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Innovative Use of Escape Games in Teaching Secondary Mathematics: A Systematic Review for Inclusive and Sustainable Practice

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This systematic review explores the use of educational escape games in teaching secondary mathematics and how they support inclusive and sustainable classroom practices. Using the PRISMA 2020 framework, 31 peer-reviewed studies published between 2015 and 2025 were selected from databases including ERIC, ScienceDirect, and SpringerLink. The findings show that escape games can improve student engagement, motivation, and teamwork by turning lessons into puzzle-based challenges. These games often include real-world storylines, time-based tasks, and group problem-solving, helping students apply mathematical thinking in more active and meaningful ways. They support inclusion by enabling flexible participation across different learning needs. Many games use free or low-cost digital tools, making them easy to reuse, adapt, and share. As a result, they promote long-term, sustainable teaching practices. While the review notes some obstacles like limited planning time and access to technology, it also offers practical ideas to help teachers, leaders, and curriculum developers overcome these barriers.

Keywords: Escape games, mathematics education, student engagement, inclusive teaching, sustainable practices

Introduction

In recent years, the use of escape games in education has gained attention, particularly in STEM subjects such as mathematics (Veldkamp et al., 2020; Saleh Alabdulaziz, 2023; Babo et al., 2023). These games turn traditional instruction into interactive, challenge-based learning where students work together to solve puzzles, complete tasks, and "escape" from a physical or digital space (Veldkamp et al., 2020; Stohlmann, 2023). In this paper, the term 'students' refers to secondary school learners enrolled in formal mathematics classrooms, typically between the ages of 13 and 18. Educational escape games borrow from recreational escape rooms but are purposefully designed to support learning (Fotaris & Mastoras, 2019; Ho, 2018; Moffett & Cassidy, 2023). In mathematics classrooms, they are now being used to teach abstract topics through interactive storylines and collaborative problem-solving that make learning more engaging and meaningful (Andrews & Bagdasar, 2023; Fuentes-Cabrera et al., 2020).

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Escape games effectively promote collaboration and problem-solving, both of which are central to mathematics learning (Chen et al., 2025; Watkins et al., 2024). Instead of relying on passive listening or repetitive practice, students are invited to apply mathematical reasoning in real-time and often under time constraints (Stohlmann, 2020; Lim & Jakop, 2019). This kind of experience can help students make deeper connections between concepts and improve their persistence when facing difficulties (Jiménez et al., 2020; Rech et al., 2021). At the same time, the growing interest in gamification coincides with a call for more inclusive and sustainable teaching practices in mathematics education (Işık & Kaban, 2025; Zapata et al., 2024; Muchuweni et al., 2025). Many students, especially those with learning barriers or low confidence in mathematics, often feel excluded from traditional approaches (Işık & Kaban, 2025; Zapata et al., 2024). Escape games can support inclusion by offering varied entry points, multisensory tasks, and team roles that allow all students to participate meaningfully (Wolf et al., 2024). These games also support sustainable teaching by using digital resources that can be adapted and reused, reducing the need for constant reinvention while supporting long-term curriculum goals (Lathwesen & Belova, 2021; Babo et al., 2023).

Despite these promising developments, there is limited consolidated evidence on how escape games are used specifically in secondary mathematics education, and what impact they have on instruction, equity, and sustainability. This paper aims to fill that gap of limited consolidated research by systematically reviewing current research on the design, implementation, and outcomes of educational escape games in secondary mathematics classrooms. The review explores how these games are used to support learning and what evidence exists regarding their instructional value, inclusivity, and potential for long-term integration. To give a clear example, one well-known platform is Breakout EDU. It offers digital escape rooms where students go on missions, like trying to unlock a secret vault, by solving algebra problems. Each correct answer gives part of a code that opens a digital lock. As students work together under pressure, they use skills like simplifying expressions, solving equations, and thinking through multi-step problems. This kind of activity helps build teamwork, persistence, and stronger engagement with mathematics.

Problem Statement

Traditional mathematics instruction in secondary schools often struggles to engage students meaningfully, especially in diverse and under-resourced classrooms (Saleh Alabdulaziz, 2023; Lim & Jakop, 2019). Many students find mathematics abstract, demotivating, or disconnected from real-life problem-solving (Fuentes-Cabrera et al., 2020; Zapata et al., 2024). At the same time, teachers face increasing pressure to deliver instruction that is both inclusive and sustainable, while addressing varied student needs and promoting long-term understanding. Escape games have emerged as a promising educational tool to foster student engagement, collaboration, and active learning in mathematics (Stohlmann, 2023; Andrews & Bagdasar, 2023; Işık & Kaban, 2025). However, despite growing interest in gamified learning strategies, there is limited synthesized evidence on how escape games are designed and implemented specifically in secondary mathematics education, and what their

instructional, inclusive, and sustainable impacts truly are. This gap presents a challenge for mathematics teachers and researchers seeking innovative approaches that go beyond surface-level engagement. There is a need to critically examine existing studies to understand how escape games support mathematics teaching and to identify the conditions under which they are most effective. If this gap is not addressed, teachers may continue to implement escape games without clear guidance or alignment to learning goals, risking their use as disconnected novelty activities rather than powerful teaching tools. Without evidence of inclusive and sustainable design, these games may also fail to meet the needs of diverse students or be overlooked in long-term instructional planning. A lack of synthesized research leaves both teachers and policymakers uncertain about how to scale and support such innovations in real classrooms.

Research Questions

The purpose of this review was to examine how escape games are used in secondary mathematics classrooms and to explore their value in promoting instructional effectiveness, inclusion, and sustainability. The review is guided by the following questions:

1) How are escape games designed and implemented to support learning in secondary mathematics education?
2) What evidence exists on the instructional, inclusive, and sustainable benefits and challenges of using escape games in secondary mathematics classrooms?

Literature Review

This section reviews current research on the use of escape games in secondary mathematics classrooms. It is organized into two parts. The first part examines how these games are designed and implemented to support learning. The second part explores their instructional value, inclusive potential, and sustainable use in diverse classroom settings.

Design and Implementation of Escape Games in Secondary Mathematics Education

Escape games in secondary mathematics are usually designed as interactive, puzzle-based activities where students work together to solve mathematical challenges in order to progress through a storyline or "escape" a scenario (Lim & Jakop, 2019; Saleh Alabdulaziz, 2023). These games can be digital or physical, and many are built around a central theme or mission to make learning more purposeful and exciting (Stohlmann, 2023; Andrews & Bagdasar, 2023). In most cases, puzzles require students to apply their knowledge of mathematical content such as algebra, geometry, or number operations in real-world or simulated situations (Fuentes-Cabrera et al., 2020; Jiménez et al., 2020; Babo et al., 2023). For example, students might be asked to

crack a code by solving radical equations or uncover a hidden location using geometric reasoning. By connecting mathematics to stories and context, students are not only solving problems but doing so in ways that feel relevant, urgent, and rewarding.

Several common design features have emerged across literature. Many escape games include puzzles that increase in difficulty to help maintain flow and keep students engaged throughout the activity (Chen et al., 2025; Ho, 2018). They also use storytelling elements that provide a clear context for the tasks, which can boost curiosity and motivation (Montoro et al., 2020; Zapata et al., 2024). Time limits and assigned group roles are often built into the structure to encourage collaboration and accountability (Berrizbeitia, 2024; Zapata et al., 2024). For example, in one game, students can work in teams to help a stranded astronaut return to Earth by solving geometry and algebra puzzles at different "space stations." As they progress, the puzzles become more complex, and each team member takes on a specific role, such as decoder, clue tracker, or verifier. These features not only support student engagement but also mirror the kind of challenge-based learning that mathematics teachers are increasingly aiming for.

The way escape games are implemented in classrooms can vary depending on the teacher's goals and available resources (Wolf et al., 2024; Donaghy et al., 2023). Some teachers use them as warm-up activities or lesson hooks, while others incorporate them into review sessions, formative assessments, or end-of-unit projects (Glavaš & Stašcik, 2017). Digital platforms like Breakout EDU, and Desmos Activity Builder are popular tools for delivering escape games online or in blended settings, especially where time and space are limited. These tools allow for creative design and customization, but they also require some technical skill and preparation (Moffett & Cassidy, 2023; Luque-Sánchez & Montejo-Gámez, 2023; Muchuweni & Jojo, 2026). Teachers who start with a template or modify existing games often find it easier to get started than those designing from scratch. Time for planning and testing is key.

Successful implementation goes beyond just the game materials (Veldkamp et al., 2020; Horn, 2023). Teachers need to carefully plan how each puzzle aligns with the learning objectives, ensure the tasks are suitable for their students' ability levels, and create space for all students to contribute (Setti et al., 2025; Ang et al., 2020). This involves thoughtful grouping, scaffolding, and monitoring of student participation during gameplay (Montel et al., 2025; Borrás-Gené et al., 2024). Several studies, Neumann et al. (2020), Rech et al. (2021), and Pg Abu Bakar et al. (2023), emphasize that escape games are most effective when teachers provide clear instructions, monitor progress, and debrief with students afterwards to help them reflect on the mathematical thinking involved. Without this level of preparation and follow-through, the games risk becoming more of a distraction than a meaningful learning experience.

Despite the growing body of research, there remains a gap in studies that provide detailed guidance on how escape games are intentionally designed to align with specific secondary mathematics standards. Many existing papers describe the benefits generally, but few go deep into how teachers plan, sequence, or scaffold game elements to fit key mathematics objectives. This review aims to highlight practical examples of such design choices and their impact on learning.

There is also limited research that looks at the drawbacks teachers face when implementing escape games in diverse classrooms. While several studies highlight benefits like engagement or collaboration, fewer examine the constraints related to class size, digital access, or student support needs. This review identifies these gaps and brings attention to the conditions under which escape games are most feasible and effective. In essence, the design and implementation of escape games in secondary mathematics requires a balance of creativity, structure, and intentionality. When done well, these games can turn routine lessons into engaging, collaborative problem-solving experiences that support deeper learning.

Instructional, Inclusive, and Sustainable Impacts of Escape Games

Research by Işık and Kaban (2025), Andrews and Bagdasar (2023), and Rech et al. (2021) suggests that educational escape games can contribute to teaching and learning in secondary mathematics classrooms. When designed with clear learning goals and linked to curriculum standards, these games may support instructional quality by increasing student motivation, encouraging active participation, and creating opportunities for applying mathematical concepts in more interactive ways (Chen et al., 2025; Zapata et al., 2024). Compared to traditional worksheets or lectures, escape games are often described as promoting hands-on and collaborative problem-solving (Stohlmann, 2020; Chen et al., 2025).

Several studies, including Pg Abu Bakar et al. (2023), Fuentes-Cabrera et al. (2020), and Jiménez et al. (2020), report improvements in student performance and attitudes toward mathematics when escape games are used as part of instruction or revision activities. These outcomes are often linked to opportunities for reflection or feedback after gameplay, which may help students connect the experience to mathematical reasoning (Işık & Kaban, 2025; Jiménez et al., 2020). However, the extent to which these improvements reflect sustained gains in mathematical understanding is not consistently examined across studies.

Escape games are also discussed in relation to inclusive teaching practices. The literature indicates that these activities can offer flexible and differentiated learning opportunities, allowing students to participate in different ways depending on their strengths and needs (Kube et al., 2024; Setti et al., 2025). Digital escape rooms, in particular, may include visual supports, step-by-step tasks, and multiple solution paths, which can help students who experience difficulty in more traditional learning environments (Wolf et al., 2024; Kube et al., 2024). Teachers are also reported to adapt game content to suit different classroom contexts, including language, culture, and curriculum requirements. While these features are frequently described, there is limited evidence examining how they affect specific groups of learners.

From a sustainability perspective, escape games are often presented as adaptable and reusable teaching tools (Lathwesen & Belova, 2021; Babo et al., 2023). Many games are built using digital platforms that allow teachers to modify and share activities across different topics and grade levels (Wolf et al., 2024; Moffett & Cassidy, 2023). This flexibility may support long-term instructional use and collaborative planning. At the same time, the literature highlights practical challenges that may affect sustainability, including the time required to design games, the need for technical skills,

and differences in access to digital resources (Donaghy et al., 2023; Veldkamp et al., 2020; Borrás-Gené et al., 2024).

Although there is a growing body of research on the instructional and motivational value of escape games, there is limited evidence on their long-term integration into teaching practice. Most studies focus on one-time interventions or pilot activities. There is a need for more longitudinal research that examines how teachers adapt and refine escape games over time to meet curriculum needs and student diversity.

Additionally, the sustainability and inclusion aspects of escape games are often mentioned but not explored in depth. Few studies (Borrás-Gené et al., 2024; Kube et al., 2024; Wolf et al., 2024) evaluate how well these games serve multilingual students, students with disabilities, or classrooms with limited resources. This review aims to highlight these gaps and identify strategies that make escape games more equitable and viable for everyday teaching. In essence, escape games appear to offer instructional, inclusive, and sustainable possibilities when thoughtfully designed and purposefully used. Their impact is likely to be stronger when they are aligned with clear learning outcomes and integrated within broader strategies for innovative and equitable mathematics instruction.

Theoretical and Conceptual Framework

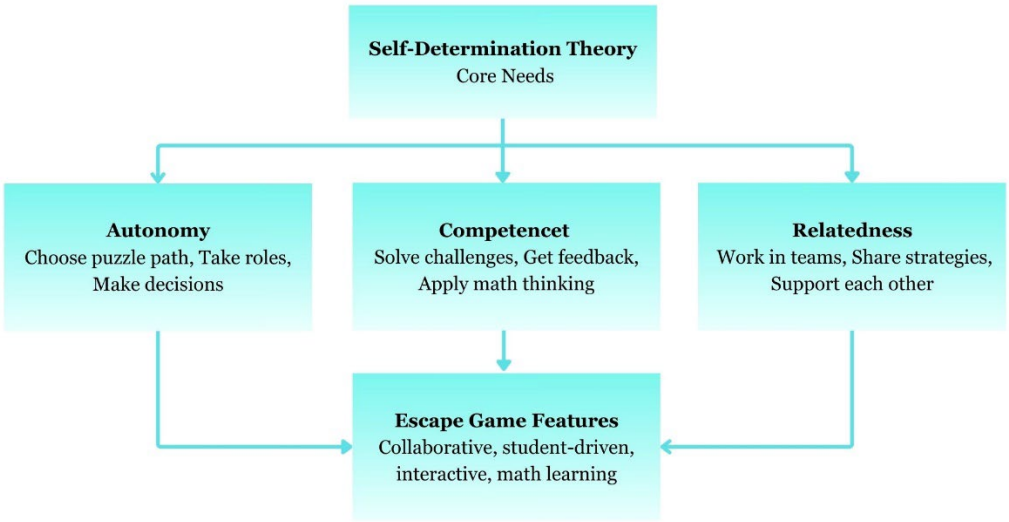
This review is grounded in Self-Determination Theory (SDT), developed by Ryan and Deci (2000), which is widely used to understand what drives motivation and engagement in learning. According to SDT, students are more likely to be intrinsically motivated when three core psychological needs are met: autonomy, competence, and relatedness. These needs are not just preferences but essential conditions for students to thrive academically and emotionally (Deci & Ryan, 2012; Legault, 2016).

Educational escape games naturally support autonomy, competence, and relatedness (Chen et al., 2025; Pg Abu Bakar et al., 2023; Veldkamp et al., 2022). First, autonomy is fostered as students are given control over their actions during the game. They can decide how to approach each puzzle, take on roles within their team, and contribute in ways that feel meaningful to them. This sense of ownership helps students feel more invested in the activity and less pressured by external rules or evaluations (Ryan & Patrick, 2001; Montoro et al., 2020). Second, competence is built as students work through progressively challenging tasks and receive immediate feedback based on their success in solving puzzles (Işık & Kaban, 2025; Ho, 2018). Completing each challenge reinforces their confidence in applying mathematical thinking, which is especially important for students who often feel left behind in traditional mathematics classrooms. Third, relatedness is a core feature of escape games (Watkins et al., 2024; Kube et al., 2024). These activities are usually done in small teams, where students must collaborate, communicate, and support each other. The shared goal of "escaping" brings a sense of unity, allowing students to build peer connections and feel that they belong to a learning community. For many students, this

social aspect is what makes the experience enjoyable and memorable (Neumann et al., 2020; Rech et al., 2021).

By using SDT as the guiding framework, this review focuses on how escape games can promote intrinsic motivation, which is linked to deeper learning, greater persistence, and more positive attitudes toward mathematics (Ryan, 2009; Deci et al., 2017). The theory also helps explain why escape games are not only engaging but also potentially inclusive because they give all students a chance to experience success, connect with others, and make meaningful choices. Through this lens, the review explores how escape games, when designed with intention, can help create more motivating, equitable, and sustainable mathematics classrooms. The connection between SDT and key features of escape games is illustrated in Figure 1.

Figure 1. SDT applied to Escape Games in Secondary Mathematics Education. (*developed by the authors*)



Methodology

This study followed the PRISMA 2020 guidelines for conducting and reporting systematic reviews (Page et al., 2021). The process was designed to ensure transparency, consistency, and academic rigor in identifying, selecting, and analyzing relevant studies on the use of escape games in secondary mathematics education. The aim was to gather research evidence that speaks directly to the two guiding questions of this review: how escape games are designed and implemented in mathematics classrooms, and what instructional, inclusive, and sustainable impacts they offer.

Search Strategy

A comprehensive search was conducted across three major academic databases: ERIC, ScienceDirect, and SpringerLink. These databases were selected because they offer broad coverage of peer-reviewed literature in education,

instructional technology, and STEM teaching. The search terms were carefully chosen to capture both the general and specific uses of escape games in mathematics education, with a particular focus on the secondary level.

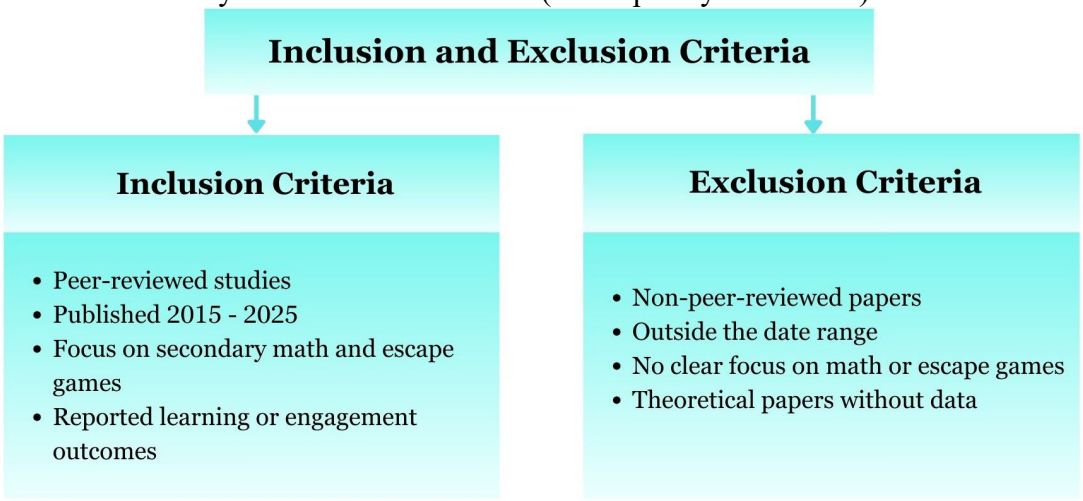
The search strategy included combinations of keywords such as "escape room" and "mathematics education," "digital escape game" and "secondary mathematics," "escape game" and "inclusive teaching," as well as "mathematics escape room" and "student engagement." These combinations were used to search article titles, abstracts, and keywords within each database. Boolean operators (AND/OR) were applied to broaden the search and capture studies using different but related terminology. This approach ensured that the search produced a wide range of relevant literature.

Inclusion and Exclusion Criteria

To keep the review focused and relevant, clear inclusion and exclusion criteria were used during the screening process. Studies were included if they were peer-reviewed, published between 2015 and 2025, and focused specifically on the use of escape games in secondary mathematics education. Only studies that reported learning outcomes, engagement levels, or instructional impacts were considered. This helped ensure that the review addressed practical teaching strategies and stayed aligned with the guiding questions.

Studies were excluded if they were not peer-reviewed, fell outside the date range, or did not focus clearly on both mathematics and escape games. The review also excluded papers that were purely theoretical or that lacked data on classroom outcomes. This helped keep the analysis grounded in actual practice and focused on studies that offered useful insights for teachers and curriculum developers. The full inclusion and exclusion criteria are shown in Figure 2.

Figure 2. Inclusion and Exclusion Criteria for the Systematic Review on Escape Games in Secondary Mathematics Education (developed by the authors)



To provide greater transparency, a summary of the characteristics of the included studies is presented in Table 1. The table outlines the country of study, research design, participant group, grade or age range, and type of escape game used. This

summary helps clarify the scope, context, and comparability of the 31 studies included in the review.

Table 1. Characteristics of Included Studies in the Systematic Review (n = 31)

Study Characteristic	**Summary of Included Studies (n = 31)**
Publication period	Studies published between 2015 and 2025
Educational level	Secondary school mathematics classrooms (approximately ages 13–18)
Countries represented	The studies were conducted across multiple international contexts, covering 18 countries
Escape game formats	Digital escape rooms, physical classroom escape rooms, and hybrid approaches
Common digital tools reported	Genially, Google Forms, Breakout EDU, Desmos, and other web-based platforms
Research designs used	The included studies used a range of approaches, including quasi-experimental designs, qualitative case studies, mixed-methods studies, and descriptive implementation reports
Participant groups	Most studies focused on secondary mathematics students, while some also included teachers or pre-service teachers
Data sources collected	Common evidence included achievement measures (e.g., pre/post tests), student questionnaires, classroom observations, interviews, and reflective feedback
Main outcomes examined	Engagement, motivation, collaboration, mathematics learning outcomes, inclusion, sustainability, and implementation challenges

Note: All 31 included studies informed the thematic synthesis; the studies listed in Table 2 are illustrative examples linked to each theme

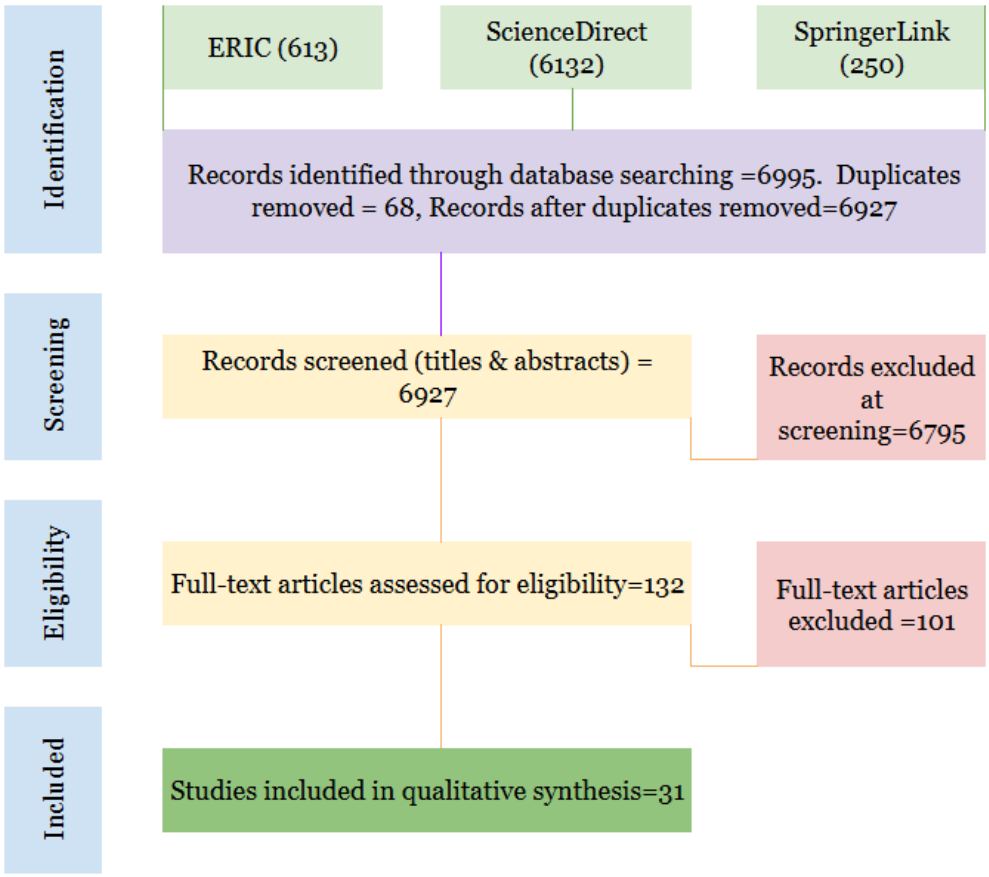
Study Selection Process

Study selection followed the PRISMA 2020 framework. Records were identified through searches in ERIC, ScienceDirect, and SpringerLink. After removing duplicates, titles and abstracts were screened against the inclusion and exclusion criteria. A subset of articles was then assessed in full text for eligibility. Following this process, 31 studies met all criteria and were included in the qualitative synthesis. The full screening and selection process is presented in Figure 3. All 31 studies that met the inclusion criteria informed the thematic synthesis presented in the Results section.

Data Analysis

The 31 included studies were analysed using thematic analysis. Key findings related to the design, implementation, instructional outcomes, inclusion, sustainability, and challenges of escape games were extracted from each study. These findings were coded and grouped into themes based on repeated patterns across the studies. The analysis followed an inductive approach, allowing themes to emerge from the data while remaining aligned with the two research questions guiding the review.

Figure 3. PRISMA 2020 Flow Diagram Showing the Selection of Studies for the Systematic Review on Math Escape Games (developed by the authors)



Results

The final set of 31 studies included in this review came from research conducted across 18 countries, highlighting the global interest in using escape games in mathematics education. The reviewed studies covered a variety of formats, including paper-based puzzles, hybrid classroom games, and fully digital escape rooms designed using online tools. This section presents the main findings from these studies, focusing on how escape games are used to support learning and what evidence exists about their instructional value, inclusiveness, and sustainability.

Common Instructional Goals

The reviewed studies identified several instructional goals for using escape games in secondary mathematics, including reinforcing content knowledge, encouraging collaboration, and building problem-solving persistence (Stohlmann, 2023; Jiménez et al., 2020; Fuentes-Cabrera et al., 2020). Many games focus on core topics such as algebra, geometry, and logic, where students apply mathematical concepts through interactive puzzles (Stohlmann, 2020; Rech et al., 2021).

Another commonly reported goal is improving communication and teamwork. Since most escape games are played in small groups, students are required to explain their thinking, share strategies, and support one another (Chen et al., 2025; Berrizbeitia, 2024). This collaborative structure often increases participation, especially among less confident students, and helps build a sense of classroom community (Andrews & Bagdasar, 2023; Watkins et al., 2024). However, most studies describe these outcomes qualitatively, with limited measurement of how collaboration directly influences mathematical learning.

The reviewed literature also shows that escape games promote persistence. The puzzle-based format encourages students to try different strategies until they succeed, supporting sustained engagement (Pg Abu Bakar et al., 2023; Işık & Kaban, 2025). Some studies reported that this persistence was particularly visible during gameplay, but few examined whether it transferred to long-term problem-solving beyond the activity.

There is also evidence that escape games support mathematical understanding. A small number of studies, such as Jiménez et al. (2020) and Işık and Kaban (2025), used pre- and post-tests and reported improvements in mathematics achievement, particularly in algebra. These studies provide stronger evidence because they directly measured learning gains. In contrast, many other studies relied on student perceptions, observations, or self-reported engagement (Chen et al., 2025; Berrizbeitia, 2024). While these findings suggest positive experiences, they provide more limited evidence of actual improvement in mathematical understanding.

In addition to these goals, several instructional design features were consistently reported. Stohlmann (2023), Chen et al. (2025), and Wolf et al. (2024) highlight the use of time-based challenges, where students are given limited time to complete tasks (Ho, 2018; Berrizbeitia, 2024; Montoro et al., 2020). These time constraints often increased focus and urgency, although their effectiveness depended on careful implementation.

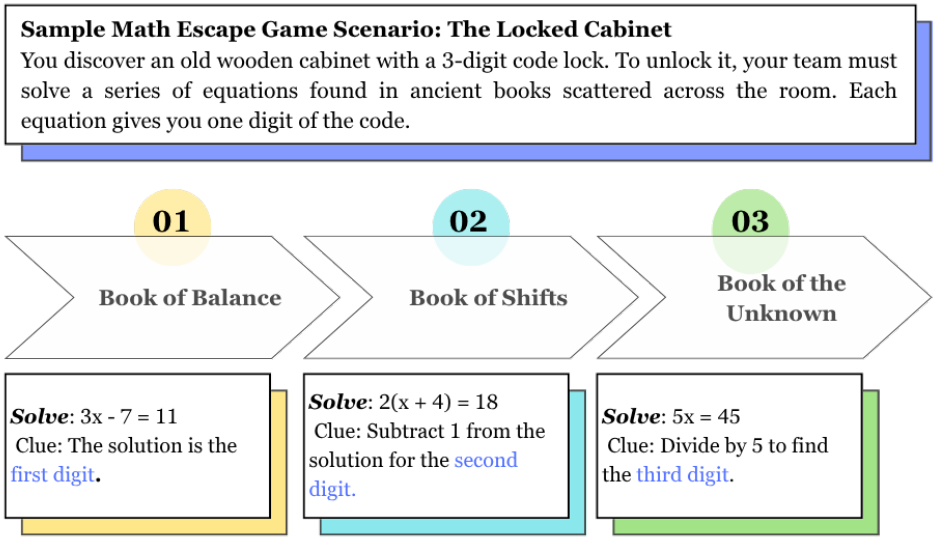
Narratives and real-world contexts were also widely used. Many escape games are built around themes, where students solve mathematical problems as part of a storyline (Fuentes-Cabrera et al., 2020; Horn, 2023; Zapata et al., 2024). These narratives helped make mathematics more meaningful and were particularly effective in engaging students who are less motivated in traditional lessons (Donaghy et al., 2023; Moura & Santos, 2019; Babo et al., 2023; Rech et al., 2021).

The reviewed studies further emphasised student autonomy and peer interaction. Students are often given freedom to navigate tasks and make decisions within their groups (Kube et al., 2024; Veldkamp et al., 2022; Pg Abu Bakar et al., 2023). This structure supports independent thinking while encouraging collaboration (Neumann et al., 2020; Rech et al., 2021; Chen et al., 2025; Borrás-Gené et al., 2024). These features were consistently linked to increased engagement across the studies.

In essence, the findings suggest that escape games support both mathematical understanding and the development of soft skills such as teamwork and persistence. However, the strength of evidence varies. Stronger evidence was found in studies using structured assessments, while studies based on self-reported data provided more limited support. This indicates that the effectiveness of escape games depends not only on their design, but also on how learning outcomes are measured and

evaluated. Figure 4 shows a sample puzzle from a mathematics escape game where students solve equations to unlock a digital cabinet in a fictional scenario.

Figure 4. Escape Game Puzzles using Linear Equations to Unlock a Digital Cabinet in a Fictional Library Scenario. (developed by the authors)



Inclusive and Sustainable Practice

The reviewed studies show that escape games can support both inclusive teaching and sustainable classroom practices in secondary mathematics. Studies by Işık and Kaban (2025), Babo et al. (2023), and Saleh Alabdulaziz (2023) report that these games can be adapted for students with different learning needs. For example, puzzles can vary in difficulty, include scaffolds, and align with curriculum goals, making them suitable for mixed-ability classrooms. However, most of this evidence is based on classroom observations and teacher reports, with limited studies directly measuring the impact of these adaptations on learning outcomes.

Many escape games are also developed using free or low-cost platforms such as Desmos Activity Builder (Wolf et al., 2024; Moffett & Cassidy, 2023). These tools allow teachers to create, reuse, and modify activities without requiring expensive resources. This supports sustainability by reducing the need for constant material development. In addition, sharing and adapting these resources across teaching teams can support long-term use. However, some studies note that sustainability depends on teacher access to time, training, and technical support, which are not always available (Donaghy et al., 2023; Wolf et al., 2024).

Inclusion is further supported through design features such as visual clues, team roles, and simplified instructions. Chen et al. (2025) show that teachers modified games to support multilingual classrooms and varied literacy levels. These adaptations made it easier for more students to participate. However, only a few studies examined how these changes affect specific groups of students, such as those with disabilities or those in under-resourced settings, indicating a gap in the literature.

Group-based problem-solving was consistently reported as supporting participation and engagement. Working in teams allowed students to contribute in different ways and build confidence. These features were commonly associated with student confidence, participation, and collaborative engagement during gameplay. However, most studies focused on short-term classroom activities, and there is limited evidence on how inclusive practices are sustained over time. As summarized in Table 2, the themes reported reflect patterns identified across all 31 included studies. The listed studies provide illustrative examples linked to each theme.

Table 2. Summary of Thematic Findings from the Systematic Review on Escape Games in Secondary Mathematics Education

Theme	Description	Key Studies
Instructional Goals	Algebra, logic, communication	Stohlmann (2023), Jiménez et al. (2020)
Design Features	Timed puzzles, narratives	Ho (2018), Zapata et al. (2024)
Inclusion	Visual clues, group roles	Kube et al. (2024)
Sustainability	Reusability, digital tools	Babo et al. (2023), Moffett & Cassidy (2023)

Thematic Discussion

Instructional Value

The findings of this review show that escape games can support instructional improvement in secondary mathematics by making abstract concepts more accessible and meaningful. When students solve problems within puzzles or story-based contexts, they are not only applying procedures but also engaging with the purpose of mathematics (Stohlmann, 2023). This suggests that escape games can shift learning from routine practice to more meaningful problem-solving experiences.

The results also indicate that escape games support inquiry-based learning. Students explore ideas, test strategies, and adjust their thinking as they work through challenges. This active involvement helps deepen understanding, especially when students are required to explain their reasoning to peers (Horn, 2023). In this way, learning becomes both cognitive and social, as students construct understanding through interaction.

However, the strength of this instructional impact depends on how learning is measured. As shown in the Results section, stronger evidence was found in studies that used pre- and post-assessments to measure achievement gains, particularly in algebra-focused activities. In contrast, many studies relied on student perceptions or classroom observations, which provide useful insights into engagement but offer more limited evidence of actual learning. This suggests that claims about improved mathematical understanding should be interpreted with caution unless supported by measurable outcomes.

The findings further suggest that the effectiveness of escape games is closely linked to how they are designed and implemented. Games that are clearly aligned with curriculum goals and supported by teacher facilitation tend to produce stronger instructional outcomes. In these cases, escape games function as structured learning tools rather than isolated activities, as they are integrated with guidance and reflection that support conceptual understanding.

These patterns suggest that the instructional value of escape games is not only based on their design features, but also on how they support key motivational processes during learning. From an SDT perspective, escape games create conditions that support autonomy, competence, and relatedness. Students are given choices in how they approach tasks (autonomy), experience success through solving progressively challenging problems (competence), and engage in collaborative problem-solving with peers (relatedness). These conditions help explain why escape games are often associated with increased motivation, persistence, and engagement in mathematics learning.

The findings suggest that escape games have strong potential to enhance mathematics instruction. However, their effectiveness is not automatic and depends on careful alignment with learning goals, appropriate teacher facilitation, and the use of reliable measures to assess student learning.

Inclusive Teaching

The review also indicates that escape games can support inclusive teaching in secondary mathematics by creating multiple entry points for student participation. In classrooms with varied ability levels, these activities allow students to approach problems using strategies that match their strengths and learning preferences. This suggests that escape games can reduce barriers often present in traditional instruction, where tasks are fixed and less flexible.

Collaboration plays a central role in supporting inclusion. As shown in the Results section, team-based formats encourage students to explain their thinking, take on different roles, and support one another during problem-solving. This interaction not only increases participation but also helps less confident students engage more actively. From an SDT perspective, this reflects the role of relatedness, as students feel connected to their peers and valued within the group.

Escape games can also be adapted to meet diverse learning needs. Teachers often include visual aids, simplified instructions, and differentiated levels of difficulty, which help make mathematics more accessible (Pg Abu Bakar et al., 2023; Işık & Kaban, 2025). These adaptations support competence by allowing students to experience success at their level. However, as noted in the Results, most studies describe these inclusive practices through classroom observations, with limited evidence on how they impact specific student groups, such as those with disabilities or those in under-resourced contexts. This suggests that while inclusion is frequently reported, it is not always systematically evaluated.

The findings further show that escape games support sustainable teaching practices, particularly through the use of digital tools. Platforms such as those described by Wolf et al. (2024) and Zapata et al. (2024) allow teachers to design,

reuse, and adapt activities across different topics and grade levels. This reduces the need for constant material development and supports long-term instructional planning. In addition, the ability to share resources across teaching teams promotes collaboration and reduces individual workload. However, sustainability is not only about access to tools. It also depends on teacher capacity, including time, training, and institutional support. Without these conditions, the long-term use of escape games may be difficult to maintain (Donaghy et al., 2023; Wolf et al., 2024).

Despite these benefits, the findings also highlight several challenges that affect both inclusion and sustainability. One major challenge is the time required to design escape games that are both engaging and aligned with curriculum goals (Ho, 2018; Veldkamp et al., 2020). This can limit their use, especially for teachers working in high-demand environments. In addition, while digital tools are often described as accessible, differences in device availability, internet access, and teacher confidence can create unequal opportunities for implementation (Donaghy et al., 2023; Wolf et al., 2024).

Student experiences also vary. While many students respond positively to the interactive and collaborative nature of escape games, others may feel pressure due to time limits or competitive elements (Berrizbeitia, 2024). This suggests that design features intended to increase engagement may also create barriers for some students if not carefully managed. Adjustments such as flexible timing, reduced competition, and structured team support are therefore important for maintaining an inclusive environment.

Another key challenge relates to teacher facilitation. As noted in the Results, escape games are most effective when supported by clear guidance and structured debriefing (Neumann et al., 2020; Rech et al., 2021). Without this support, activities may focus more on game completion than on mathematical understanding. This highlights that the effectiveness of escape games depends not only on their design, but also on how they are integrated into teaching practice.

The findings suggest that escape games can support inclusive and sustainable mathematics teaching when they are carefully designed, supported by teachers, and aligned with student needs. From an SDT perspective, their value lies in creating learning environments that support autonomy, competence, and relatedness. However, these benefits are not automatic and depend on addressing practical challenges related to time, resources, and classroom implementation.

Conclusion

This review has shown that escape games offer an innovative and engaging approach to teaching mathematics at the secondary level. By turning mathematical problem-solving into a collaborative, story-driven challenge, escape games help create learning experiences that are not only enjoyable but also deeply connected to curriculum goals. They support student motivation, strengthen teamwork, and encourage persistence, all of which are critical for meaningful mathematics learning. One of the key strengths of escape games is their flexibility. They can be used to differentiate instruction, support diverse learning needs, and adapt content to fit

different classroom contexts. Whether used for review, assessment, or concept reinforcement, escape games give students more than one way to succeed and participate meaningfully in mathematics lessons. At the same time, it is important to acknowledge the issues involved in implementation. Time constraints, lack of training, and access to digital tools can limit the use of escape games, particularly in under-resourced schools. However, with proper support, collaboration, and access to shared resources, these barriers can be reduced. Professional development, leadership support, and curriculum integration all play a role in making escape games more sustainable and widely used. At the same time, the review shows that the evidence base is uneven, with stronger support for engagement and participation than for long-term improvements in mathematical understanding.

The motivational impact of escape games also reflects the core principles of SDT, which emphasizes the importance of fostering autonomy, competence, and relatedness in learning environments. As schools work toward more equitable and inclusive teaching practices, escape games offer a promising path forward. They bring creativity and play into serious learning, help students build confidence in mathematics, and give teachers a fresh tool to meet the needs of today's students. In essence, the findings suggest that escape games can support instructional improvement, inclusion, and sustainable teaching when they are carefully designed and aligned with mathematics learning goals.

Limitations

This systematic review has some limitations. The search included only peer-reviewed studies published between 2015 and 2025 and retrieved from ERIC, ScienceDirect, and SpringerLink, so some relevant studies may not have been included. The studies also differed in design, context, and outcomes, which limited direct comparison. In addition, issues of inclusion and sustainability were often mentioned briefly rather than examined in depth. To reduce these limitations, clear inclusion and exclusion criteria were applied, the PRISMA 2020 process was followed, and a thematic analysis was used to identify common patterns across studies.

Implications

For Teachers

For secondary mathematics teachers interested in using escape games, the research suggests a few practical starting points. A practical starting point is to begin with low-tech or paper-based escape games before moving to digital tools. This allows teachers to experiment with the structure of puzzles, student grouping, and time management without needing advanced technical skills or extra resources. Simple games can still be highly engaging and serve as a foundation for more complex digital versions later.

It is also important to align puzzles with curriculum standards and learning goals. Games should be more than just fun; they should reinforce key mathematical skills and concepts. Teachers can design tasks that connect directly to topics like algebra, geometry, or problem-solving, helping students practice in a more meaningful context. Embedding mathematics objectives into the puzzles ensures that instructional value remains central. Using mixed-ability groups is another key strategy for making escape games successful in diverse classrooms. When students of different skill levels work together, they can learn from one another, share ideas, and contribute in different ways. Stronger students can help explain concepts, while others may excel at logic, teamwork, or spotting patterns. This structure encourages collaboration, reduces competition, and makes the activity more inclusive. In brief, escape games can be a useful tool for teachers when they are introduced gradually and linked to clear mathematics outcomes.

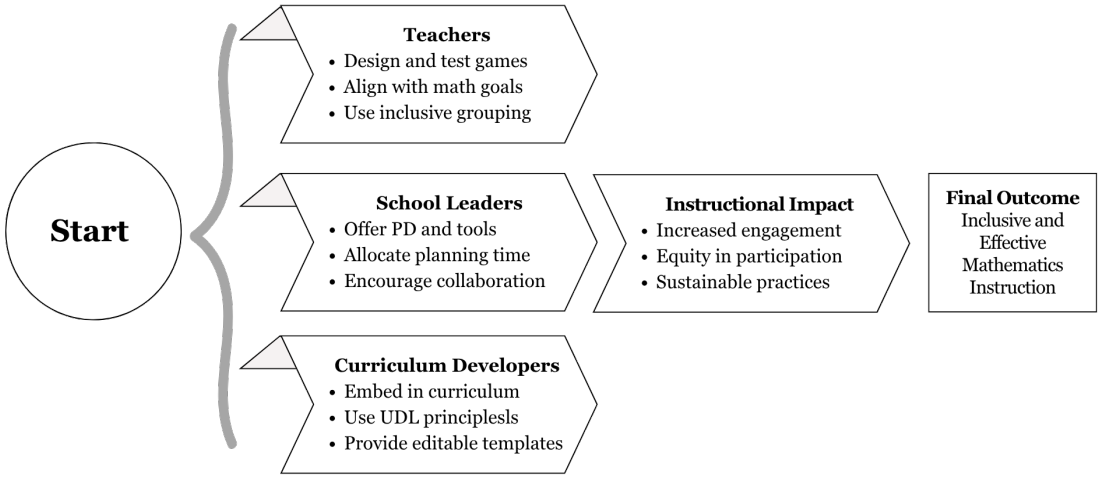
For School Leaders

School leaders can support teachers by making it easier to use escape games in the classroom. They can offer short workshops or team sessions to help teachers learn how to design and run these games. Even basic training on tools can give teachers the confidence to try game-based learning. Leaders can also help by giving teachers planning time and access to digital tools. Escape games take more time to prepare at first, so shared planning time and examples from other teachers can make the work easier. Making sure classrooms have devices, Wi-Fi, and simple platforms also supports success. Leadership support is important for making escape games more sustainable in everyday teaching practice.

For Curriculum Developers

Curriculum developers can help by including escape game activities in textbooks or teaching guides. These games can be used for revision, extra practice, or to make lessons more engaging. Adding them as optional tasks shows that interactive learning is valued alongside traditional methods. To make escape games work for more students, developers should design them with flexibility. Tasks should be easy to adapt to different skill levels, language needs, and learning styles. This can include offering different ways to answer questions, using visuals, or adding support for those who need help. Developers can also provide templates or links to digital tools. These resources make it easier for teachers to use escape games, even if they have little time or tech experience. Including structured escape game examples in curriculum materials may support wider adoption and long-term use. Figure 5 summarizes these roles.

Figure 5. Key Roles of Teachers, School Leaders, and Curriculum Developers in Promoting Inclusive and Effective Mathematics Instruction through Escape Games (developed by the authors)



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