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Gamification and AI for Engaging Risk Management Education: A Systematic Literature Review and an AI Chatbot Exemplifying Gamified Communication

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Risk Management Education (RME) helps individuals and organisations to manage risks and make informed decisions. Yet it often feels abstract and difficult to engage with. The increasing complexity of modern risks calls for more interactive educational approaches. These approaches can help foster meaningful communicational relations between learners, technologies and institutions in RME. Gamification and artificial intelligence (AI) offer one potential solution. This article presents a Systematic Literature Review (SLR) of 18 studies on gamification and AI in RME using PRISMA guidelines, based on abstracts and validated with clustering analysis of full texts. Keywords, terms and entities were classified into categories to identify conceptual gaps. Results indicated that gamified elements like simulations, scenarios, collaboration and feedback can support RME. AI in RME appeared rarely and mostly conceptually, yet it shows potential for adaptive guidance and personalisation. Integrated RME–gamification–AI approaches were scarce, revealing a research gap. To illustrate this case, we present Arvo, an AI-based chatbot developed in parallel with this research, informed by SLR findings and exemplifying gamified communication for climate risk education. A research agenda is proposed for gamification and AI in RME, focusing on simulations, storytelling and AI chatbots to guide theory and practice.

Keywords: Artificial intelligence, Chatbot, Gamification, Risk management education, Systematic literature review

1 Introduction

Risk management (RM) refers to identifying, analysing and addressing uncertainties that affect objectives (ISO 2018). It applies across domains such as healthcare, finance, climate adaptation and digital security, serving as a protective and enabling function that helps reduce threats and leverage opportunities. Building on this foundation, Risk Management Education (RME) equips learners with the knowledge, values and skills to apply RM in practice. RME has become increasingly important as risks grow more complex and unpredictable in both physical and digital environments. Yet its implementation varies significantly across countries and institutions, with differences in learning goals, content and instructional methods (Guntzburger, Pauchant & Tanguy 2017; Masár, Brezina & Hudakova 2019). However, RME often appears abstract and hard to engage with, especially when lacking practical examples, facing demanding content or limited resources (Taillandier & Adam 2018: 442). To address these issues, more interactive approaches are needed to foster meaningful communication among learners, technologies and institutions. Gamification and artificial intelligence (AI) are promising tools to enhance engagement, personalise learning and strengthen participation.

Gamification refers to the use of game-like elements (e.g. points, narrative, challenges) in non-game contexts to make learning more engaging (e.g. Deterding et al. 2011; Hakulinen, Auvinen & Korhonen 2013). For instance, Moreta, Gamboa & Palacios (2016) applied gamification in project risk education via a web application for risk identification, analysis and mitigation, showing how game-based methods enhance engagement and practical relevance in RME. This aligns with Hamari, Koivisto & Sarsa's (2014) meta-analysis, which concluded that gamification often supports motivation, participation and learning outcomes, though effects depend on context and implementation.

In parallel to gamification, *artificial intelligence* offers new ways to support learning by performing tasks that typically require human intelligence, such as providing feedback, supporting decisions and simplifying complex information (Duan, Edwards & Dwivedi 2019). AI can also personalise learning, automate tasks and detect learning difficulties early (Chen, Chen & Lin 2020). While not explicitly focused on AI, Oliveira et al. (2023) discuss how automation can aid the design of tailored gamification. These capabilities matter in RME, where learners face uncertainty and tough decisions. To be effective, such systems must offer explainability not only technically but also communicationally, allowing users to understand, trust and engage meaningfully with AI-supported decision-making (Adadi & Berrada 2018). One practical realisation is conversational agents, such as AI *chatbots*. As Pokrivcakova (2019: 143) notes, such systems simulate natural verbal interaction with a virtual tutor using simple if–then logic. Building on this, Chen, Chen & Lin (2020) report that students respond positively to these tools, and natural language interaction enhances interactivity, tailoring and engagement. This suggests openness to AI-supported tools in education. In our research, we demonstrate this potential through Arvo, a chatbot developed in the PERIL project (ilmastoriski.fi 2024) to support climate-related RME via interactive and personalised dialogue. Arvo is discussed in Section 4.

As described above, both gamification and AI have potential to enhance engagement in RME, especially when grounded in motivational and pedagogical principles. For example, Self-Determination Theory (SDT) suggests that learners engage more when their needs for autonomy, competence and relatedness are supported (Deci & Ryan 2000: 231). Gamified elements like challenges, feedback and role-play foster these drivers, particularly in demanding contexts such as RME. Likewise, pedagogical benefits are more likely when the design is intentional and tied to clear goals (De Freitas 2006: 58).

Despite growing interest in gamification and AI in education more broadly, their applications in the RME context remain underexplored, especially when combined. To our knowledge, no systematic review has addressed this. This paper responds to that gap with a Systematic Literature Review (SLR) on how gamification and AI have been used, individually or combined, to support RME. The aim is to map current research and identify conceptual and thematic patterns in the literature through content analysis. To illustrate practical application, we later introduce Arvo, a chatbot prototype for climate-related RME in Finnish enterprises. Developed in parallel with the SLR, Arvo exemplifies how gamification and AI can be combined to support risk communication. It is presented as an example informed by the review, rather than part of it. Thus, we focus on three research questions: **RQ1**: How has gamification been used to support RME? **RQ2**: How has AI been used to support RME? **RQ3**: How gamification and AI together have been used to support RME? The paper is structured as follows. Section 2 outlines the methodology. Section 3 presents the SLR results. Section 4 illustrates the capabilities of AI via the Arvo chatbot. Section 5 discusses the findings and Section 6 concludes with implications.

2 Method

We follow established SLR guidelines, namely the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) (Page et al. 2021) to ensure a comprehensive and transparent review process. In addition to the literature review, we conduct an inductive categorical content analysis of abstracts, classifying key terms (keywords, concepts, entities) into thematic categories. Although all full texts were read to confirm contextual accuracy, the primary analysis relied on abstracts, which provide concise representations of each study's scope while reducing contextual noise and ensuring consistency across studies. The process follows the open coding, categorisation and abstraction principles of Elo and Kyngäs (2008: 109–110), supporting the identification of research emphases and conceptual gaps. The analysis aligns with Yin's (2009: 43) principle of analytical generalisation, where findings from a focused dataset inform broader theoretical understanding and reflects Lasswell's (1971: 84) view of communication as structured around actors, content, channels and effects. Additionally, we validate the abstract-based approach with a robustness check, applying unsupervised machine learning to cluster the full texts with hierarchical agglomerative clustering (Ward 1963) using established text mining methods (Aggarwal & Zhai 2012) in Orange Data Mining, an analytics platform (Demšar et al. 2013). This is to confirm the main thematic structures and to add contextual nuances (see Section 3.3).

2.1 Literature Search

To address the research questions, we conducted a systematic literature search in the Scopus database (2025), chosen for its multidisciplinary coverage of major publishers and domains (e.g. ACM, Elsevier, Springer, Wiley and IEEE). The search focused on three main conceptual areas: *RME, gamification, and AI.* For each, we constructed an extended search string with relevant synonyms and related expressions (see Table 1).

Table 1. Three main phrases and corresponding search strings

Main phrase	Search string
1. Risk Management Education (RME)	("Risk management teach*" OR "Risk management educat*" OR "Risk management train*" OR "Risk management coach*" OR "Risk management pedagog*" OR "Risk management instruction*" OR "Risk management drill*" OR "Risk management develop*" OR "Risk management tuition")
2. Gamification	(Gamificat* OR Game* OR Gaming OR Play* OR "Serious game*" OR "Utility game*" OR "Educational game*" OR "Game based learn*" OR "Game-based learn*" OR Edutainment OR "Immersive learn*" OR "Digital learn*" OR "Gamified e-learn*" OR "Pervasive gam*" OR "Playful experienc*" OR "Playful gam*" OR Ludificat* OR Ludus OR ludic OR Paidia)
3. Artificial intelligence (AI)	("Artificial intelligence" OR A.I. OR "A. I." OR AI OR "Explain* AI" OR XAI OR "Machine learning" OR "Artificial neural network" OR "Autonomous systems" OR "Deep learning" OR "Neural networks" OR "Pattern recognition" OR "Natural language processing" OR Chatbot* OR "Virtual companions" OR "Autonomous surgical robotics" OR "Robotic personal assistant")

The search carried out on January 15, 2025, covered titles, abstracts and keywords. Three search combinations were applied: #1: "RME" AND "gamification" → 211 results, #2: "RME" AND "AI" → 288 results, #3: "RME" AND "gamification" AND "AI" → 75 results.

2.2 Eligibility Criteria

To ensure relevance and coverage, we followed PRISMA guidelines (Page et al. 2021). Studies were eligible if they addressed RME with gamification and/or AI and included relevant terms in the *title*, *abstract* or *keywords*. Studies from 2000–2025 were included, with no restrictions on discipline, document or source type, design or language. The final dataset includes journal articles, conference proceedings, reviews, book chapters and monographs in computer science, education, engineering, business and social science.

Given the interdisciplinary and emerging nature of the field, inclusion was broad. Studies were accepted even if the link to RME, gamification or AI was indirect or exploratory. The main analysis focused on abstracts and keywords, as the aim was not to evaluate outcomes but to identify combined approaches, emphases and gaps in a fragmented field. Abstracts and keywords were appropriate as they typically highlight each study's core contributions, while full texts were used for robustness check (see Section 3.3).

2.3 Study Selection

A total of 574 abstracts were initially retrieved from Scopus. After applying the eligibility criteria and removing duplicates, 18 studies were included in the final analysis. Figure 1 illustrates the selection flow, according to PRISMA guidelines.

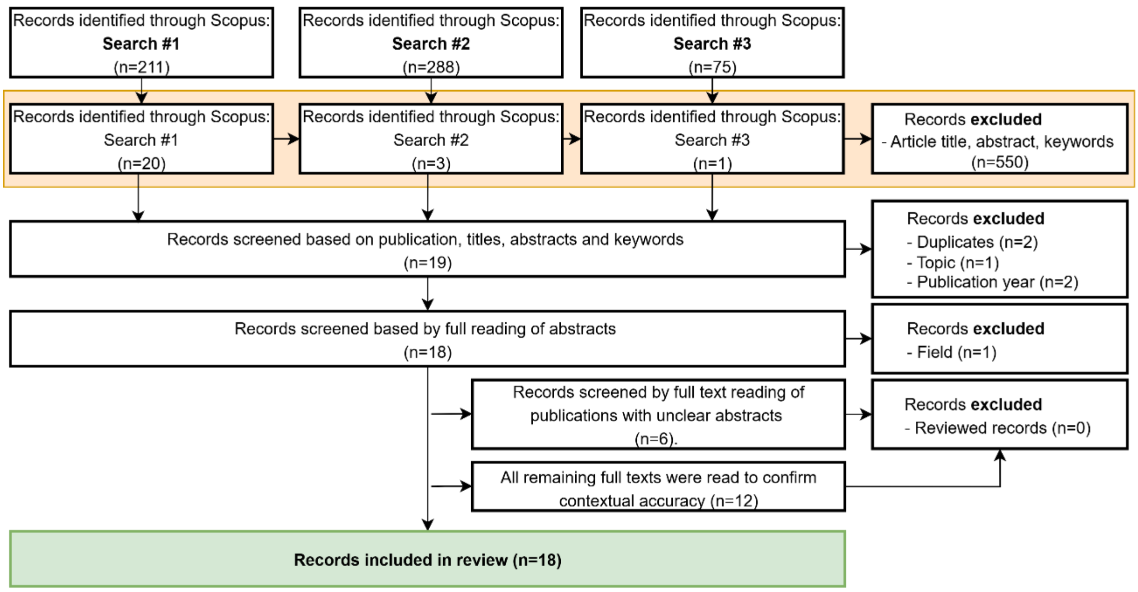

Figure 1. PRISMA flow diagram of literature review process

We screened titles, abstracts and keywords of all identified studies for topical relevance. Eligible records had to include at least one of: "RME and gamification", "RME and AI" or all three terms. In this phase, 550 records and two duplicates were excluded (Study 2 appeared in all searches but lacked explicit AI, so two hits were removed as duplicates and one was retained under search #1, reflecting the field's fragmented nature). One study proved to be topically irrelevant to RME with AI and two fell outside the inclusion period. After screening, 19 records remained, of which one conference summary was excluded on the basis of field. Six abstracts were clarified by a full text review. Finally, the remaining 12 full texts were read to confirm contextual accuracy. In total, **18 studies were included in the review**, regardless of language (17 in English, one in Spanish), design, or empirical strength. Each study was summarised using a structured form based on abstracts and keywords, capturing authors, year, methods, definitions and thematic focus. Inclusion decisions were made jointly by the researchers, coding independently and all steps discussed to ensure consensus and reliability. Next, we describe the findings.

3 Results

3.1 Overview of Selected Studies

The 18 studies are summarised in Table 2. The analysis is based on their abstracts and keywords. Each entry lists study ID, authors, gamification elements (applied or conceptual), AI presence, RME focus, Scopus search group and cluster assignment (from the full text robustness check described in Section 3.3). The table offers a concise overview of thematic content and methodological features to support further synthesis.

Table 2. Overview of selected studies on gamification and AI in RME

ID	Authors	Gamification Elements & AI Mention	Risk Management Education Focus	Search Groups	Cluster
1	Pons Lelardeux et al. (2017a)	Gamification: Applied & Conceptual - simulation, role-play, scenario tasks; collaborative game-based learning AI: No	Surgical safety and communication training	RME+ Gamification	C1
2	Tasantab et al. (2023)	Gamification: Applied - simulation, scenario-based learning, role-based AI: No*	Disaster preparedness training	RME+ Gamification, RME+AI	C6
3	Pons Lelardeux et al. (2017b)	Gamification: Applied - multiplayer, simulation, decision making, voting AI: No	Surgical risks: wrong patient/site errors	RME+ Gamification	C1
4	Bashynska et al. (2019)	Gamification: Applied - business game, scenario-based, simulation AI: No	Financial risk (investment)	RME+ Gamification	C4
5	Orasanu et al. (2017)	Gamification: Conceptual - scenario-based decision training (implicit) AI: No	Aviation risk perception and decision-making	RME+ Gamification	C7

ID	Authors	Gamification Elements & AI Mention	Risk Management Education Focus	Search Groups	Cluster
6	Barot et al. (2011)	Gamification: Conceptual - immersive simulation, adaptive scenario, characters AI: No**	High-risk industrial operations	RME+ Gamification	C7
7	Briner et al. (2010)	Gamification: Conceptual - relevance for gamified progression logic AI: No	Clinical risk management in hospitals	RME+ Gamification	C7
8	Maytorena et al. (2007)	Gamification: Conceptual - cognitive modelling relevant for gamified information exploration AI: No	Project risk identification	RME+ Gamification	C3
9	Kielland (2009)	Gamification: Conceptual - coping framework relevant for gamified decision-making AI: No	Social risk management (child mobility)	RME+ Gamification	C7
10	Gomez-Alvarez (2016)	Gamification: Applied - serious game, turn-based board mechanics, team strategy AI: No	Risk management in software projects	RME+ Gamification	C3
11	Pambudi & Ashari (2019)	Gamification: Applied - drills, interactive and experiential learning models AI: No	Disaster risk preparedness in elementary schools	RME+ Gamification	C6
12	Taillandier & Adam (2018)	Gamification: Applied - serious game, simulation, role-based decision-making AI: No	Territorial/natural risk management (coastal flooding)	RME+ Gamification	C3
13	Hussein (2011)	Gamification: Applied - in-class gaming, simulation, role-play, Kahoot AI: No	Project risk management education	RME+ Gamification	C3
14	Kan et al. (2007)	Gamification: Conceptual - scenario-based analysis providing basis for gamified simulations AI: No	Tsunami risk assessment and response	RME+ Gamification	C5
15	Firdose & Rao (2018)	Gamification: No AI: Yes (machine learning, neural networks)	Risk prediction in software engineering	RME+AI	C4
16	Bondarenko et al. (2023)	Gamification: Conceptual - link via emphasis on digital skill development and innovation AI: No**	Climate risk management in higher education	RME+ Gamification	C2
17	Goretti & Musacchio (2024)	Gamification: Applied - serious games, collaborative gameplay, rewards AI: No	Seismic risk management education for youth	RME+ Gamification	C3
18	Ommer et al. (2024)	Gamification: Conceptual - link via storytelling, simulations, VR/AR AI: No	Flood risk preparedness and perception	RME+ Gamification	C6

As shown in Table 2, most studies applied gamification either directly using serious games (i.e. games designed for purposes of something other than entertainment (Michael & Chen 2006)), simulations or scenario-based tasks (e.g. studies 1–4, 10–13, 17), or discussed it conceptually in connection to cognition, decision-making or communication frameworks (e.g. studies 5–9, 14, 16, 18). Only one study (15) explicitly focused on AI via machine learning and neural networks for risk prediction. To note in Table 2, *Study 2 appeared in the AI-related search group but did not discuss AI technologies explicitly while **studies 6 and 16 only referred indirectly to smart systems. This highlights the scarcity of research integrating gamification and AI in RME, suggesting that their combined use remains an underexplored area in the current literature.

The studies cover diverse RME contexts, from disaster preparedness and clinical training to environmental, project and financial risks across all educational levels. This shows gamification's broad relevance across learners and institutions. Overall, the data reflect a fragmented yet emerging field. Gamification is more often applied or explored with RME than AI, and research at their intersection remains limited. This mapping confirms the need for further research on AI–gamification integration in RME to support engagement, interactivity and decision-making.

3.2 Classification of Keywords, Terms and Entities Found

To examine thematic emphases, we extracted *key terms* and *entities* from abstracts using inductive categorical content analysis. We also collected author and Scopus-indexed *keywords* where available. In total, 697 items were identified. After removing duplicates and irrelevant entries (e.g. geographic locations), 558 remained. To improve reliability, we prioritised author keywords, then index keywords and finally contextual interpretations. Terms were iteratively grouped into 38 content-related subcategories. For example, '*Visualisation'* included terms such as 'illustrate', and 'visual support'. When terms belonged to multiple categories, contextual meaning guided classification. The 38 subcategories were further organised under seven main thematic categories based on conceptual similarity: **1. Learning-Related Goals, 2. Context for Studying RME, 3. Tools and Technologies for Decision-Making, 4. Support, 5. Possible Elements to Explore in Gamifying RME, 6. Components and Mechanics,** and **7. Risk Management Education (Gamified Solution)**. The classification of main and subcategories, with mentions and references, is in Appendix 1. Within each main category, subcategories are listed in descending order of frequency, providing a basis for analysing thematic emphases in relation to gamification and AI in RME, while also revealing conceptual gaps.

As only one study explicitly focused on AI in RME, we treated AI as supporting rather than central. Still, AI-related terms appeared across categories, especially tools, technologies and interaction models. This reinforces AI's role as a communicational bridge enhancing interaction, personalisation and visualisation in gamified educational systems. The categories also reflect communicational relations: between learners and content (e.g. Personalisation, Knowledge/Information), between human actors (e.g.

Collaboration, Role), and between humans and digital agents (e.g. Interaction, Decision-making/Support). Low-frequency themes (fewer than 10 mentions) with practical and pedagogical relevance for RME included Usability, Uncertainty, Complexity, Implementation, Cost/Money, Virtual Reality and Software. Although central to learning environment design, these rare mentions highlight underexplored areas. Subsections 3.4–3.10 examine the thematic categories as entry points to how gamification and AI contribute to RME, drawing on abstract-level frequencies as the primary analytical basis.

3.3 Validation with Full Text Clustering: Robustness Check

To complement the abstract-based analysis in Section 3.2, we conducted a robustness check on the full texts of all 18 studies using unsupervised machine learning. Texts were pre-processed into a term frequency-inverse document frequency (TF-IDF) weighted matrix, distances computed with cosine similarity (Manning, Raghavan & Schütze 2008). Hierarchical agglomerative clustering with Ward's method (Ward 1963) was then applied. The dendrogram was cut at seven clusters (C1–C7) to yield interpretable and coherent groupings, balancing granularity better than alternative cuts. For each cluster, the 20 top-weighted terms were extracted and used to assign thematic labels, compared with abstract-based categories (Appendix 1). The cluster assignments for each study are shown in Table 2. This robustness check served as a secondary validation step and also highlighted contextual nuances, such as local cases, roles and technical tools.

The thematic clusters (C1–C7) are labelled as follows: **C1: Surgical Simulation Safety** (e.g. *patient, operating room, checklist, nurse, surgery*) emphasises surgical teamwork and safety training. **C2: Climate Economy Technologies** (e.g. *climate, knowledge economy, decarbonization, smart technology, employment*) highlights techno-economic approaches to climate challenges. **C3: Gamified Risk Education** (e.g. *game, project, teaching, learning, feedback*) covers education where gamified elements support risk learning. **C4: Business Risk Computing** (e.g. *algorithm, accounting, business game, optimization*) captures computational and financial risk analysis**. C5: Island Coastal Hazards** (e.g. *atoll, island, tide, tsunami, lagoon*) indicates geo-specific hazards in marine environments. **C6: Disaster Preparedness Education** (e.g. *disaster, preparedness, hazard, school, warning*) underlines community and school-based readiness training. **C7: Human Factors in Risk Decisions** (e.g. *CRM, hospital, crew, error, behavior*) points to decision-making shaped by human factors in aviation and medical risk contexts. Cluster references in Sections 3.4–3.10 indicate terms from each cluster's top 20-weighted items. This explains why some widely mentioned abstract-level concepts are not cluster-defining.

3.4 Learning Related Goals

The reviewed studies most often emphasised Learning, Education and Educating (41 mentions), followed by Development, Improvement or Innovation (24), Knowledge and Information (23), and Skills (10). These findings point to a strong emphasis on general learning goals, continuous improvement and decision-making competencies as core objectives in gamified and AI-supported RME. Full text clustering reinforced these patterns, while also highlighting domain-specific emphases. Learning-related terms appeared in C1–C4 and C6, used in contexts such as medical teamwork or project decision-making and through tools like simulations and collaborative platforms. Even categories with fewer abstract-mentions, such as Skills (10), gained visibility by recurring across multiple clusters (C1-C4, C6, C7), indicating broader relevance.

3.5 Context for Studying Risk Management Education

The studies addressed core RME contexts, with Preparedness, Prevention and Training (53 mentions), followed by Risk Assessment, Evaluation and Perception (38), Disaster Risk Management, Initiatives and Reduction (14) and Safety / Security (4). These findings underscore the central role of proactive risk anticipation in RME. The clustering showed the distribution of these contexts. Preparedness and assessment terms were widespread across clusters, while disaster themes were strong in C2, C5 and C6. Safety / Security, rarely noted in abstracts, became evident in C1. This indicates that some RME contexts were reflected across multiple clusters, while others appeared in more specific domains.

3.6 Tools and Technologies for Decision-Making

The studies highlighted tools for decision-making in RME. Technology, Systems / Tools (22 mentions), Communication / Interaction methods (17), Monitoring (13), Virtual Reality (8), and Software (6). These reflect growing interest in interactive, technology-assisted environments ranging from real-time data to virtual simulations. Some studies referenced AI methods (*'machine learning', 'industry 4.0', 'robots'*), suggesting potential for intelligent, adaptive systems in RME. Clustering supported this categorisation. Technology was central in C1–C3. Communication in C3. Monitoring, though frequently mentioned in abstracts, became cluster-defining only in C5–C7, VR in C1 and C3, consistent with surgical training and gamified teaching contexts. Software was a smaller theme, evident in C4 and C7. Although many tools and technologies were mentioned, only a few defined clusters, highlighting the RME contexts where they were most applied.

3.7 Support

Support-related terms addressed elements essential for implementing gamified and AI-enhanced RME. Models and Frameworks (16 mentions), Quality Standards / Assurance (7), Data Collection and Processing (6), Visualisation (5) and Cost or Money (2). These highlight theoretical frameworks, quality alignment, data use and feedback visualisation, with financial and computational costs influencing feasibility. Among these, '*agent-based modelling*' (study 12) provided an AI-related approach. Clustering clarified domain links. Models and frameworks were visible not only in general but in C3, C4 and C7. Quality appeared in C1, C3 and C4. Data collection and processing, marginal in abstracts, became central in C4, C5 and C7, linking them to business, environmental monitoring and decision systems. Visualisation was specific to C3, tied to gamified learning. Cost emerged only in C4, reflecting its business orientation.

3.8 Possible Elements to Explore in Gamifying RME

This category highlights concepts that could inform gamifying RME. Key themes were Cognition, Imagination and Emotions (25 mentions), Risks in General or Vulnerabilities (23), the Combination of Theory and Practice (20), Identifying (12), Strategies (9), Implementing (5), Complexity (4) and Uncertainty (4). These underline the need to address real-world situations, combine theory and practice through case-based approaches and engage cognitive and emotional processes. Identification related to recognising key factors and errors. Strategies focused on risk management goals and prevention, with serious games (e.g. studies 10, 12) as pedagogical tools. Complexity and uncertainty pointed to preparing learners for unstable or unpredictable conditions. Clustering revealed where the elements were most evident. Practical application appeared broadly in C1–C4, C6 and C7, while risks and vulnerabilities were central in C5–C7. Cognition and imagination were defining mainly in C6. Identifying appeared in C1, C3 and C6 and strategies in C3 and C4. Implementation occurred in C3, C4 and C7. Complexity was linked to C1 and C5 and uncertainty to C5. Thus, while some elements, such as practical application and risks spanned multiple contexts, others like complexity and uncertainty remained domain-specific yet valuable for gamifying RME.

3.9 Components and Mechanics

This largest category covers the operational dimensions of RME. Key themes included Team, Collaboration and Multiplayer (22 mentions), Story, Characters and Role (19), Rules, Requirements, Instruction and Assistance (17), Simulation (14), Motivation (12), Effectiveness, Efficacy and Optimisation (10), Customisation or Personalisation (8), Decision-Making or Support (7), Behaviour (6), Human Factors and Interaction (6) and

Usability (2). Teamwork, role-play and storytelling were often linked to digital environments using narrative structures. Roles and characters helped to build situational understanding and shared decision-making. Motivational design centered on challenge, engagement and ownership, while personalisation and efficiency highlighted the communicational interplay between users and systems. AI aspects were also visible here. '*Autonomous characters*' (study 6) illustrated adaptive, agent-like behaviour in virtual environments, while '*predictive optimization of risk management*' (study 15) linked optimisation tasks directly to computational intelligence. Clustering confirmed this categorisation. Teamwork cut across (C1, C3, C7), while story and roles, though widely mentioned, became defining only in C3. Instruction was central in C1 and simulation in C1 and C3. Motivation appeared in C4 and optimisation/effectiveness in C3 and C4. Personalisation was evident in C3 and C6, while decision-making and behaviour clustered in C7, human factors and usability in C1 and C7, highlighting their role in human-centered approaches. Thus, clusters were shaped around just a handful of components and mechanics, despite the wider variety mentioned in abstracts.

3.10 Risk Management Education (Gamified Solution)

The final category covers general references to Games and Gamification (24 mentions). Gaming in its various forms appeared in a total of eight articles (1,3,4,6,10,12,13,17), ranging from learning, digital and video games to business and board games. The term '*game'* is used inclusively to cover both gamification and serious games, as many abstracts and index terms did not distinguish between them. Clustering aligned with the abstract-level results and showed where games were most prominent. Game-related terms appeared consistently in C1, C3 and C4, indicating gamification was central in these domains. Apart from one exception (study 6), all identified studies clustered in contexts where gamification was a key focus. This coherence confirms the validity of the category for analysing gamified approaches to RME. The following demonstration shows how gamification and AI can be combined in practice to address the research gap.

4 Exemplification: Arvo Chatbot as Gamified Communication for RME in Practice

The SLR and analysis highlighted that while gamification and AI are explored in RME, their integration remains scarce. To explore their combined potential in practice, we developed Arvo, a prototype chatbot available for testing online at https://ilmastoriski.fi (operates in Finnish). Arvo was designed alongside the SLR to support climate RME and decision-making in South Ostrobothnia, Finland, following user-centered design and gamification principles, drawing on SDT (Deci & Ryan 2000) and communication-oriented gamification (Maltseva, Fieseler and Trittin-Ulbrich 2019). Operating on a GPT-based large language model (LLM) via Azure, Arvo combines a curated regional knowledge base with prompt rules to ensure contextual accuracy and conversational style. User logs support refinement and visual cues such as animated expressions provide gamified feedback. This design exemplifies gamified communication and aligns with prior research showing that AI chatbots can increase interactivity and engagement in educational topics (Chen, Chen & Lin 2020; Pokrivcakova 2019). It also builds on previous work into gamification as a communicative strategy, especially in sustainability and corporate social responsibility (CSR), where game-like elements can increase attention and shape perception when appropriately contextualised (Maltseva et al. 2019: 45, 58).

The design of Arvo maps directly onto our seven main thematic categories (1–7 listed in Section 3.2) by supporting climate risk learning with regional knowledge, assessment skills and gamified AI storytelling (1). It builds preparedness through risk assessment and safe practices (2). It applies an LLM for natural AI interaction, with user dialogues and diverse technologies (3). Arvo applies relevant climate risk models in practice, considers economics and its animated professor character strengthen support (4). Visual and textual cues evoke emotions, link theory with practice, offer strategies and address complexity and uncertainty (5). Arvo's narrative, scenarios and personalisation motivate users, foster risk-aware behaviour and lower entry barriers (6). It also supports communicational relations between learners, AI agents and institutions, bridging local and expert knowledge. As a gamified AI solution, Arvo creates an engaging and safe environment for practising decision-making (7), consistent with our thematic categories.

Some limitations remain at the initial stage of Arvo. Outputs are intentionally tied to Finnish climate data. Also, enhanced fallback rules and further curated sources could reduce irrelevant answers. The evaluation of Arvo has so far been exploratory, with validation from over 450 user sessions since late 2024 indicating generally positive feedback on interactivity. A systematic evaluation is planned. As with other generative AI systems, occasional inaccuracies are possible, underscoring the need for users' critical approach to outputs. Overall, Arvo illustrates the underexplored intersection of Gamification and AI in RME, reflecting insights from our SLR.

5 Discussion

Gamification emerged in the reviewed studies as the most established approach to RME. Simulations, scenarios, role-play, collaboration and feedback were not only frequently mentioned but also consistently linked to competence, relatedness and autonomy. Interpreted through Self-Determination Theory (Deci & Ryan 2000) and intentional pedagogical design (De Freitas 2006), these elements appear to make abstract risks more tangible and provide opportunities for meaningful practice. This shows gamification is effective when tied to clear educational aims rather than applied as a superficial add-on.

By contrast, AI was only marginally present. Apart from one predictive modelling example, it did not play a central role in the reviewed material. Still, recurring references to interaction, personalisation and decision-making indicate that AI is conceptually understood as a communicational mediator, capable of tailoring content and sustaining feedback loops. This suggests potential for future designs even if current empirical demonstrations remain scarce. The absence of substantive integration of gamification and AI across the dataset further underlines the fragmented state of the field. One study even appeared in all three searches but did not address AI explicitly, illustrating this fragmentation. The fact that both, gamification and AI, appear relevant but rarely together with RME highlights an area that warrants closer investigation.

Methodologically, the study is limited by the small, fragmented dataset of 18 studies. We addressed this by combining inductive coding of abstracts with unsupervised full text clustering. This procedure confirmed category stability and added nuance, providing robustness despite the limited corpus. Clustering also showed that gamification centered on simulations and storytelling (C1, C3), while AI terms appeared mainly in climate economy technological (C2) and computational / business risk contexts (C4). These patterns reinforce the current focus of RME research but also reveal blind spots that inform the preliminary research agenda in Section 6. Still the findings are more indicative rather than comprehensive, underscoring the need for broader, systematic inquiry.

6 Conclusions and Directions for Future Research

This article examined how gamification and AI have been used to support RME through a SLR of 18 studies, complemented by the Arvo chatbot case. **RQ1**: Gamification was widely applied across domains such as surgical safety, disaster preparedness, financial training and project risks. Core elements such as simulations, scenarios, role-play, collaboration and feedback, foster competence, relatedness and autonomy in line with SDT and intentional pedagogical design (Deci & Ryan 2000; De Freitas 2006; Taillandier & Adam 2018). **RQ2**: AI appeared mainly as conceptual references and occasionally as digital agents. While empirical use was limited, the potential for adaptive guidance, personalisation and conversational support is well recognised (Pokrivcakova 2019; Chen, Chen & Lin 2020). **RQ3**: No study combined RME, gamification and AI in a substantive way. This scarcity confirms a conceptual and empirical gap even though both, gamification and AI approaches could reinforce each other. Arvo illustrates how such integration could operate in practice by linking storytelling, visual cues and adaptive dialogue in RME. It reflects themes identified in the SLR and exemplifies gamified communication. A systematic evaluation is still forthcoming.

Building on these findings, a preliminary research agenda can be sketched: 1. studying immersive simulations and storytelling for decision-making in complex risk contexts, 2. designing AI-driven personalisation that balances adaptivity, usability and cost in RME, 3. evaluating gamified interfaces, such as AI chatbots as communicational mediators of risk knowledge. The small and fragmented dataset means that some studies may have been missed. Still, the two-layered analysis provides a solid base for synthesis.

In line with our stated aim, gamification and AI offer complementary strengths for RME, fostering communicational relations between learners, digital agents and institutions. Yet their integration remains underexplored. Future research should systematically design and assess communicative, gamified AI tools that support decision-making in complex learning environments, in line with Lasswell's (1971) communicational model, where actors (e.g. learners) use content (e.g. risk information) through channels (e.g. simulations, role-play) to produce effects (e.g. increased engagement). Taken together, these directions underline the practical and theoretical value of strengthening communicational relations in RME through gamification and AI.

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Appendix 1. Classification of Keywords, Terms and Entities Found

Appendix 1 lists the categories derived from inductive content analysis of the abstracts. Subcategories are shown in descending order of frequency to illustrate the relative salience of terms and entities. The table provides the analytical basis for sections 3.4–3.10, where categories are further examined and linked with full text clustering* results.

1. Learning Related Goals	Mentions	Appears in the studies (ID)	Full text validation
Learning / Education / Educate	41	1,2,3,4,5,6,7,8,10, 11,12,13,16,17	C1, C2, C3, C4, C6
Development / Improvement / Innovation	24	2,3,4,6,7,8,10,12,13, 14,15,16,17	C2, C3
Knowledge / Information	23	1,2,3,7,8,11,12,13, 14,16	C2, C3
Skills	10	1,2,3,4,11,12,16	C1, C2, C3, C4, C6, C7
2. Context for Studying Risk Management Education	Mentions	Appears in the studies (ID)	Full text validation
Risk Management (Preparedness / Prevention / Training)	53	1,2,3,4,5,6,7,8,9,10, 11,12,13,15,16,17,18	C1, C2, C4, C5, C6, C7
Risk Assessment / Evaluation / Perception	38	1,3,4,5,6,7,8,9,12, 13,14,15,18	C1, C5, C6, C7
Disaster risk management / Initiatives / Reduction	14	2,11,12,14	C2, C5, C6
Safety / Security	4	7,11,12	C1
3. Tools and Technologies for Decision-Making	Mentions	Appears in the studies (ID)	Full text validation
Technology / System / Tools	22	1,2,3,4,5,7,12, 15,16,17	C1, C2, C3
Communication / Interaction	17	1,2,3,4,7,9,18	C3
Monitoring	13	4,6,7,8,11,12, 13,14	C5, C6, C7
Virtual Reality	8	1,3,6	C1, C3
Software	6	10,12,15	C4, C7
4. Support	Mentions	Appears in the studies (ID)	Full text validation
Models / Frameworks	16	1,2,4,6,7,9,12,15, 16,17	C3, C4, C7
Quality (Standards / Assurance)	7	4,6,7,15,16,17	C1, C3, C4
Data Collection and Processing	6	7,8,11,13,18	C4, C5, C7
Visualisation	5	2,3,6,10,18	C3
Cost / Money	2	4,15	C4
5. Possible Elements to Explore in Gamifying RME	Mentions	Appears in the studies (ID)	Full text validation
Cognition, Imagination and Emotions	25	2,3,4,6,8,10,12,14,16,18	C6
Risks in General / Vulnerabilities	23	3,4,5,6,9,11,12,14,15	C5, C6, C7

Practical Application / Combine Theory and Practice	20	1,2,3,4,6,9,12,13,15	C1, C2, C3, C4, C6, C7
Identifying	12	3,5,7,8,9,11,13,15	C1, C3, C6
Strategies	9	5,7,9,10,12	C3, C4
Implementing	5	2,4,7	C3, C4, C7
Complexity	4	1,2,12	C1, C5
Uncertainty	4	5,8,15	C5
6. Components and Mechanics	Mentions	Appears in the studies (ID)	Full text validation
Team / Collaborative / Multiplayer	22	1,3,12,13,17	C1, C3, C7
Story / Characters / Role	19	2,5,6,7,8,9,11,12,14,16,18	C3
Rules / Requirements / Instruction / Assistance	17	2,3,4,6,7,13,16	C1
Simulation	14	1,2,6,12,13,18	C1, C3
Motivation	12	5,10,12,13,16,17	C4
Effectiveness / Efficacy / Optimisation	10	3,4,10,12,15,17	C3, C4
Customisation / Personalisation	8	1,4,5,6,8	C3, C6
Decision Making / Support	7	3,5,7,8,12	C7
Behaviour	6	2,3,6,9	C7
Human Factors and Interaction	6	1,3,7,12	C1, C7
Usability	2	6,13	C1, C7
7. Risk Management Education (Gamified Solution)	Mentions	Appears in the studies (ID)	Full text validation
Game / Gamification	24	1,3,4,6,10,12,13,17	C1, C3, C4

* Technical note. In addition to the methods described in Section 3.3, the top-term lists per cluster were extracted with a Python script linked to Orange Data Mining. Texts were converted into a corpus, pre-processed with a standard natural language processing (NLP) pipeline (lowercasing, tokenisation with regular expression for word characters, stopword removal, lemmatisation and TF-IDF weighting), terms cleaned (POS endings removed, meta/HTML/URL tokens dropped) and weights aggregated across variants. For each cluster, the 20 strongest terms were reported with four metrics: relative strength (rel100), share of top-K (%), document coverage (%) and lift. Thresholds (lift ≥ 1.0, coverage ≥ 25%) were applied only to improve readability, not to affect the analysis.