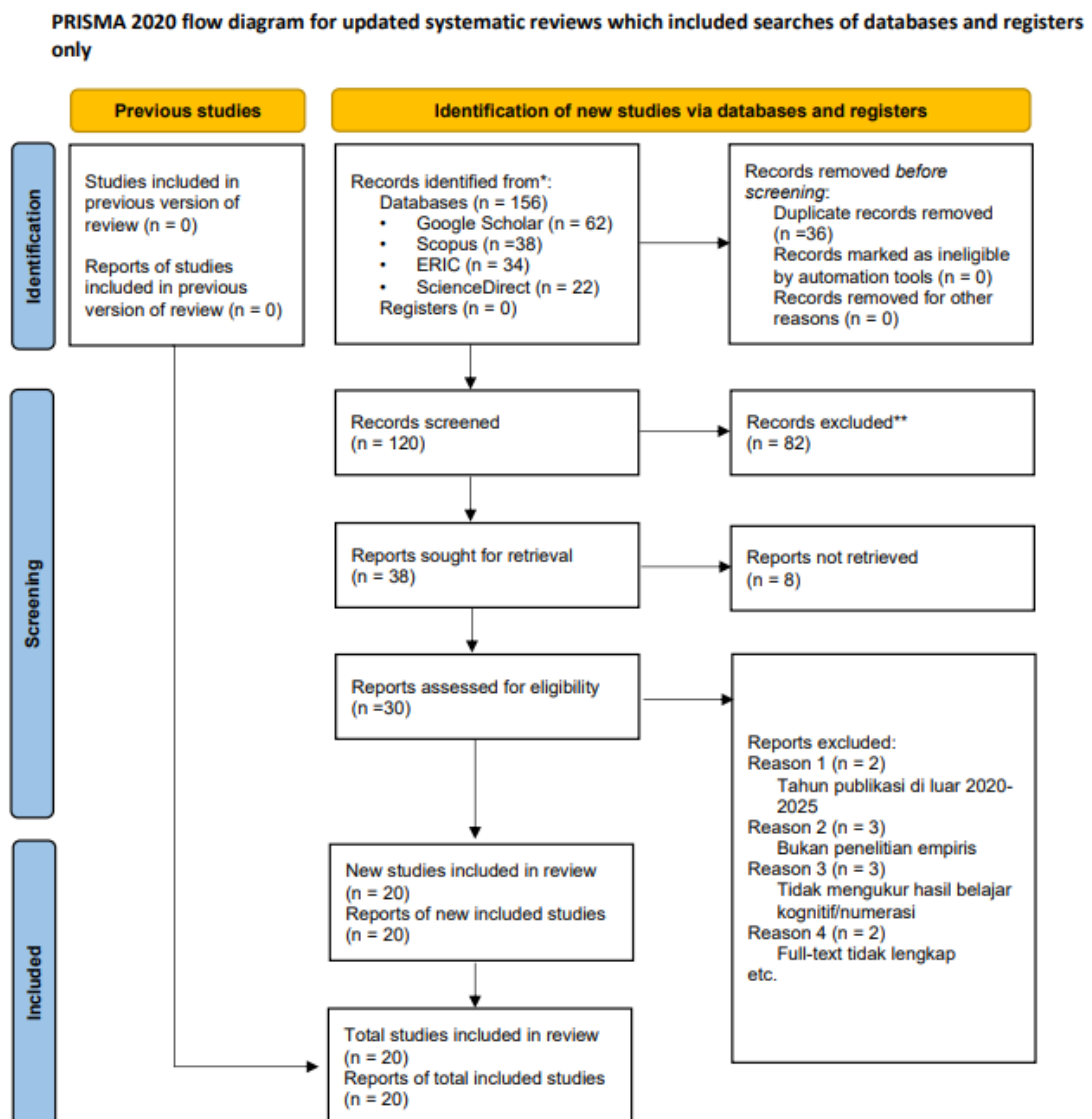


Figure 1. PRISMA 2020 Flow Diagram of Article Selection

As a modification of the conventional SLR approach, this study specifically emphasizes the analysis of numeracy puzzle design within escape rooms, which has been relatively underexplored in previous research. This focus is expected to generate practical recommendations for elementary school teachers in designing effective and meaningful game-based numeracy instruction.

RESULTS AND DISCUSSION

Results

The Effectiveness of Escape Room–Based Interactive Media in Improving Elementary School Students’ Numeracy Literacy

In the context of mathematics learning in elementary schools, the selection of appropriate instructional media is a crucial factor in enhancing student engagement and developing strong numeracy literacy. One innovative learning approach that has recently gained considerable attention is escape room–based interactive media, as it is capable of creating challenging, collaborative, and meaningful learning experiences. Through this

approach, students do not merely learn numeracy concepts procedurally but are also encouraged to apply mathematical knowledge in authentic problem-solving contexts. The findings of this SLR are consistent with previous studies indicating that interactive learning media, particularly those involving 3D visualization and digital object manipulation, are proven to significantly improve numeracy performance.¹⁰ This type of media provides a more immersive learning experience and supports mathematical problem-solving processes. Therefore, a more in-depth investigation is needed regarding the effectiveness of escape room-based interactive media in improving elementary school students' numeracy literacy.

Table 1. *Effectiveness of Escape Room-Based Interactive Media on Students' Numeracy Literacy (N = 20)*

Research Focus	Key Findings / Implementation Patterns	Implications for Numeracy Literacy
Effectiveness of escape room-based interactive media in improving elementary students' numeracy literacy	1. Overall effectiveness: Most studies indicate that educational escape rooms effectively enhance students' motivation, cognitive engagement, and numeracy problem-solving skills. Both physical and digital escape rooms stimulate critical thinking and the application of mathematical concepts in challenging yet enjoyable contexts. 2. Impact on numeracy literacy: A significant improvement was observed in students' numeracy abilities, particularly in problem-solving, mathematical reasoning, and the application of number concepts in real-life contexts. Several studies reported learning gains with medium to high effect sizes. 3. Effectiveness by type of escape room: Digital escape rooms offer greater implementation flexibility and allow automatic adjustment of difficulty levels, while physical escape rooms are more effective in fostering collaboration and	Theoretical implications: The SLR findings strengthen constructivist and situated learning theories, where students construct numeracy understanding through contextualized and meaningful problem-solving experiences. Implications for numeracy literacy: Escape rooms enhance computational skills, mathematical reasoning, numerical representation, and the application of mathematical concepts in situations requiring strategic and collaborative thinking. Pedagogical implications: Teachers are encouraged to adopt escape rooms as an active learning strategy that integrates numeracy concepts with authentic problem-solving, creating motivating and cognitively challenging learning experiences. Policy implications: There is a need for school-level policy

¹⁰ Alfi Laila, A., Hikmah, F., & Arifin, M. F. (2025). Pengembangan pocket book berbasis augmented reality untuk meningkatkan literasi numerasi pada materi bangun datar dan bangun ruang siswa sekolah dasar. *Jurnal Pendidikan Dasar Nusantara*, 6(1), 12–23.

mathematical communication support in providing among students. technological infrastructure, teacher training in designing educational escape rooms, and the development of implementation guidelines aligned with the Indonesian mathematics curriculum.
4. General trends: Research trends indicate a shift toward escape room designs that integrate digital technology, gamification elements, and numeracy-based puzzles aligned with the elementary mathematics curriculum.

The analysis of twenty articles indicates that escape room–based interactive media is highly effective in enhancing elementary school students’ numeracy literacy. In general, this media fosters a more interactive, challenging, and student-centered learning process through puzzle-solving activities that require the application of numeracy concepts. The types of escape rooms used across the studies include physical escape rooms with mathematics-based manipulation puzzles, digital escape rooms with interactive interfaces, and hybrid escape rooms that combine both physical and digital elements. These escape room–based media have been proven to increase students’ motivation in learning mathematics and their active participation during instruction, thereby strengthening both cognitive and emotional engagement with numeracy concepts that are often perceived as abstract and difficult.

In terms of effectiveness in improving numeracy literacy, the reviewed studies consistently report significant improvements in mathematical problem-solving skills, numerical reasoning, and the application of number concepts and operations in meaningful contexts. Several studies recorded learning gains with effect sizes ranging from medium to high. These improvements suggest that escape room activities support deeper conceptual understanding of numeracy through exploration, collaboration, and hands-on experiences. Students become more proficient in identifying mathematical patterns, formulating problem-solving strategies, and connecting numeracy concepts to real-life situations, making learning more contextualized and meaningful.

In terms of the types of escape rooms used, digital escape rooms demonstrate advantages in implementation flexibility, the ability to provide instant feedback, and automatic adjustment of difficulty levels according to students’ abilities. Meanwhile, physical escape rooms are more effective in developing mathematical communication skills and student collaboration, as they require direct interaction and group discussion to solve puzzles. Several studies incorporate gamification elements such as point systems, leaderboards, and engaging adventure narratives to enhance students’ intrinsic motivation. This approach not only enriches the learning experience but also strengthens students’ positive dispositions toward mathematics.

From the perspective of general research trends, there is a clear emerging direction in the development of educational escape rooms toward more innovative, adaptive, and technology-integrated designs. Recent studies indicate that the integration of narrative storytelling, tiered numeracy-based puzzles, and constructive feedback within escape rooms can enhance 21st-century skills such as critical thinking, creativity, communication, and collaboration. Therefore, escape rooms function not only as a learning aid but also as a

medium for developing mathematical competencies and fostering positive learning dispositions among elementary school students.

The implications of this study encompass several important aspects. Theoretically, the findings strengthen constructivist learning theory and situated learning theory, in which numeracy knowledge is constructed through contextualized and meaningful problem-solving experiences. From a pedagogical perspective, teachers are encouraged to integrate escape rooms into mathematics instruction as an active learning strategy that fosters curiosity, engagement, and deep learning.

Characteristics of the Most Effective Escape Room-Based Interactive Media in Improving Elementary School Students' Numeracy Literacy

Table 2. *Characteristics of Escape Room-Based Interactive Media in Relation to Students' Numeracy Literacy*

Research Focus	Key Findings / Implementation Patterns	Implications for Numeracy Literacy
Characteristics of escape room-based interactive media that are most effective in improving elementary school students' numeracy literacy	1. Tiered numeracy-based puzzle design: Effective escape rooms use puzzles with progressive difficulty, starting from basic numeracy concepts to more complex applications, thereby supporting students' cognitive scaffolding. 2. Integration of gamification elements: The use of point systems, leaderboards, timers, and engaging adventure narratives has been shown to increase students' intrinsic motivation and engagement in completing numeracy challenges. 3. Collaboration and mathematical communication: Well-designed escape rooms for group work encourage students to discuss, share problem-solving strategies, and communicate mathematical thinking verbally. 4. Immediate and constructive feedback: Feedback systems that provide instant hints or corrections when students make errors support more effective learning and reduce frustration. 5. Contextualization with real-life situations: Puzzles that	1. Enhances numerical problem-solving skills and mathematical reasoning as students are required to apply multiple strategies to solve puzzles. 2. Develops positive dispositions toward mathematics and reduces math anxiety through enjoyable and non-intimidating learning experiences. 3. Improves mathematical communication and collaboration skills, which are essential competencies in 21st-century numeracy literacy. 4. Ensures adaptive and responsive learning tailored to individual student needs through timely feedback. 5. Enhances knowledge transfer from learning contexts to real-life applications.

incorporate everyday contexts such as shopping, measuring, or time management make numeracy learning more meaningful and applicable.	6. Ensures the effectiveness and suitability of escape rooms with elementary students’ cognitive developmental characteristics, leading to optimal learning outcomes.
6. Design validation and pilot testing: Nearly all effective escape rooms undergo expert validation in mathematics and pedagogy, as well as phased pilot testing to ensure quality and appropriateness.	

Based on the table presenting the analysis of twenty research articles on the characteristics of escape room–based interactive media that are most effective in improving elementary school students’ numeracy literacy, it can be explained that educational escape rooms demonstrate their main strength in the aspect of tiered numeracy-based puzzle design. Nearly all studies indicate that when puzzles are designed with progressive levels of difficulty—starting from basic concepts such as simple number operations to more complex applications such as multi-step problem solving—students’ cognitive engagement increases significantly. This tiered design allows students of varying ability levels to experience early success, which builds confidence, while still providing sufficient challenge to promote further cognitive development.

In addition, another key characteristic is the integration of gamification elements, including point systems, leaderboards, countdown timers, and engaging adventure narratives. These elements have been shown to enhance students’ intrinsic motivation to complete numeracy challenges by creating a sense of urgency, healthy competition, and immersion in an engaging storyline. Several studies report that students learning through narrative-based escape rooms demonstrate higher persistence when dealing with difficult numeracy problems compared to conventional instructional methods.

The characteristics of collaboration and mathematical communication are also crucial aspects of escape room effectiveness. Escape rooms designed for small-group work encourage students to share ideas, discuss problem-solving strategies, and verbally communicate their mathematical thinking. This process not only strengthens conceptual understanding but also develops mathematical communication skills, which are an essential component of numeracy literacy. Students learn to explain their reasoning, question assumptions, and build collective understanding through meaningful mathematical dialogue.

The characteristics of immediate and constructive feedback are also found to be highly important in supporting effective learning. Escape rooms equipped with automated feedback systems or teacher facilitation that provides timely hints help students identify errors, reflect on their strategies, and make immediate improvements. This reduces frustration and ensures that the learning process remains productive and positive. Contextualization with real-life situations also distinguishes effective escape rooms from conventional drill-and-practice activities. Puzzles that integrate authentic contexts such as

event planning, pocket money management, or map navigation make numeracy learning more relevant and meaningful for students.

Finally, design validation and iterative testing using a design-based research approach or development models such as ADDIE ensure that the developed escape rooms are not only aesthetically engaging but also pedagogically effective. Validation processes involving experts in mathematics, pedagogy, and educational technology, along with pilot testing with target students, ensure that the level of difficulty, activity duration, and types of puzzles are appropriate for elementary students' cognitive development. Overall, these characteristics position escape room-based interactive media as an innovative, engaging, and effective tool for improving elementary school students' numeracy literacy.

The interpretation of these data indicates that the effectiveness of escape room-based interactive media in improving elementary school students' numeracy literacy lies in its ability to integrate cognitive, affective, and social dimensions into a single coherent and meaningful learning experience. Well-designed escape rooms not only train computational skills but also develop positive mathematical dispositions, strategic thinking skills, and collaborative abilities within problem-solving contexts. Media such as digital escape rooms with adaptive difficulty, physical escape rooms with mathematical manipulatives, and hybrid escape rooms that combine both approaches have been shown to function not merely as visual aids, but as active knowledge-construction environments that encourage students to think critically, collaborate, and connect numeracy concepts with real-life applications. These findings indicate that when escape rooms are developed with strong instructional design, puzzles that are both challenging and achievable, constructive feedback systems, and contexts relevant to students' lives, significant improvements in numeracy literacy, learning motivation, and knowledge transfer can be achieved. Thus, educational escape rooms are not merely entertainment-based activities, but rather a powerful pedagogical strategy for fostering deep, meaningful, and sustainable numeracy understanding in elementary school students.

Discussion

The findings of this study indicate that escape room-based interactive media is highly effective in improving elementary school students' numeracy literacy. This effectiveness is attributed to educational escape rooms that create active, challenging, and contextualized learning experiences, thereby strengthening students' engagement in understanding numeracy concepts in a more concrete and meaningful way. This study reveals that the implementation of digital escape rooms in science and mathematics learning has been proven to significantly enhance students' learning performance, motivation, and problem-solving skills in elementary schools. In addition, other studies emphasize that digital escape rooms improve students' gameful experiences, collaboration, and motivation through activities that combine cognitive challenges with engaging game elements. Thus, this literature synthesis confirms that escape room-based approaches function not only as instructional tools but also as a means of developing students' numeracy competence and higher-order thinking skills in elementary mathematics learning.

In the context of elementary education in Indonesia, the implementation of escape room-based interactive media is aligned with the direction of the Merdeka Curriculum

policy, which emphasizes project-based learning, problem-solving, and the development of holistic competencies. Numeracy literacy learning requires strategies that are able to connect abstract mathematical concepts with their practical applications in students’ everyday lives, so that learners can understand the relevance of numeracy in a concrete and meaningful way. Therefore, escape rooms serve as an ideal medium for bridging the gap between procedural knowledge and conceptual understanding through authentic and collaborative problem-solving experiences. Several studies have shown that gamification and the use of escape rooms in learning can enhance cognitive activation and reduce students’ learning anxiety.¹¹ Clarke, in his study, also developed the EscapED framework, which provides systematic guidelines for designing effective educational escape rooms across various educational levels, including elementary school.¹² These findings are further supported by other studies indicating that interactivity in augmented reality–based media can enhance students’ cognitive engagement and facilitate their understanding of numeracy concepts.¹³ The three-dimensional visualization offered by interactive media enables students to connect abstract concepts with concrete representations, thereby significantly improving learning outcomes.

The findings of this study indicate that the effectiveness of escape room–based interactive media in elementary schools lies in its ability to integrate cognitive, motivational, and social aspects into a single coherent and meaningful learning experience. The process of completing escape rooms enables students to learn through active exploration, safe trial and error, collaboration with peers, and reflection on the strategies used, all of which are central to meaningful learning in the context of numeracy. Other studies included in systematic reviews have shown that escape rooms can improve learning outcomes through mechanisms such as engagement, flow experience, and situated learning.¹⁴ In addition, other studies have found that educational escape rooms can strengthen critical thinking skills, creativity, and teamwork abilities, which are essential competencies in 21st-century numeracy literacy.¹⁵ Thus, the effectiveness of escape room–based interactive media is not only reflected in improved numeracy test scores, but also in students’ ability to understand the meaning and application of mathematical concepts in a deeper, more sustained manner that is relevant to their real-life experiences.

The success of escape room–based interactive media is also closely related to instructional design that is systematically developed and aligned with effective learning

¹¹ López-Belmonte, J., Segura-Robles, A., Fuentes-Cabrera, A., & Parra-González, M. E. (2020). Evaluating activation and absence of negative effect: Gamification and escape rooms for learning. *International Journal of Environmental Research and Public Health*, 17(7), 2224.

¹² Clarke, S. J., Peel, D. J., Arnab, S., Morini, L., Keegan, H., & Wood, O. (2020). EscapED: A framework for creating educational escape rooms and interactive games for higher/further education. *International Journal of Serious Games*, 7(3), 73-86.

¹³ Alfi Laila, A., Hikmah, F., & Arifin, M. F. (2025). Pengembangan pocket book berbasis augmented reality untuk meningkatkan literasi numerasi pada materi bangun datar dan bangun ruang siswa sekolah dasar. *Jurnal Pendidikan Dasar Nusantara*, 6(1), 12–23.

¹⁴ Veldkamp, A., van de Grint, L., Knippels, M. C. P. J., & van Joolingen, W. R. (2020). Escape education: A systematic review on escape rooms in education. *Educational Research Review*, 31, 100364.

¹⁵ Fotaris, P., & Mastoras, T. (2019). Escape rooms for learning: A systematic review. *Proceedings of the European Conference on Games Based Learning*, 235-243.

principles. A well-designed escape room must consider the alignment between numeracy learning objectives, students' cognitive characteristics, puzzle difficulty levels, and the balance between challenge and support within the learning experience. In a systematic literature review on educational escape games, it is explained that effective escape room design should take into account the pedagogical framework, assessment strategy, and debriefing process in order to maximize learning outcomes.¹⁶ Research in the context of surgical education also shows that escape rooms designed with clear learning objectives and structured reflection produce better learning outcomes compared to activities that focus solely on entertainment value.¹⁷ Therefore, the effectiveness of escape rooms should be understood as the result of high-quality instructional design, alignment with the numeracy curriculum, and teachers' ability to facilitate learning effectively, so that improvements in numeracy literacy can be optimally achieved.

Compared to conventional numeracy learning methods that are still predominantly used in elementary schools, escape room-based interactive media demonstrates significant advantages in enhancing students' numeracy literacy and engagement. Traditional methods tend to rely on repetitive drill-and-practice activities that are less contextual, whereas escape rooms position students as active problem solvers who must apply various numeracy concepts to achieve meaningful goals. In a systematic literature review on digital game-based learning in mathematics education, it was found that game-based approaches lead to significant improvements in conceptual understanding, motivation, and attitudes toward mathematics compared to traditional methods.¹⁸ Similar studies also show that digital escape rooms produce higher learning performance scores and problem-solving abilities, with substantial effect sizes compared to conventional learning methods.¹⁹ Thus, escape room-based interactive media is not merely an alternative to conventional methods, but has also been shown to be more effective in developing comprehensive numeracy literacy, encompassing computational skills, mathematical reasoning, problem-solving abilities, and a positive mathematical disposition.

Based on the findings and analysis, the next step is to expand the implementation of escape room-based interactive media through the development of design models that are contextualized within the Indonesian curriculum, along with systematic teacher training. Future development should integrate accessible digital technologies, provide templates and toolkits to facilitate teachers in designing their own escape rooms, and establish a repository of numeracy-based puzzles that can be adapted for various elementary mathematics topics. The EscapED framework, which has been developed previously, can serve as a practical reference for educators in designing effective educational escape

¹⁶ Grepperud, G. (2025). Educational escape games: A systematic literature review. *Education Sciences*, 15(1), 89.

¹⁷ Kinio, A. E., Dufresne, L., Brandys, T., & Jetty, P. (2019). Break out of the classroom: The use of escape rooms as an alternative teaching strategy in surgical education. *Journal of Surgical Education*, 76(1), 134-139.

¹⁸ Bakar, N. A., Maat, S. M., & Rosli, R. (2023). Mathematics learning through digital game-based learning: A systematic literature review. *Education and Information Technologies*, 28(2), 1-23.

¹⁹ Huang, S. Y., Kuo, Y. H., & Chen, H. C. (2020). Applying digital escape rooms infused with science teaching in elementary school: Learning performance, learning motivation, RetryMAContinue and problem-solving ability. *Thinking Skills and Creativity*, 37, 100681.

rooms.²⁰ In addition, several researchers recommend collaboration among researchers, education practitioners, and game designers to create escape rooms that balance educational value and entertainment while aligning with specific learning objectives.²¹ Thus, the future development and implementation of educational escape rooms should be directed not only at improving numeracy literacy, but also at building an innovative, collaborative, and sustainable mathematics learning ecosystem in elementary schools through a multidisciplinary approach that integrates pedagogical expertise, technological innovation, and creative design.

CONCLUSION

The most important finding of this study is that escape room–based interactive media has a significant impact on improving elementary school students’ numeracy literacy through active, challenging, and contextualized learning experiences. The analysis of twenty articles shows that escape rooms—whether digital, physical, or hybrid—can enhance numerical problem-solving skills, mathematical reasoning, conceptual representation, and the application of number concepts in real-life situations. Students not only demonstrate improved learning performance with medium to high effect sizes, but also show stronger intrinsic motivation, more positive attitudes toward mathematics, and higher cognitive and emotional engagement. Gamification elements, tiered puzzle design, adventure narratives, and immediate feedback systems have been shown to play important roles in strengthening deep numeracy understanding, thereby making the learning process more meaningful and aligned with experiential learning principles.

The strength of this study lies in its contribution to providing a comprehensive synthesis of the effectiveness of educational escape rooms while mapping the key characteristics that enable this media to optimize elementary students’ numeracy literacy outcomes. This study successfully integrates findings from various research to demonstrate that escape rooms support constructivism theory, situated learning, and gamified learning, which emphasize learning through direct experience, social interaction, and authentic problem-solving. In addition, this study enriches the educational literature by offering a solid pedagogical framework for designing escape rooms that are aligned with the mathematics curriculum, students’ cognitive developmental needs, and 21st-century competency demands. Another important contribution is the presentation of practical implications for teachers and educational institutions, including learning optimization strategies,

²⁰ Clarke, S. J., Peel, D. J., Arnab, S., Morini, L., Keegan, H., & Wood, O. (2020). EscapED: A framework for creating educational escape rooms and interactive games for higher/further education. *International Journal of Serious Games*, 7(3), 73-86.

²¹ Veldkamp, A., van de Grint, L., Knippels, M. C. P. J., & van Joolingen, W. R. (2020). Escape education: A systematic review on escape rooms in education. *Educational Research Review*, 31, 100364.

teacher training needs, adaptive digital technology integration, and design guidelines based on expert validation and field testing to produce effective and sustainable learning media.

Despite its broad contributions, this study has several limitations that should be acknowledged. The main limitation lies in its reliance on literature published within a specific time range, meaning that variations in context, setting, and methodological quality across studies may affect the generalizability of the findings. Many of the studies included in the analyzed articles have not examined long-term implementation, so the sustainability of escape room-based learning effects on numeracy literacy cannot yet be fully confirmed. In addition, several technical and pedagogical challenges remain insufficiently addressed, such as teachers' readiness to design tiered puzzles, the complexity of managing instructional time, the availability of technological infrastructure, and differences in students' collaborative abilities. Since most studies employ limited samples and controlled experimental settings, further research is needed in the form of broader field experiments, longitudinal analyses, and the development of more adaptive implementation models to ensure that the effectiveness of escape rooms can be consistently applied in real elementary school learning environments. The effectiveness of interactive media in numeracy learning is also reinforced by Alfi Laila et al., whose study found that the use of augmented reality results in high-category improvements in numeracy achievement²². This finding further strengthens the evidence that interactive media, including educational escape rooms, has significant potential to improve elementary school students' numeracy achievement.

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²² Alfi Laila, A., Hikmah, F., & Arifin, M. F. (2025). Pengembangan pocket book berbasis augmented reality untuk meningkatkan literasi numerasi pada materi bangun datar dan bangun ruang siswa sekolah dasar. *Jurnal Pendidikan Dasar Nusantara*, 6(1), 12-23.

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