STEAME FOR SAVING LIFE

Guidelines for developing and implementing Disaster Risk Reduction Education in Elementary School Curriculum

O1/A2
Methodological guidelines for incorporating STEAME-DRRE activities in Elementary curriculum-content instruction

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Steame for Saving Life

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Deliverable leading partner: Competence Center for a Sustainable and Resilient Built Environment using Smart Technologies (SURE)

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Table of Contents

1. BRIEF DESCRIPTION

This report presents the methodological guidelines developed within Work Package O1/A2 of the STEAME-DRREC – "STEAME for Saving Life" project. Its main purpose is to support the systematic integration of Disaster Risk Reduction Education (DRREC) into elementary school curriculum-content instruction through the interdisciplinary STEAME framework, which brings together Science, Technology, Engineering, Arts, Mathematics, and Entrepreneurship.

The report responds to the need for pedagogically sound, curriculum-aligned, and age-appropriate approaches that enable teachers to embed disaster risk reduction, natural hazards, climate-related risks, preparedness, safety, and resilience into everyday classroom practice. Rather than treating DRR as an isolated or occasional topic, the report proposes its integration across existing subjects and learning objectives, supporting both subject-specific knowledge and broader transversal competences.

The document is organised around three main areas. First, it develops a methodological framework for STEAME-DRREC education, drawing on pedagogical approaches such as Project-Based Learning, Context-Based Learning, storytelling, inquiry-based learning, design thinking, simulation, role-playing, and game-based learning. It also includes supporting strategies and cross-curricular approaches, such as collaborative learning, scenario analysis, systems thinking, visual thinking strategies, citizen science, media and digital literacy, art-based learning, environmental literacy, and social-emotional learning.

Second, the report provides guidance for the integration of STEAME-DRREC activities into elementary school curricula, with particular attention to the Greek and Cypriot educational contexts. It introduces a context-based pedagogical integration model in which natural hazard themes function as meaningful learning contexts, while appropriate pedagogical methods transform these contexts into curriculum-connected activities. The report further offers curriculum-aligned examples for lower and upper primary education, showing how DRREC can be incorporated across subjects such as Language, Environmental Studies, Geography, Mathematics, Visual Arts, ICT, Skills Labs, Drama, and civic-oriented learning.

Third, the report presents a set of digital, technological, and AI-supported tools that can enhance DRREC implementation in elementary education. These include digital maps and GIS tools, simulation software and apps, AI chatbots and scenario builders, AI-assisted content creation tools, electronic games, and augmented or virtual reality environments. These tools are discussed as pedagogical resources for visualisation, inquiry, modelling, communication, creativity, collaboration, and preparedness, with emphasis on age appropriateness, teacher guidance, ethical use, and alignment with learning objectives.

Overall, the report provides a structured and practical framework for supporting teachers in the design and implementation of meaningful STEAME-DRREC learning experiences. It aims to strengthen pupils' risk literacy, scientific reasoning, digital competence, creativity, collaboration, emotional awareness, civic responsibility, and preparedness, contributing to the development of a culture of safety, sustainability, and resilience from the early years of schooling.

2. INTRODUCTION

In recent years, the integration of Disaster Risk Reduction Education (DRR) into formal curricula has become a global priority, driven by the growing impact of climate change and natural hazards on human lives and sustainable development (Bruin et al., 2020). Education plays a pivotal role in fostering disaster resilience, as emphasized by the United Nations Office for Disaster Risk Reduction (UNDRR, 2020), by equipping learners with the awareness, knowledge, and skills needed to respond effectively to crises. Within this evolving landscape, the STEAME framework—encompassing Science, Technology, Engineering, Arts, Mathematics, and Entrepreneurship—offers a dynamic, interdisciplinary approach that aligns well with DRR goals. Through real-world, inquiry-based learning, STEAME encourages students to explore complex societal challenges, making it particularly suitable for integrating DRR themes (Milara & Orduña, 2024).

A growing body of research suggests that combining DRR with STEAME pedagogy can significantly enhance student engagement and learning outcomes. For instance, Anggraeni et al. (2025) proposed a model that utilizes crisis-related issues such as floods and wildfires to facilitate transdisciplinary outdoor STEAM education, creating authentic learning contexts that foster sustainability literacy. Similarly, immersive serious games and virtual environments have proven effective in improving knowledge retention and behavioral readiness in emergency scenarios (Feng et al., 2018; Rajabi et al., 2022).

STEAME-DRR integration also aligns well with Project-Based Learning (PBL), a pedagogical approach that enables students to explore complex problems, engage in inquiry and reflection, and develop innovative solutions (Conradty & Bogner, 2020). Furthermore, DRR education benefits from constructivist and cognitivist learning theories, where structured instructional design and concept scaffolding contribute to meaningful knowledge acquisition (Bruin et al., 2020; Weibell, 2011).

Project-Based Learning (PBL), a core methodology within STEAME, enables students to engage in authentic, meaningful investigations of disaster-related scenarios, blending theoretical understanding with practical application. Alongside PBL, storytelling emerges as a powerful cognitive and social constructivist tool in DRR education. As Bruner (1991) argues, narratives help learners make sense of the world by connecting personal or collective experiences to wider environmental or societal issues. In the context of DRR, storytelling—through survivor testimonies, community simulations, and oral histories—supports emotional engagement, preparedness, and the preservation of communal knowledge (Harvey, 1996; Kargillis et al., 2014). Together, these experiential and narrative-based methodologies promote deep learning, critical thinking, and emotional resilience, empowering students to navigate and mitigate risks in disaster-prone contexts.

Given the lack of interdisciplinary competence, limited professional development, and institutional constraints affecting STEAME-DRR implementation (Milara & Orduña, 2024), this work package introduces a methodological framework with guidelines to support the integration of STEAME-DRR into the regular instruction of school subjects.

Given the lack of interdisciplinary competence, limited professional development, and institutional constraints affecting STEAME-DRR implementation (Milara & Orduña, 2024), this work package (O1/A2) introduces a methodological framework with guidelines to support the integration of STEAME-DRR into the regular instruction of school subjects. These guidelines aim to bridge the gap between theoretical aspirations and practical classroom realities by offering educators clear, adaptable, and pedagogically sound strategies for embedding disaster risk reduction and climate-related content within existing curricula. Importantly, the development of these guidelines is informed not only by current educational needs but also by the findings of the literature review conducted in O1/A1, which identified best practices, theoretical models, and empirical evidence related to DRR and STEAME education. This evidence base ensures that the proposed framework is grounded in both research and field-tested methodologies. In alignment with the above rationale and the educational priorities for integrating STEAME-DRR into the school curriculum Work Package O1/A2 aims to the followings:

To complement these curriculum-based strategies, this section also proposes a suite of digital, technological, and AI-powered tools tailored for DRR education. These tools are selected not only for their technical capacities but also for their pedagogical alignment with STEAME principles and age-appropriate learning. From simulations and interactive maps to AI-generated scenarios and VR environments, digital resources offer educators powerful means to enhance student engagement, contextualize hazards, personalize instruction, and foster creativity. The tools outlined in the following section are organized by type and educational function, offering practical guidance for both lower and upper primary school application. Together with the curriculum integration guidelines, they form a comprehensive, scalable, and future-ready approach to embedding DRR meaningfully in 21st-century classrooms.

Objectives of the Work Package O1/A2

The primary objective of O1/A2 is to develop a comprehensive and adaptive set of methodological guidelines for integrating STEAME-DRREC activities into elementary school curricula. These guidelines will outline pedagogical approaches, strategies, tools, and resources essential for incorporating topics related to natural hazards, disaster risk reduction, and climate change within the STEAME framework. The guidelines will serve as a foundation for designing both student activities (O2/A1) and teacher training modules (O3/A1). They will be compiled into a digital manual and presentation materials to support training, implementation, and dissemination efforts at local, national, and European levels, ultimately contributing to the project's overarching goal of promoting resilience and safety through education.

3. METHODOLOGICAL FRAMEWORK

The proposed interdisciplinary guideline framework integrates key elements from constructivist and cognitivist learning theories, Project-Based Learning (PBL), disaster risk pedagogy, and the principles of STEAME education. Cognitivist perspectives highlight the significance of sequencing and scaffolding, which are vital for helping students comprehend the multifaceted systems underlying disaster scenarios (Bruin et al., 2020). At the same time, PBL provides a pedagogical structure that naturally complements both STEAME and Disaster Risk Reduction (DRR) education by promoting sustained engagement with real-world problems. PBL encourages collaborative, interdisciplinary learning experiences where students apply communication, critical thinking, and problem-solving skills (Thomas, 2000). In DRR contexts specifically, PBL has been effectively employed in activities such as community hazard mapping and resilience planning, enabling learners to co-design solutions tailored to local risk environments (Kapucu & Hu, 2016; Mulilis & Duval, 1995).

Building on this foundation, the DRREC model (Define, Research, Reflect, Execute, Create) offers a practical and iterative framework that structures the learning process around authentic problem-solving. Through its cyclical stages, students define real-world challenges, conduct meaningful inquiry, critically reflect on findings, implement actionable solutions, and communicate results. This model fosters core competencies—such as creativity, collaboration, critical thinking, and resilience—that are essential in both STEAME-based education and DRR pedagogy (Psycharis et al., 2020). As such, the DRREC model forms the pedagogical cornerstone of the methodological framework developed in this study, offering educators a structured pathway to embed STEAME-DRR principles within the regular curriculum.

From a content integration perspective, STEAME education provides the interdisciplinary foundation needed to engage students in complex, real-life challenges: science and mathematics support hazard analysis and prediction; engineering and technology enable solution development; the arts facilitate effective risk communication; and entrepreneurship promotes community resilience planning (Anggraeni et al., 2025). Furthermore, the concepts and skills outlined in the curriculum across various subjects are developed through interdisciplinary activities framed within Disaster Risk Reduction (DRR) contexts. This integrated approach not only enhances subject-specific learning but also fosters transferable competencies aligned with DRR education goals. It addresses persistent challenges in STEAM implementation, including the need for coherent cross-disciplinary planning and teacher preparedness (Milara & Orduña, 2024).

Accordingly, the methodological framework developed for this project draws on a combination of key pedagogical approaches and methods, instructional strategies and techniques, as well as holistic and cross-curricular approaches to effectively support the integration of STEAME and Disaster Risk Reduction (DRR) into classroom practice. The core components of this framework are outlined below. The methodological approaches and methods are presented in detail in relation to Disaster Risk Reduction (DRR) in Chapter 3.1, the instructional strategies and techniques are discussed in Chapter 3.2, and the holistic and cross-curricular approaches are outlined in Chapter 3.3.

3.1. Methodological approaches and methods

The key methodological approaches and methods include:

a) Project-Based Learning (PBL)
b) Context-Based Learning (CBL)
c) Storytelling for Risk Awareness
d) Inquiry-Based Learning (IBL)
e) Design Thinking (DTh)
f) Simulation and Role-Playing – Classroom Simulation Design
g) Game-Based Learning (GBL)

Each of the key methodological approaches listed above is examined in detail in the subsections that follow.

Project-Based Learning (PBL)

Project-Based Learning (PBL) is a dynamic, student-centered pedagogy where learners investigate authentic, complex questions or problems over an extended period, culminating in public products or presentations (Thomas, 2000; Bell, 2010). It is grounded in constructivist (Piaget, 1972) and experiential learning theories (Dewey, 1938; Kolb, 1984), which posit that knowledge is actively constructed when students engage meaningfully with real-life contexts. In Disaster Risk Reduction (DRR) education, PBL encourages the integration of scientific knowledge, civic responsibility, and problem-solving skills. Through this framework, learners move beyond rote learning and begin to understand hazards as dynamic systems shaped by both natural processes and human decisions (Krajcik & Blumenfeld, 2006).

Recent studies affirm PBL's capacity to improve conceptual understanding, social collaboration, and risk awareness in DRR contexts. Larsson et al. (2022) found that students involved in disaster-related PBL showed stronger systems thinking and deeper engagement with STEM content compared to peers in traditional classrooms. Their research, conducted in Swedish schools, included student-led risk assessments and engineering design challenges focused on flood-prone communities. These projects improved environmental literacy and strengthened collaborative learning dispositions. Similarly, Mutch and Tatebe (2021) documented New Zealand primary students mapping local vulnerabilities and proposing retrofitting plans for community buildings—demonstrating both practical knowledge and civic responsibility.

Germany provides a robust model for institutionalized DRR PBL through its "Schools for Sustainability" program, where students co-design flood mitigation projects. They analyze drainage data, collaborate with civil engineers, and build small-scale models to simulate hydraulic resilience. These projects, embedded in STEAME curricula, allow for meaningful cross-subject application of math, environmental science, digital design, and ethics (BMZ, 2022). In Japan, the "BOSAI Education Project" integrates PBL by engaging students in tsunami evacuation planning in collaboration with local officials and scientists. Pupils identify safe zones, conduct time-distance studies, and prepare policy briefings presented to town councils. These activities elevate student voice while building procedural fluency (Shaw et al., 2019).

In Italy, high school students in Liguria participate in a “Resilient Cities” PBL initiative, developing community-wide wildfire preparedness plans. Learners use GIS software to assess vegetation density, model wind patterns, and propose early warning signage and escape route maps. Their findings are publicly displayed and often integrated into local civil protection strategies (ISPRA, 2021). In New Zealand, intermediate-level students in Auckland's North Shore conducted project work to analyze tsunami evacuation infrastructure. They examined shoreline erosion, walked potential evacuation routes, and produced interactive maps and posters for family use. The project was supported by geoscientists and local Māori elders, encouraging scientific insight while incorporating cultural knowledge and language (Mutch & Tatebe, 2021).

PBL is particularly effective in promoting transdisciplinary learning. DRR projects often require learners to explore natural science (e.g., fault mechanics or meteorology), mathematics (e.g., elevation models or statistical risk), civic literacy (e.g., emergency law), and art (e.g., visual communication campaigns). In Spain, secondary school students participating in the “Escuelas Seguras” initiative designed multimedia PSAs and sustainable architecture models to reduce earthquake vulnerability. These efforts involved digital fabrication tools, video editing software, and scientific simulation—integrating creativity and analytical reasoning.

Pedagogically, PBL fosters autonomy, agency, and ethical responsibility—key traits for young people facing future uncertainty. It develops metacognitive skills, such as planning, reflection, and peer feedback, and enhances resilience through iterative design and problem-solving (Krajcik et al., 2021). When embedded in STEAME-based DRR curricula, PBL not only deepens academic understanding but cultivates the mindset needed for collective risk mitigation and sustainable development. Students emerge not merely as informed learners, but as empowered contributors to their communities' safety and resilience.

Context-Based Learning (CBL)

Context-Based Learning (CBL) is a learner-centered approach that situates learning within authentic, real-world scenarios, making academic content more relevant and meaningful. It is grounded in situated cognition theory (Brown et al., 1989), which posits that knowledge is most effectively acquired and retained when applied in the context where it is used. In the realm of Disaster Risk Reduction (DRR) education, CBL encourages students to explore and analyze local hazards, infrastructures, and community vulnerabilities through hands-on, place-based inquiry.

Recent empirical research underscores the effectiveness of CBL in enhancing environmental awareness and civic engagement in DRR. For instance, Donnelly and Lamb (2020) implemented a context-based DRR curriculum in primary schools in Australia, which included activities like mapping local flood zones and analyzing past weather events. Students who participated in the program exhibited higher retention of scientific content and improved disaster preparedness behaviors compared to those who received traditional textbook-based instruction.

International DRR programs such as 'Risk Watch' in Canada and 'My Hazard, My Responsibility' in the Philippines have embedded CBL strategies into primary education. In these programs, children explore their own communities to identify vulnerabilities—such as proximity to rivers or poorly constructed buildings—and engage in solution-building through school-community collaboration. This locally relevant engagement not only deepens conceptual understanding but also strengthens the connection between students and their immediate environments.

In Chile, schools participating in national DRR initiatives encourage students to interview local emergency responders and visit municipal planning offices to understand evacuation routes and flood defense systems (UNESCO, 2020). Such place-based learning activities transform students into active investigators and stakeholders. These activities align well with interdisciplinary learning goals, as students draw from geography, science, mathematics, and social studies to develop a comprehensive view of risk and resilience.

From a theoretical standpoint, CBL bridges the gap between abstract content and lived experience. It allows learners to construct scientific and social knowledge in context, promoting metacognition and action-oriented outcomes (Gilbert, 2006). When embedded within STEAME frameworks, context-based approaches enable students to synthesize data, explore causal relationships, and apply ethical reasoning to real-life risk scenarios. This fosters a generation of learners who are not only informed but also empowered to contribute to community safety and sustainability.

Storytelling for Risk Awareness

Storytelling is a pedagogical tool that integrates emotional, linguistic, and cognitive engagement to support children's understanding of complex phenomena, including natural hazards. Rooted in narrative theory (Bruner, 1991) and socio-cultural learning perspectives (Fleer & Ridgeway, 2022), storytelling is especially suitable for Disaster Risk Reduction (DRR) education at the primary level. It provides a developmentally appropriate, emotionally safe structure for discussing risk, encouraging reflection, and practicing responses to emergency scenarios (Paladino et al., 2020).

Recent studies emphasize the efficacy of storytelling in improving risk awareness and memory retention in DRR education. For instance, Ebersöhn et al. (2022) documented how students in rural South African schools, when engaged through storytelling about floods and fires, showed increased knowledge of evacuation procedures and greater empathy for affected individuals. This narrative-based instruction was more effective than traditional lecture methods, especially among early learners, where emotional connection fosters deeper cognitive processing.

International DRR programs also integrate storytelling to strengthen preparedness and resilience. Programs such as “Rettet die Retter” in Germany and “Aprende a Protegerte” in Spain use illustrated stories, role-play scripts, and short videos to teach children what to do during emergencies such as fires or floods. These stories often include familiar characters—such as firefighters or pets—and concrete actions, helping children internalize safety behaviors (UNESCO, 2020; BBK, 2023). In Japan, the “Kataribe” approach uses survivor testimonies from past disasters (e.g., the 2011 Tōhoku earthquake and tsunami) to teach students how to recognize warning signs and take protective action. Similarly, in New Zealand, Māori narratives—such as the legend of Ruaumoko, god of earthquakes—are integrated into DRR curricula to build cultural and geological understanding simultaneously (Barrett & Notario, 2021). These culturally relevant stories help children anchor scientific concepts in their social and spiritual worldviews.

Storytelling in DRR education extends beyond oral tradition into multimodal activities. In Chile, the “Aprende a Protegerte” program uses comic books and animated films to simulate fire and earthquake scenarios in a child-friendly format (UNESCO, 2020). After reading or watching a narrative, students complete reflection sheets, perform skits, or create their own safety posters. These activities combine literacy, creativity, and procedural learning in ways that resonate with young audiences.

Theoretically, storytelling operates as a scaffold, supporting children’s transition from personal experience to abstract reasoning (Vygotsky, 1978). It allows educators to contextualize risk knowledge, cultivate empathy, and build communication and decision-making skills—core competencies in DRR. When embedded in STEAME curricula, storytelling enables students not only to process disaster-related content but also to co-construct knowledge through collaboration and imagination, laying the groundwork for resilience-oriented mindsets.

Inquiry-Based Learning (IBL)

Inquiry-Based Learning (IBL) is a pedagogical strategy that places students at the center of their learning through questioning, exploration, and evidence-based reasoning. Rooted in constructivist theory (Piaget, 1972; Vygotsky, 1978), IBL emphasizes the development of scientific literacy by allowing learners to pose problems, gather data, and construct explanations. In the context of Disaster Risk Reduction (DRR), IBL empowers students to investigate natural hazards, understand their causes and effects, and critically evaluate human and environmental interactions (Pedaste et al., 2015).

Recent research demonstrates that IBL enhances both conceptual understanding and critical thinking in DRR-related topics. For instance, Akyildiz and Sensoy (2020) implemented inquiry-driven DRR modules in Turkish primary schools, guiding students through activities such as testing soil permeability to predict flood risks. Compared to traditional lecture formats, students engaged in IBL showed higher retention and a greater ability to transfer knowledge to real-life risk scenarios. Similarly, Nadelson and Seifert (2022) reviewed over 50 STEM education studies and found that inquiry-based DRR education significantly improved systems thinking, especially when students investigated environmental triggers like deforestation or urban planning deficiencies.

International DRR curricula increasingly incorporate IBL principles to foster scientific inquiry. In Germany, the “School on Fire” program developed by the German Red Cross encourages students to investigate local fire safety infrastructure, test smoke alarms, and evaluate emergency plans for their schools and neighborhoods. These hands-on investigations culminate in student-generated safety protocols and peer training sessions. In New Zealand, inquiry learning is integrated into earth science and geography lessons, where students use GPS tools and geological maps to explore tectonic fault zones and monitor volcanic activity. Such projects foster scientific inquiry while linking DRR with place-based knowledge (Barrett & Notario, 2021). In Austria, the Austrian Red Cross implements DRR modules that engage students in analyzing local risk maps, simulating hazard scenarios, and designing school-wide preparedness campaigns. Through interviews with civil protection officers and site visits to local response centers, students develop a nuanced understanding of how theoretical knowledge connects to institutional practice (Austrian Red Cross, 2023). These examples show how IBL transforms learners into active participants in both academic and civic life. In the U.S., the Federal Emergency Management Agency’s (FEMA) “Student Tools for Emergency Planning” (STEP) program encourages learners to investigate emergency preparedness at home through surveys and science experiments (FEMA, 2023). These experiences allow students to transition from passive recipients of risk knowledge to active researchers and planners in their communities.

IBL also supports transdisciplinary connections across STEAME subjects. In a DRR-themed unit, students might formulate questions such as, “Which construction materials best resist earthquakes?” or “How do urban green spaces affect stormwater absorption?” They would then gather data via simulations, measurements, or experiments, analyze the results in math or science classes, and present solutions using digital tools in art or media lessons. Another rich example involves students investigating, “How does rainfall intensity affect urban flooding?” using mathematical models, environmental sensors, and GIS technologies. Their findings are synthesized into visual reports, digital presentations, or interactive community exhibits. These projects not only deepen disciplinary knowledge but also promote transferable skills such as collaboration, data literacy, and critical thinking. By engaging students in applied, real-world problem-solving, this approach aligns DRR education with both curricular goals and 21st-century competencies.

The educational benefits of IBL extend well beyond knowledge acquisition. It cultivates agency, resilience, and decision-making under uncertainty—core psychological capacities in disaster contexts (Hmelo-Silver et al., 2007). IBL fosters self-efficacy by encouraging students to ask meaningful questions, pursue investigations, and propose real-world solutions, thereby nurturing adaptive thinking and a sense of personal and civic responsibility. It also supports the development of environmental ethics, helping students link abstract scientific ideas to tangible experiences in their communities. When integrated into STEAME-based DRR education, IBL contributes to the holistic development of learners—equipping them with both the competencies and values needed to act as informed, ethical, and proactive citizens in a risk-prone and interdependent world.

Design Thinking (DTh)

Design Thinking (DT) has emerged as a powerful pedagogical methodology for fostering innovation, empathy, and human-centered problem solving—qualities that are particularly relevant in the context of Disaster Risk Reduction (DRR). As an iterative and solution-focused process, DT typically follows five phases: empathize, define, ideate, prototype, and test. In educational settings, this approach empowers students to explore disaster-related challenges from multiple stakeholder perspectives, identify local vulnerabilities, and develop creative, feasible solutions that enhance community resilience. Unlike traditional top-down instruction, DT invites learners to investigate real-world problems, collaborate across disciplines, and respond adaptively—mirroring the kind of dynamic decision-making required in actual disaster scenarios.

In recent years, DRR educators have increasingly adopted DT frameworks to engage students in designing early warning systems, evacuation plans, communication tools, and even low-cost structural reinforcements tailored to their communities. For instance, a study by Purwaningsih et al. (2023) involving secondary school students in Indonesia used the DT model to guide learners in developing flood preparedness prototypes. Students reported increased awareness of local risk factors and demonstrated enhanced teamwork, creativity, and empathy—core 21st-century competencies emphasized in global DRR frameworks. Similarly, interdisciplinary projects using DT in STEAME-oriented classrooms have enabled students to prototype disaster-proof housing models, emergency kits, and apps for crisis communication, blending engineering and entrepreneurial thinking with DRR content (Agustina & Salamah, 2023).

The integration of DT into DRR not only deepens conceptual understanding but also cultivates agency and innovation among young learners. It supports an experiential learning environment where trial-and-error, community input, and iterative improvement are seen as part of the learning process. However, successful implementation requires adequate teacher training, flexible curricula, and supportive school cultures that allow time for project development and field testing. When well supported, DT becomes a transformative strategy for preparing students not only to understand disasters—but to actively design solutions for mitigating their impact.

Simulation and Role-Playing

Simulation and role-playing are experiential learning methods that immerse students in realistic, high-stakes scenarios, allowing them to practice critical responses in controlled environments. Rooted in experiential learning theory (Kolb, 1984) and sociocultural learning models (Vygotsky, 1978), these pedagogies support emotional engagement, collaborative problem-solving, and deep conceptual understanding. In Disaster Risk Reduction (DRR) education, simulation enables students to rehearse procedures and decisions relevant to emergency events—such as earthquakes, floods, or fires—thus bridging theory with action (Boone et al., 2020).

Research supports the value of simulation-based DRR learning in increasing preparedness and emotional resilience. In Iceland, schools collaborate with the Icelandic Civil Protection Directorate to run role-playing scenarios that simulate volcanic eruptions or glacier floods (jökulhlaups). Students take on roles such as emergency responders, meteorologists, and municipal leaders, and use real-time geophysical data to plan evacuations. These structured exercises help young learners understand the intersection of natural science, infrastructure, and public communication. Evaluations show that such immersive simulations lead to greater knowledge retention and improved decision-making under stress (Gudmundsson et al., 2021).

In Italy, the national “Io Non Rischio Scuola” (I Don’t Take Risks School) program immerses students in scripted disaster scenarios including earthquakes, tsunamis, and landslides. Learners enact roles such as rescue personnel, journalists, and local residents, collaboratively navigating the crisis using prepared scripts and authentic materials. These activities promote not only procedural knowledge, but also empathy and civic awareness (Italian Civil Protection, 2023). In Spain, the Andalusian “Plan de Autoprotección Escolar” engages students in earthquake simulation drills where they role-play injured individuals, safety officers, and emergency responders. These full-school exercises include real-time evacuations, triage stations, and communications coordination, supported by regional emergency services. Evaluations in Seville and Granada have shown long-term gains in hazard awareness, evacuation fluency, and student confidence (Junta de Andalucía, 2022). Similarly, Germany’s “Ready-Steady-Go!” initiative tasks students with simulating responses to severe weather in fictional towns. They assess risks, allocate emergency resources, and conduct simulated press briefings—linking geography, digital literacy, and ethical reasoning within the DRR context.

Effective classroom simulation design often combines physical interaction with structured reflection. Props, maps, checklists, or digital alerts simulate real-world cues, while debriefing discussions help learners analyze their decisions and revise their plans. Digital simulations also enhance access. For example, the “Stop Disasters!” online game (UNDRR, 2022) allows students to design safe towns, balance emergency budgets, and protect communities from earthquakes, floods, or wildfires. Teachers can scaffold the game experience with worksheets or risk assessment tasks, reinforcing systems thinking and problem-solving under constraints.

Pedagogically, simulations align with core DRR goals: preparing students to act—not just know—in crisis situations. They cultivate transferable skills such as cooperation, leadership, and ethical decision-making. When embedded within STEAME frameworks, simulation-based learning provides a rich, interdisciplinary arena where science, engineering, civic literacy, and empathy meet. This active learning approach helps students internalize safety knowledge, experience risk from multiple perspectives, and prepare for real-world uncertainty with both competence and compassion.

Game-Based Learning (GBL)

Game-Based Learning (GBL) has become an increasingly effective instructional strategy for enhancing engagement, motivation, and experiential learning in the classroom—particularly in complex subjects such as Disaster Risk Reduction (DRR). By embedding learning objectives into interactive game mechanics, GBL allows students to explore real-world disaster scenarios in a safe, immersive environment. In DRR contexts, educational games simulate crisis situations—such as earthquakes, floods, or wildfires—enabling learners to make decisions, observe consequences, and reflect on the effectiveness of their actions. These simulations foster systems thinking, emotional preparedness, and decision-making under pressure, aligning closely with the competencies promoted by international DRR frameworks (UNDRR, 2020).

Recent studies highlight the educational benefits of GBL in DRR. Sutarto et al. (2024) implemented a digital role-playing game in Indonesian middle schools where students took on roles as disaster responders, community members, and planners. The study found that GBL significantly improved students’ hazard awareness, teamwork, and critical thinking, while also increasing motivation and retention. Similarly, Alharthi and Alghamdi (2023) used a hybrid board-and-digital game to teach earthquake preparedness in Saudi schools. Students not only demonstrated improved conceptual understanding but also reported increased confidence in applying safety protocols. These findings are consistent with broader research showing that GBL enhances risk perception, proactive behavior, and collaboration when designed with curricular alignment and scaffolded reflection (Asad et al., 2023).

The successful integration of GBL into DRR education, however, depends on factors such as game quality, contextual relevance, and teacher facilitation. While digital tools offer scalability, even low-tech board games or card-based activities can be effective when grounded in local realities and supported by discussion. GBL also opens pathways for cross-disciplinary integration—linking science, geography, art, and civic education through shared themes of risk, resilience, and systems thinking. When thoughtfully designed, GBL transforms passive risk instruction into active, student-centered exploration of how to prepare for and respond to disasters.

3.2. Supporting Strategies and Techniques for Integrating STEAME-DRR

In addition to the above core approaches and methods, the framework also incorporates a range of supporting strategies and techniques to enhance implementation and classroom adaptability. These complementary strategies enrich the primary methodologies by promoting active participation, deeper critical thinking, civic engagement, and scientific literacy. Together, they strengthen the framework's ability to support meaningful STEAME-DRR learning experiences that are grounded in real-world contexts and adaptable across diverse school environments. These strategies do not replace the core pedagogical approaches of the framework; rather, they operate as enabling mechanisms that help teachers translate interdisciplinary disaster risk reduction education into practical, participatory, and context-sensitive classroom activities.

Peer Teaching and Collaborative Learning

Peer teaching and collaborative learning involve students working in pairs or small groups to teach one another, exchange explanations, discuss ideas, and solve problems collectively. Within a STEAME-DRR framework, this strategy supports active engagement, teamwork, communication, shared responsibility, and collaborative problem-solving in disaster risk reduction contexts.

This approach is grounded in social interdependence theory, which identifies positive interdependence, individual accountability, promotive interaction, interpersonal skills, and group processing as essential elements of effective cooperative learning (Johnson & Johnson, 2009). These principles are relevant to STEAME-DRR because disaster-related problems require students to analyse risk scenarios, interpret scientific and social data, evaluate alternative solutions, and communicate preparedness or mitigation strategies.

Research on peer-led and peer-assisted learning in STEM education shows that structured peer collaboration can support conceptual understanding, problem-solving, academic achievement, and persistence (Wilson & Varma-Nelson, 2016; Shanbrom et al., 2023; Meador et al., 2024). Related research on learning assistants also indicates that collaborative STEM learning environments can enhance students' sense of belonging (Clements et al., 2022). In these models, peer leaders or facilitators guide discussion, pose scaffolding questions, encourage participation, and help learners articulate their reasoning.

In STEAME-DRR practice, peer teaching and collaborative learning may involve explaining hazard-related scientific concepts, designing flood- or earthquake-preparedness plans, reviewing engineering solutions, analysing local risk data, creating disaster awareness campaigns, or participating in emergency-response role-play simulations. These activities are consistent with DRR frameworks that emphasise understanding risk, preparedness, resilience, and the integration of risk reduction into education systems (UNDRR, 2015; GADRRRES, 2022).

For effective implementation, collaboration should be structured through clear learning objectives, assigned roles, shared goals, guiding questions, monitoring of group dynamics, and individual accountability, consistent with key conditions of effective cooperative learning (Johnson & Johnson, 2009). When peer feedback, reflection prompts, guided inquiry tasks, and problem-based scenarios are connected to disaster risk contexts, they can support purposeful, inclusive, and real-world DRR learning aligned with broader DRR education and school safety frameworks (UNDRR, 2015; GADRRRES, 2022).

Scenario Analysis

Scenario Analysis is a supporting strategy that enables learners to engage with real or hypothetical disaster events, reflect on decision-making pathways, and evaluate outcomes in risk contexts. Through such scenarios, students explore possible outcomes, assess different responses, and develop strategic thinking about uncertainty, consequences, vulnerability, preparedness, and resilience (Riddell et al., 2019; Strong et al., 2020; Ba et al., 2021).

Scenario-based approaches are used in disaster risk reduction to examine uncertain, interconnected, and multi-hazard situations. Exploratory scenario analysis can support the consideration of alternative pathways in disaster risk assessment and the testing of possible policy or response options under uncertainty (Riddell et al., 2019). Scenario development can also support the understanding, communication, management, and mitigation of disaster risks (Strong et al., 2020). Multi-hazard scenario methods further examine interacting hazards, cascading effects, emergency response processes, and system resilience (Ba et al., 2021).

In classroom practice, students may analyse earthquake, flood, wildfire, or extreme-weather scenarios; compare emergency response plans; create risk matrices or evacuation maps; and simulate stakeholder decision-making, reflecting the use of scenario-based approaches for disaster-risk understanding, communication, emergency management, and response planning (Strong et al., 2020; Ba et al., 2021). These activities can support evidence-based interpretation of risk information and are consistent with DRR education approaches that emphasise participation, skills, action, and community relevance (Riddell et al., 2019; Masocha et al., 2025).

Scenario Analysis is consistent with DRR education approaches that emphasise participation, action, skills, attitudes, and community relevance rather than knowledge transmission alone (Masocha et al., 2025). It is also relevant to education infrastructure and school continuity, as scenario-based recovery analyses can inform disaster-risk management policies and post-disaster education continuity (Opabola & Galasso, 2024).

For effective implementation, scenarios should be realistic, age-appropriate, locally relevant, and supported by guiding questions, structured roles, decision points, evaluation criteria, and reflection, consistent with scenario-development guidance for disaster risk reduction and DRR education approaches that emphasise participation, skills, action, and community relevance (Strong et al., 2020; Masocha et al., 2025).

Systems Thinking and Complexity Mapping

Systems Thinking and Complexity Mapping support deeper understanding of complexity and interconnectivity in DRR contexts by helping learners examine disaster risk as the result of interacting social, environmental, technological, infrastructural, and institutional factors. Rather than viewing disasters as isolated events, students explore how hazards, exposure, vulnerability, preparedness, governance, communication, resources, and community behaviour influence one another before, during, and after a disaster. This perspective is consistent with contemporary DRR approaches that emphasise understanding disaster risk, systemic vulnerability, preparedness, resilience, and governance (UNDRR, 2015; Sillmann et al., 2022).

This approach is grounded in systems thinking and system dynamics, which emphasise feedback loops, time delays, non-linear relationships, and the unintended consequences of decisions in complex systems (Sterman, 2000). In STEAME-DRR education, this helps students recognise that risk is not produced by a single cause, but by the interaction of multiple connected elements. Such a perspective is particularly relevant to systemic and interconnected risks, which require integrated approaches to understanding, communication, preparedness, governance, and resilience (UNDRR, 2015; Sillmann et al., 2022).

In classroom practice, students may create causal loop diagrams, concept maps, impact webs, risk chains, or stakeholder maps to visualise how different factors contribute to disaster risk. For example, they may examine how urbanisation, poor drainage, extreme rainfall, social vulnerability, weak communication, and delayed response can combine to intensify flood impacts. Systems-based approaches and causal diagramming have been used to analyse cascading impacts in complex risk contexts, supporting their relevance for DRR learning and for understanding interconnected causes, consequences, and possible intervention points (Sterman, 2000; Cradock-Henry et al., 2020).

For effective implementation, systems thinking activities should be supported by guiding questions, clear visual tools, collaborative discussion, and reflection. These design elements help students use systems thinking to examine relationships, feedbacks, cascading effects, and possible points for intervention. Overall, Systems Thinking and Complexity Mapping support critical thinking, risk literacy, interdisciplinary learning, and more informed decision-making within STEAME-DRR (Sterman, 2000; Cradock-Henry et al., 2020; Sillmann et al., 2022).

Visual Thinking Strategies (VTS)

Visual Thinking Strategies (VTS) use visual media such as images, photographs, maps, diagrams, artworks, or infographics to foster observation, interpretation, evidence-based reasoning, and discussion. VTS is based on guided visual inquiry, where learners observe carefully, describe what they see, support interpretations with visual evidence, listen to alternative viewpoints, and construct meaning through discussion (Yenawine, 2013).

In the DRR context, visual materials can initiate dialogue about vulnerability, preparedness, response, exposure, resilience, and community risk. Disaster risk is often communicated through visual forms, including hazard maps, satellite images, photographs of affected areas, evacuation diagrams, early-warning graphics, risk matrices, and preparedness infographics. Disaster risk visualisations can help users assess, understand, and manage natural hazard and disaster risks when they are designed around user needs and contexts (Twomlow et al., 2022).

In classroom practice, students may analyse images of flood-prone areas, wildfire impacts, damaged infrastructure, emergency shelters, evacuation routes, or climate-related hazards. Through structured questions, they can identify visible signs of vulnerability, discuss possible causes and consequences, compare preparedness and response measures, and consider how different communities may experience risk differently. These practices are consistent with VTS-based observation, interpretation, visual evidence, and discussion, as well as with user-centred disaster-risk visualisation (Yenawine, 2013; Twomlow et al., 2022).

The use of visual materials in STEAME-DRR is also linked to disaster risk communication. Effective disaster risk communication should move beyond one-way information delivery and include dialogue, participation, and informed engagement with risk (Stewart, 2024). Therefore, VTS can provide a pedagogical structure for discussing visual risk information, while disaster-risk visualisation research supports the importance of clear, usable, and context-sensitive visual communication in risk contexts (Yenawine, 2013; Twomlow et al., 2022; Stewart, 2024).

For effective implementation, teachers should select visuals that are age-appropriate, locally relevant, ethically used, and open to meaningful interpretation. Discussion can be guided by questions such as: "What is happening in this image?", "What do you see that makes you say that?", "What more can we find?", and "How does this visual show vulnerability, preparedness, or response?" These questions reflect the VTS emphasis on careful observation, evidence-based interpretation, and discussion (Yenawine, 2013).

Citizen Science Activities

Citizen Science Activities involve students in authentic data collection on local environmental indicators, such as rainfall, erosion, air quality, water conditions, flood exposure, heat, or seismic activity. Within a STEAME-DRR framework, these activities connect classroom learning with local risk conditions by enabling students to observe, record, analyse, and interpret data from their school or community environment. Citizen science is widely understood as public participation in scientific research and knowledge production, supporting scientific literacy and engagement with research processes (Bonney et al., 2009).

In educational contexts, community and citizen science can support environmental learning outcomes, including science content knowledge, inquiry skills, environmental awareness, and community-level learning (Ballard et al., 2024). In DRR contexts, global mapping of citizen science projects shows that such approaches have supported scientific knowledge, early warning, and the assessment and management of disaster impacts (Hicks et al., 2019).

Citizen-generated data can complement official data sources by providing local observations useful for monitoring environmental or risk-related indicators (Fraisl et al., 2023). Community-based and citizen science approaches have also been applied in flood risk reduction, supporting people-centred DRR in line with the Sendai Framework (Wolff, 2021). Recent DRR-focused citizen science research further highlights active participation, knowledge production, data accuracy, spatial and temporal data expansion, and citizen-related outcomes as important factors in citizen science programmes for disaster risk reduction (Poudel et al., 2025).

In classroom practice, students may measure rainfall, document erosion, map flood-prone areas, monitor air quality, record heat conditions, or contribute observations related to seismic or other environmental risks. Where appropriate, they may collaborate with teachers, scientists, municipal authorities, or community stakeholders to identify vulnerabilities, discuss possible solutions, and communicate risk-reduction recommendations. These activities make STEAME-DRR learning place-based and action-oriented by linking observation, measurement, data interpretation, mapping, communication, and community preparedness (Bonney et al., 2009; Hicks et al., 2019; Ballard et al., 2024).

For effective implementation, citizen science activities should include clear data collection protocols, ethical guidance, attention to data quality, collaboration with relevant stakeholders, and reflection on data reliability and limitations. These conditions are consistent with citizen science research that emphasises data quality, participation, scientific learning, and responsible use of citizen-generated data (Bonney et al., 2009; Fraisl et al., 2023; Poudel et al., 2025).

3.3. Holistic and Cross-Curricular Approaches for Integrating STEAME-DRR

In order to embed disaster risk reduction education within a broader educational context, the methodological framework includes several holistic and cross-curricular approaches. These strategies bridge emotional, ecological, creative, civic, and cognitive dimensions of learning, aligning STEAME and DRR objectives through interdisciplinary and reflective educational practice:

Eco-Centric Education / Environmental Literacy

Eco-Centric Education / Environmental Literacy situates DRR within the broader context of sustainability, ecosystem dynamics, and human–environment relationships. It helps students examine how climate change, biodiversity loss, environmental degradation, land-use change, and unsustainable resource management can increase vulnerability to natural hazards and intensify disaster risk. This perspective is consistent with DRR education approaches that connect environmental conditions, exposure, vulnerability, preparedness, and human decision-making (Bernal & Apdohan, 2023; Tyas et al., 2025).

Environmental literacy supports the development of knowledge, skills, attitudes, and values needed to understand ecological systems and act responsibly within them. In DRR education, this is relevant because ecosystem degradation can reduce natural protection against hazards, while sustainable environmental practices can support resilience and adaptive capacity. Eco-school and green curriculum studies indicate that school-based environmental approaches can support environmental literacy, environmental awareness, and eco-friendly behaviour among students (Nurwidodo et al., 2020; Triyandana et al., 2025).

In classroom practice, Eco-Centric Education / Environmental Literacy can involve analysing local environmental risks, mapping vulnerable ecosystems, studying climate change and extreme weather, investigating soil erosion or water quality, designing biodiversity protection projects, or developing school-based sustainability and preparedness actions. These activities make STEAME-DRR learning interdisciplinary, place-based, and action-oriented by connecting ecological understanding, monitoring, mapping, mitigation, communication, data analysis, and community action (Nurwidodo et al., 2020; Bernal & Apdohan, 2023; Tyas et al., 2025).

For effective implementation, activities should connect ecological concepts with real local risks and encourage students to reflect on both environmental responsibility and disaster preparedness. In this way, Eco-Centric Education / Environmental Literacy links sustainability, ecosystem awareness, risk reduction, adaptive behaviour, and environmental stewardship within STEAME-DRR (Triyandana et al., 2025; Tyas et al., 2025).

Media & Digital Literacy Integration

Media & Digital Literacy Integration enables students to critically evaluate disaster-related content, such as news reports, social media posts, emergency alerts, images, videos, maps, and misinformation. Within a STEAME-DRR framework, these skills are relevant because learners increasingly access disaster information through digital platforms, where official warnings, scientific information, rumours, emotional content, and misleading claims may circulate at the same time (Hilberts et al., 2025).

This approach supports students in assessing the credibility, source, purpose, evidence, and potential bias of disaster-related information. It also helps them distinguish between verified information, misinformation, disinformation, speculation, and opinion. This is particularly important in crisis contexts, where misinformation on social media can increase public confusion, reduce trust in reliable sources, misdirect resources, and negatively affect emergency response and decision-making (Hilberts et al., 2025).

In educational practice, media and digital literacy can be integrated into DRR through activities such as analysing disaster news coverage, comparing official emergency messages with social media posts, evaluating online sources, identifying misleading images or claims, and creating responsible risk communication materials. These activities can support critical evaluation of disaster-related information, risk understanding, and responsible digital communication during emergencies, consistent with the need for digital media-based disaster mitigation education for younger generations (Anindhita et al., 2024).

Recent research also supports the relevance of digital literacy in disaster-related learning, although the evidence should be interpreted carefully. Maddatuang, Bahri, and Tabbu (2025) show that digital literacy and disaster mitigation understanding are associated with students' computational and spatial thinking abilities, which are relevant for interpreting risk-related information. Anindhita et al. (2024) further highlight the need to design disaster mitigation education that reflects how young people access, interpret, and share information through digital media (Maddatuang et al., 2025; Anindhita et al., 2024).

For effective implementation, teachers should guide students to verify information through official sources, cross-check claims, interpret visual and textual evidence, recognise emotional manipulation, and communicate responsibly during crises. These practices align with research emphasising the role of digital literacy and timely misinformation management in reducing confusion and supporting informed responses during natural disasters (Hilberts et al., 2025).

Art-Based Learning & Creative Expression

Art-Based Learning and Creative Expression involve students in creating visual arts, theatre, comic strips, songs, storytelling, murals, or multimedia presentations to reflect on disaster-related experiences, narratives, and community memories, convey risk-awareness messages, and foster emotional connection with disaster risk reduction. Within a STEAME-DRR framework, this approach connects scientific content with imagination, empathy, communication, and community-oriented action.

Artistic media can make disaster-risk concepts more accessible by translating scientific evidence, practical knowledge, and lived experience into emotionally engaging forms of communication. The arts can support public dialogue, attitude change, and action by helping learners and communities connect with risk beyond technical data or abstract information (ODI, 2019).

Recent research supports the use of arts-based and creative approaches in DRR and resilience education. Sevilla et al. (2023) show how historical research, memory, emotion, museum exhibits, and transmedia storytelling can support interdisciplinary conversations about multi-hazard risk. Semmens et al. (2023) demonstrate how science, art, and community engagement can be combined through murals, storytelling, photovoice, forums, and community activities to increase knowledge of weather and climate science, local hazards, and mitigation strategies. Bubeck et al. (2024) show that community-based theatre can function as a risk communication tool, supporting risk perception, perceived flood knowledge, self-efficacy, public awareness, and social participation.

In classroom practice, students may design preparedness posters, create comic strips about evacuation procedures, compose songs about climate resilience, produce short videos on emergency planning, or create murals representing community resilience, reflecting the role of arts-based and transmedia approaches in risk communication and community engagement (ODI, 2019; Sevilla et al., 2023; Semmens et al., 2023). Theatre-based activities, such as performances about flood response or coastal risk, can also function as participatory risk communication tools that support public awareness and societal engagement (Bubeck et al., 2024).

For effective implementation, artistic activities should be connected to accurate scientific content, clear DRR objectives, ethical representation of disaster experiences, and opportunities for reflection, so that creative work functions as a medium for risk communication, public dialogue, interdisciplinary learning, and community engagement (ODI, 2019; Sevilla et al., 2023; Semmens et al., 2023; Bubeck et al., 2024). In this way, Art-Based Learning and Creative Expression support inquiry, interpretation, communication, empathy, preparedness, and resilience-building within STEAME-DRR.

Citizen Science Activities

Citizen Science Activities involve students in community-based data collection, such as monitoring rainfall, recording erosion, observing air or water quality, documenting flood exposure, or mapping local hazards. Within a STEAME-DRR framework, these activities connect classroom learning with local risk conditions by engaging students in observation, measurement, recording, analysis, and interpretation of data from their school or community environment (Bonney et al., 2009; Hicks et al., 2019).

Citizen science is based on public participation in scientific research and knowledge production, and it can support scientific learning, scientific literacy, and engagement with real-world data collection processes (Bonney et al., 2009). In DRR contexts, citizen science has been used to advance scientific knowledge, support early warning, and contribute to the assessment and management of disaster impacts across different hazards and geographical contexts (Hicks et al., 2019).

Students may collaborate with teachers, researchers, municipal authorities, or community stakeholders to identify vulnerabilities, discuss possible solutions, and communicate risk-reduction recommendations. Such collaboration is consistent with DRR-focused citizen science approaches that emphasise locally grounded knowledge, shared understanding of hazards, communication, participation, responsibility, and empowerment of communities exposed to disaster risk (Hicks et al., 2019).

For effective implementation, citizen science activities should include clear data collection protocols, attention to data quality, ethical guidance, stakeholder collaboration, and reflection on data reliability and limitations. These conditions align with citizen science models that aim to produce both scientific and educational outcomes and with DRR-focused frameworks that highlight scientific competence, equity, responsibility, and empowerment in citizen science initiatives (Bonney et al., 2009; Hicks et al., 2019).

Mindfulness & Social-Emotional Learning (SEL)

Mindfulness and Social-Emotional Learning (SEL) can support students in DRR contexts, where discussions of hazards, emergencies, vulnerability, loss, and uncertainty may create emotional discomfort or stress. SEL includes competencies such as self-awareness, self-management, social awareness, relationship skills, and responsible decision-making, which are relevant to emotional regulation, communication, cooperation, and constructive responses in challenging situations (CASEL, 2020).

In STEAME-DRR learning, practices such as mindful breathing, journaling reflections, guided debriefing, peer sharing, and structured emotional check-ins can provide space for reflection and supportive discussion. In emergency education contexts, SEL and psychosocial support are recognised as important for children's and young people's wellbeing, connection, positive relationships, and resilience during crises (EiE Hub, 2022).

Mindfulness-based school interventions show some evidence of reducing stress among adolescents, although evidence for anxiety and depression is more cautious and context-dependent (Fulambarkar et al., 2023). Therefore, mindfulness should be used in STEAME-DRR as a supportive educational practice rather than as a therapeutic intervention.

This approach is consistent with the Comprehensive School Safety Framework 2022–2030, which promotes an all-hazards, all-risks approach to protecting learners and strengthening safety and resilience in the education sector (GADRRRES, 2022). For effective implementation, mindfulness and SEL activities should be age-appropriate, trauma-sensitive, voluntary where needed, and connected to clear DRR learning goals. In this way, Mindfulness & SEL help create emotionally safe learning conditions in which students can engage with disaster-related issues thoughtfully, collaboratively, and with a stronger sense of personal and collective preparedness.

4. INTEGRATION OF STEAME-DRREC ACTIVITIES INTO ELEMENTARY SCHOOL CURRICULA

4.1. Purpose and Scope

This section provides structured guidelines for integrating Disaster Risk Reduction Education (DRREC) into the elementary school curricula of Greece and Cyprus through a STEAME framework, incorporating Science, Technology, Engineering, Arts, Mathematics, and Entrepreneurship. Its purpose is to ensure that DRR is not treated as an isolated, occasional, or extracurricular topic, but as an interdisciplinary learning field embedded within existing curriculum objectives, classroom practices, and age-appropriate learning outcomes. This approach is aligned with the Sendai Framework for Disaster Risk Reduction 2015–2030, which emphasises understanding disaster risk, strengthening disaster risk governance, investing in resilience, and enhancing preparedness for effective response (UNDRR, 2015).

The section also aims to support the design of DRR learning experiences that are pedagogically coherent, developmentally appropriate, and connected to real-world risk contexts. At elementary level, concepts such as hazard, vulnerability, preparedness, safety, resilience, and community responsibility should be introduced through activities suitable for pupils' cognitive, emotional, and social development. This is consistent with international school safety approaches that promote an all-hazards, all-risks perspective, educational continuity, and resilience-building within the education sector (GADRRRES, 2022; Tyas et al., 2025).

The scope of this section is the integration of STEAME-DRREC activities within elementary school curricula in Greece and Cyprus. It focuses on how DRR-related learning can be embedded across existing subjects rather than added as a separate subject. In Greece, the Cross-Thematic Curriculum Framework for Compulsory Education (ΔΕΠΠΣ) supports interdisciplinary and cross-curricular teaching, allowing thematic links among subject areas, environmental education, civic learning, and active classroom engagement (Hellenic Pedagogical Institute, 2003). In Cyprus, primary education encourages active learning, critical thinking, student-centred approaches, and flexible teaching methods, while sustainability is also promoted through the country's Education for Sustainable Development initiatives (European Commission/Eurydice, 2026; UNESCO, 2023).

Within this scope, STEAME-DRREC activities may be connected to several subject areas. In Environmental Studies and Geography, pupils can explore local hazards, read maps, identify vulnerable areas, and discuss climate-related events. In Science, they can investigate earthquakes, floods, soil erosion, weather patterns, or ecosystem degradation through inquiry-based activities. In Language and Literacy, they can engage with storytelling, reflective writing, survivor narratives, interviews, and risk communication texts. In Mathematics, they can analyse rainfall data, temperature trends, population density, emergency response times, or simple risk matrices. In Visual Arts, Technology, and Design, pupils can create safety posters, evacuation maps, infographics, digital campaigns, models, or simple warning-system prototypes. These cross-curricular links support both subject-specific learning and broader competences such as critical thinking, collaboration, communication, creativity, civic responsibility, and problem-solving (Hellenic Pedagogical Institute, 2003; Tyas et al., 2025).

STEAME also functions as a cross-curricular lens for understanding disaster risk as a scientific, technological, environmental, social, ethical, and civic issue. Science supports understanding of hazards and natural processes; technology supports data collection, mapping, communication, and digital safety; engineering introduces mitigation and design thinking; the arts support expression, empathy, visual communication, and public awareness; mathematics develops data literacy and risk estimation; and entrepreneurship encourages initiative, innovation, and community-oriented solutions. Through this approach, existing curriculum goals can be enriched with safety, sustainability, preparedness, resilience, and active citizenship (UNDRR, 2015; GADRRRES, 2022; Tyas et al., 2025).

4.2. Guidelines for Integrating DRREC Across Subjects and Grades

A pedagogical integration model for STEAME-DRREC

The integration of Disaster Risk Reduction Education (DRREC) across subjects and grades can be organised through a Context-Based Pedagogical Integration Model for STEAME-DRREC. The model is structured around two interrelated components: the context and the pedagogy of the context. The context functions as the pedagogical canvas on which the lesson is designed, while the pedagogy of the context refers to the methods, techniques, and teaching approaches used to transform this context into a meaningful learning experience. This distinction is grounded in context-based, situated, and constructivist views of learning, according to which knowledge becomes more meaningful when it is connected to authentic situations, social practices, and learners' prior experiences (Brown et al., 1989; Lave & Wenger, 1991; Jonassen, 1999; National Research Council, 2000; Gilbert, 2006).

In the first component, the context is selected as a natural hazard theme related to pupils' environment, such as earthquakes, floods, wildfires, heatwaves, extreme weather events, erosion, or air pollution. The context does not replace the content of the subject; rather, it functions as an authentic situation through which curriculum objectives are taught. The use of real-life or familiar situations as a starting point for learning is a central feature of context-based education, which aims to connect school knowledge with situations that learners recognise as meaningful and relevant to their lives (Gilbert, 2006; Bennett et al., 2007).

In the second component, the pedagogy of the context determines how the selected context is used instructionally. The teacher begins with the subject objective, selects the appropriate natural hazard context, and then decides which pedagogical approach will be used: storytelling, scenario analysis, systems thinking, visual thinking strategies, citizen science, collaborative learning, media and digital literacy, art-based learning, eco-centric education, or social-emotional learning. This logic is consistent with constructivist, problem-based, and instructional design approaches, where learners build knowledge through authentic problems, purposeful activities, collaboration, inquiry, and appropriate scaffolding (Jonassen, 1999; National Research Council, 2000; Hmelo-Silver, 2004; Merrill, 2002).

Storytelling functions as an entry point into the context. A short story, scenario, comic strip, image, digital story, or testimony can introduce pupils to a situation involving characters, place, problem, decision, and consequence. In this way, the natural hazard is not presented as abstract information, but as an experience that can be explored cognitively, emotionally, and socially. Narrative organisation is particularly suitable for primary education because it helps pupils organise information, remember concepts, and connect learning with human experience and meaning (Egan, 1986; Bruner, 1990).

For the design of a DRREC activity, the teacher may follow a short sequence: first, identify the subject objective; then select the natural hazard context; introduce the context through storytelling or a visual stimulus; choose the appropriate pedagogical method; design the learning activity; define the expected learning product; and conclude with reflection on what pupils learned in the subject and what they understood about preparedness, safety, and responsibility. Thus, each activity has two explicit layers: the subject learning layer, which concerns the objectives and content of the curriculum, and the DRR layer, which concerns risk understanding, preparedness, resilience, and responsible action (Jonassen, 1999; National Research Council, 2000; UNDRR, 2015; GADRRRES, 2022).

The following Table 1 translates the Context-Based Pedagogical Integration Model for STEAME-DRREC into a practical planning tool, showing how the selected hazard context can be connected with subject objectives, pedagogical approaches, learning products, and reflection.

Table 1
Operationalization of the Context-Based Pedagogical Integration Model for STEAME-DRREC

Component	Description	Key question
Context	A natural hazard theme that functions as the canvas of the lesson.	Which natural hazard is familiar, locally relevant, and age-appropriate for pupils?
Pedagogy of the context	Methods and techniques that transform the context into a learning activity.	Which approach will help pupils achieve the subject objective while also developing DRR competences?
Connection with the subject	Alignment with curriculum objectives, concepts, and skills.	Which subject objective is served through the activity?

Table 1
Operationalization of the Context-Based Pedagogical Integration Model for STEAME-DRREC

Component	Description	Key question
Learning product	Evidence of learning, such as a map, graph, poster, instructions, narrative, model, or action plan.	How does the product show that pupils understood both the subject content and the DRR dimension?
Reflection	Connection between knowledge, preparedness, safety, and responsible behaviour.	What did we learn, and how can this knowledge help us act more responsibly?

Through this model, DRREC does not function as an additional topic, but as a way of giving meaning to everyday teaching. The context gives the lesson authenticity and connection with pupils' environment, while the pedagogy of the context organises the transition from experience to knowledge, from knowledge to activity, and from activity to preparedness and responsible action. When the context concerns a natural hazard familiar to pupils' environment, the learning process can be connected with preparedness, safety, responsibility, and resilience, as proposed by international frameworks for disaster risk reduction and school safety (UNDRR, 2015; GADRRRES, 2022; Kitagawa, 2021).

Curriculum-Aligned DRREC Integration in Grades 1–3

Integrating DRREC into the primary school curriculum should not be seen as an added burden but as a meaningful opportunity to enrich learning while enhancing students' capacity to act safely and responsibly in the face of natural hazards. To assist teachers in this process, DRREC themes can be mapped onto existing learning objectives across multiple subjects, ensuring that hazard education aligns with what students are already expected to learn.

Table 2 presents a structured guide for integrating DRREC into the Greek national curriculum for Grades 1 to 3, highlighting opportunities within core subjects under the STEAME framework. It includes specific curriculum units or chapters, identifies age-appropriate learning objectives, and proposes practical strategies for linking each to disaster risk education. This alignment ensures both educational relevance and pedagogical continuity, while fostering key competencies such as observation, collaboration, problem-solving, and civic responsibility.

Table 2
Curriculum-Aligned DRREC Integration in Grades 1–3

Subject	Grade Level	Curriculum Unit/ Theme	Learning Objectives	Suggested DRREC Integration
Language	Grade 1	Letter Σ – Weather phenomena	Recognise letters, develop vocabulary, understand oral stories	Introduce words such as rain, wind, flood, safety, shelter; use a short story such as The Cloud Brought Rain to discuss simple safety messages
	Grade 2	Newspapers, news, professions	Identify features of news writing; understand social roles	Write a short news item about heavy rainfall or a local flood; role-play as weather reporters, firefighters, or civil protection officers

	Grade 3	Earth, maps, buildings, report writing	Compose informative texts; describe places and environments	Write a short report on a local hazard; produce instructions for safe movement or emergency routes
Visual Arts	Grades 1–3	Colours, space, environment themes	Express ideas visually; develop fine motor skills	Draw safe places, emergency signs, evacuation routes, shelters, fire trucks, or preparedness posters

Table 2

Curriculum-Aligned DRREC Integration in Grades 1–3, continued

Subject	Grade Level	Curriculum Unit/ Theme	Learning Objectives	Suggested DRREC Integration
Mathematics	Grade 1	Numbers to 20, counting, sorting, patterns	Develop basic numeracy, grouping, and sequencing	Count raindrops, emergency objects, or safe steps; sort images into safe/unsafe actions; sequence simple preparedness steps
	Grade 2	Measurement, graphs, addition and subtraction	Measure, compare, and read simple charts	Create pictograms of rainfall; compare water levels; use timelines to order emergency actions
	Grade 3	Data representation, time, perimeter/area	Analyse simple data and solve practical problems	Read simple flood or weather charts; calculate the area of a safe gathering point; interpret time needed for evacuation steps
Environmental Studies	Grade 1	Communication then and now – Mass media	Understand basic forms of communication	Discuss how weather alerts, sirens, announcements, and emergency broadcasts help people stay safe
	Grade 2	Weather, water, community services, professions	Understand natural phenomena and public services	Explore rainfall, water flow, flooding, and the role of firefighters, meteorologists, health services, and civil protection
	Grade 3	Communication and information	Understand how information is shared in society	Discuss how authorities issue warnings; create a simple flood, fire, or earthquake warning poster
Skills Lab / STEAME	Grade 1	Create and innovate – STEM / educational robotics	Develop basic problem-solving and mechanical understanding	Use simple models or robotics to simulate water movement, warning signals, or safe routes

	Grade 2	Environment, climate crisis, natural disasters, civil protection	Build environmental awareness and basic response habits	Discuss causes of floods, fires, and heatwaves; role-play emergency teams; explore simple sustainability and preparedness actions
	Grade 3	Professions and community roles	Identify professions and their social contribution	Explore disaster-related professions such as firefighters, meteorologists, engineers, doctors, and civil protection workers; create digital or visual "job posters"

Table 2

Curriculum-Aligned DRREC Integration in Grades 1–3, continued

Subject	Grade Level	Curriculum Unit/ Theme	Learning Objectives	Suggested DRREC Integration
Play-Based Learning / Skills Lab	Grades 1–2	Daily routines, social awareness, cooperation	Strengthen empathy, teamwork, and safety awareness	Role-play earthquake or flood responses; sort actions into safe/unsafe categories; practise how families or classmates can help one another
Drama / Movement	Grade 3	Theatrical play and movement expression	Develop emotional expression and social connection	Perform short scenes about community responses to hazards; use movement and mime to retell a safety story or emergency

The examples presented in Table 1 show that, in Grades 1–3, DRREC can be integrated into everyday teaching through simple, concrete, and age-appropriate activities. By connecting natural hazard themes with stories, drawings, movement, games, observation, basic data handling, and creative tasks, pupils encounter risk-related ideas across different subjects and learning modalities. This repeated and developmentally appropriate exposure helps them build basic vocabulary for describing hazards, recognise safe and unsafe behaviours, practise simple protective actions, and understand preparedness as part of classroom, school, and community life. In this way, early DRREC integration lays the foundation for more advanced risk literacy, cooperation, emotional awareness, and civic responsibility in later grades.

Curriculum-Aligned DRREC Integration in Grades 4–6

In Grades 4–6, Disaster Risk Reduction Education (DRREC) can progress from basic hazard awareness to inquiry, critical analysis, and responsible action. Pupils at this stage can examine causes and consequences, interpret information, compare responses, and reflect on how individual and collective decisions affect safety and resilience. Therefore, DRREC activities should be linked to curriculum objectives that promote analytical thinking, collaboration, ethical reflection, civic responsibility, and interdisciplinary problem-solving.

Within the STEAME framework, natural hazards such as earthquakes, floods, wildfires, heatwaves, storms, erosion, and climate-related risks can serve as meaningful contexts across subjects. Pupils may analyse texts and write reports in Language, investigate hazards and environmental change in Environmental Studies and Geography, interpret data and graphs in Mathematics, and design infographics, evacuation plans, digital campaigns, models, or mitigation solutions in Arts, Technology, and Skills Lab.

Table 3 presents curriculum-aligned examples for Grades 4–6, showing how DRREC can be embedded in existing subjects while supporting academic learning and wider competences, including risk literacy, systems thinking, digital literacy, communication, creativity, cooperation, and civic engagement.

Table 3
Curriculum-Aligned DRREC Integration in Grades 4–6

Subject	Grade Level	Curriculum Unit / Theme	Learning Objectives	Suggested DRREC Integration (Floods, Earthquakes, Wildfires)
Language	Grade 4	Unit 2: Ask the Water What's Wrong Unit 9: The Show Begins	Understand narrative forms, dramatize texts, express opinion	Create dialogues between rivers and towns during a flood; write scripts where communities respond to a wildfire
	Grade 5	Unit 1: Our Friend the Environment Unit 13: Constructions Unit 15: Television	Analyze texts and media, reflect on environment, describe processes	Write news scripts about local earthquakes; explore how buildings resist tremors; create informative TV ads about fire prevention
	Grade 6	Unit 7: Life Outside the City (Floods, Deforestation) Unit 15: Cinema & Theatre	Synthesize cause-effect, critique ecological issues in the media	Create and perform short films about wildfire evacuation; compare flood vs. fire narratives in literature and film
Environmental Studies	Grade 4	Chapters on: Maps, Water Sources, Forests	Analyze nature-human interaction, describe resources and hazards	Study how deforestation increases flood and fire risks; simulate a river system and discuss overflow
	Grade 5	Topics: Waste, Water Management, Forest Fires, Technologies for Protection	Promote sustainable practices and critical thinking	Examine wildfire causes and prevention; explore how public infrastructure responds to earthquakes
	Grade 6	Climate change, Natural Disasters, Global Connections	Explore causes, effects, and responses to global and local disasters	Create classroom "disaster maps"; conduct inquiry into local earthquake patterns and global climate shifts
Visual Arts	Grades 4–6	Composition, Color Use, Social Messaging	Visual storytelling and critical expression	Create awareness posters for fire drills, flood warnings, or seismic preparedness campaigns

Table 3
Curriculum-Aligned DRREC Integration in Grades 4–6, continued

Subject	Grade Level	Curriculum Unit / Theme	Learning Objectives	Suggested DRREC Integration (Floods, Earthquakes, Wildfires)
Mathematics	Grade 4	Geometry, Graphs, Perimeter, Angles	Measure and visualize space and data	Measure safe assembly areas; graph frequency of earthquakes over time
	Grade 5	Volume, Decimals, Measurement Conversions	Apply math in real scenarios	Calculate water needed for firefighting; simulate rainfall collection in containers; compare tremor strength
	Grade 6	Data, Coordinates, Proportionality	Analyze, model, and locate data	Map safe zones using coordinates; use scale drawings to plan evacuation paths from a school
Digital Literacy	Grades 5–6	Research, Digital Presentation, Responsible Use	Use digital tools to communicate ideas	Create infographics on earthquake safety tips; design a class DRR website or blog
Theatre/Movement	Grade 6	Drama Improvisation, Collective Expression	Collaborate, reflect, and embody ideas physically	Dramatize earthquake reactions at home and school; use movement to show forest growth and destruction from fire
Skills Lab (STEAME)	Grade 4	Create and Innovate – STEM: Educational Robotics	Develop problem-solving and design thinking	Build a flood detection robot using sensors; simulate terrain response to tremors using Lego kits
	Grade 5	Take Care of the Environment – Climate Crisis, Natural Disasters, Civil Protection	Promote civic responsibility and scientific inquiry	Create a family emergency plan; role-play civil protection units; study how climate stress increases wildfire risk
	Grade 6	Create and Innovate – Getting to Know Professions	Explore careers, community helpers, emergency response roles	Interview a firefighter or geologist; simulate rescue missions; create digital profiles for emergency workers

Overall, the examples in Table 3 show that, in Grades 4–6, DRREC can move beyond basic awareness and become a structured interdisciplinary learning process. Through the STEAME framework, natural hazards such as earthquakes, floods, and wildfires function as meaningful contexts for inquiry, data analysis, communication, design, creative expression, and civic action. Pupils are encouraged to examine causes and consequences, interpret evidence, compare possible responses, and design preparedness or mitigation solutions connected to their school and local community. In this way, DRREC supports not only subject-specific learning, but also the development of risk literacy, systems thinking, digital competence, collaboration, ethical reasoning, and responsible participation in building safer and more resilient communities.

5. DIGITAL, TECHNOLOGICAL & AI TOOLS FOR DRR EDUCATION

The integration of digital, technological, and AI-supported tools in Disaster Risk Reduction Education (DRREC) should be understood as a pedagogical means of supporting inquiry, visualisation, communication, and problem-solving, rather than as an end in itself. In elementary education, such tools can help pupils visualise hazards, explore spatial patterns, interpret simple data, simulate risk scenarios, communicate preparedness messages, and create digital products related to safety and resilience. This is consistent with international DRR priorities that emphasise understanding disaster risk, strengthening preparedness, and developing knowledge and skills that support resilience in education systems (UNDRR, 2015; GADRRRES, 2022).

Within the STEAME framework, digital and technological tools can connect Science, Technology, Engineering, Arts, Mathematics, and Entrepreneurship through authentic risk-related tasks. Digital maps and GIS platforms can support spatial awareness and local risk exploration; simulations can help pupils investigate dynamic natural processes; content-creation tools can support risk communication; and games or immersive environments can provide interactive forms of inquiry and problem-solving. These uses align with broader digital education perspectives, where technology is most valuable when it is integrated into a coherent learning ecosystem and used with clear pedagogical purpose (OECD, 2023).

AI-supported tools require particular attention to teacher guidance, age appropriateness, accuracy, ethics, and critical digital literacy. Generative AI can support teachers in preparing stories, role-play scenarios, differentiated texts, discussion questions, quizzes, and visual communication materials. However, it should not replace teacher judgement, pupils' cognitive effort, or evidence-based learning. UNESCO's guidance on generative AI in education stresses the need for a human-centred approach, appropriate regulation, teacher capacity development, and responsible use of AI in ways that protect learning quality and equity (UNESCO, 2023b).

For this reason, the tools presented in this section should be used selectively and developmentally. In Grades 1–3, the emphasis should be on sensory exploration, visualisation, storytelling, play, emotional safety, basic vocabulary, and simple preparedness routines. In Grades 4–6, digital and AI-supported tools can be used for more analytical tasks, such as interpreting maps and data, comparing scenarios, modelling hazards, evaluating online information, designing awareness campaigns, and proposing school or community preparedness actions. The following subsections present illustrative categories of tools and classroom uses that can be adapted to subject objectives, grade level, local risk contexts, and the STEAME-DRREC pedagogical model.

5.1. Digital Maps & GIS Tools

Examples: Google Earth, ArcGIS Online, MapHub, seismoi-live.gr, EMSC, national seismological observatories

Digital maps and Geographic Information Systems (GIS) can support Disaster Risk Reduction Education (DRREC) by helping pupils visualise the spatial dimensions of risk. Through maps, satellite images, symbols, layers, and location-based data, students can explore where hazards occur, which areas may be more exposed, where safe gathering points are located, and how physical geography or land use may influence risk. GIS and Web GIS tools are particularly relevant to DRR education because they support hazard mapping, spatial reasoning, risk communication, and preparedness planning (UNDRR, 2015; Song et al., 2023; Handoyo, 2024).

In Grades 1–3, digital mapping should remain simple, visual, and teacher-guided. Pupils can use tools such as Google Earth to observe their school, neighbourhood, rivers, hills, roads, open spaces, and possible safe areas. They may mark locations with icons or colours, identify high ground in relation to flooding, recognise routes to safe gathering points, or create simple story maps connected to a hazard narrative. At this level, the emphasis is on spatial awareness, observation, vocabulary development, and basic safety understanding. Research on Google Earth and geography education indicates that digital globes can support geographical learning and spatial thinking when used with appropriate guidance (Britt, 2009; Patterson, 2007).

In Grades 4–6, pupils can use digital maps and GIS tools more analytically. They may explore earthquake locations, wildfire-prone areas, flood zones, elevation, rainfall patterns, land use, or proximity to emergency services. Platforms such as ArcGIS Online or MapHub can support the creation of simple risk maps, evacuation routes, shelter maps, or layered representations of hazard-related information. Web GIS research in DRR education indicates that online hazard maps and GIS-based learning can support students' understanding of disaster risk when connected to meaningful curriculum tasks and local risk contexts (Song et al., 2023; Handoyo, 2024).

These tools can be integrated across several subjects. In Grades 1–3, they are most suitable for Environmental Studies, Language through story-mapping, and Visual Arts through drawing, icons, and simple spatial representations. In Grades 4–6, they can support Geography, ICT, Skills Labs, Mathematics, and Environmental Studies through map reading, data interpretation, simple layer comparison, risk mapping, and preparedness planning. Digital mapping activities should always be age-appropriate, teacher-guided, and connected to clear subject objectives and DRR outcomes (Britt, 2009; Song et al., 2023; GADRRRES, 2022).

Example activity: Grade 2 pupils explore their school and neighbourhood in Google Earth, identify nearby rivers, open spaces, or higher ground, and mark possible safe gathering areas using simple colours or icons. Grade 6 pupils use ArcGIS Online or a similar mapping tool to compare rainfall, elevation, and land-use information, identify possible flood-exposure areas, and propose simple preparedness or mitigation measures for the school or local community.

5.2. Simulation Software & Apps

Examples: PhET Plate Tectonics Simulation, IRIS Earthquake Browser, MyShake App, FEMA earthquake safety activities/resources, Academo Virtual Oscilloscope or wave simulations.

Simulation software and interactive apps can support Disaster Risk Reduction Education (DRREC) by helping pupils visualise and explore dynamic natural processes that are difficult to observe directly, such as plate movement, seismic activity, wave behaviour, rainfall–runoff processes, slope instability, or building response to shaking. In science education, simulations are useful when they allow learners to observe representations, manipulate variables, compare outcomes, and connect abstract processes with visible phenomena (National Research Council, 2000; PhET Interactive Simulations, n.d.).

In Grades 1–3, simulations should be used mainly as teacher-guided visual demonstrations. Pupils may observe simple animations of shaking buildings, moving ground, waves, landslides, rainfall, or water flow, followed by discussion, drawing, movement, storytelling, or safety routines. At this level, the aim is not formal modelling, but basic observation, vocabulary development, cause-and-effect awareness, and simple procedural understanding. Earthquake safety activities for children also emphasise hands-on, guided classroom tasks that explain what happens during an earthquake and how pupils can stay safe before, during, and after shaking (FEMA, 2005).

In Grades 4–6, simulations can be used more analytically. Pupils may manipulate variables such as plate direction, slope, rainfall, ground type, wave amplitude, or structural stability and compare the results. The PhET Plate Tectonics Simulation allows users to explore how plates move and how changes in temperature, composition, and thickness relate to mountains, volcanoes, or oceans, while the IRIS Earthquake Browser supports investigation of earthquake patterns, plate boundaries, seismicity rate, and earthquake depth (PhET Interactive Simulations, n.d.; IRIS, n.d.). Such tools can support inquiry, evidence-based reasoning, and problem-solving when linked to clear curriculum objectives.

Earthquake-related apps can also be used to discuss warning systems, citizen sensing, and preparedness, but their use must be context-appropriate. The MyShake App, developed by the Berkeley Seismology Lab, provides earthquake information, damage reports, and public earthquake early warning alerts in California, Oregon, and Washington; therefore, in Greece or Cyprus it should be used as an example of earthquake early-warning technology rather than as a local warning tool (MyShake, n.d.). For local seismic activity, teachers should preferably use official national or regional seismological sources.

Simulation tools can be integrated across several subjects. In Grades 1–3, they are most suitable for Environmental Studies, Play-Based Learning, Language, Drama/Movement, and Visual Arts through observation, storytelling, drawing, and simple preparedness routines. In Grades 4–6, they can support Science, Geography, ICT, Mathematics, and Skills Labs through variable testing, data interpretation, comparison of scenarios, and discussion of preparedness or mitigation options. These uses align with DRR and school safety frameworks that emphasise risk understanding, preparedness, and resilience in education (UNDRR, 2015; GADRRRES, 2022).

Example activity: Grade 3 pupils watch a teacher-guided earthquake simulation, discuss what happens when the ground shakes, and practise “Drop, Cover, and Hold On.” Grade 5 pupils use the PhET Plate Tectonics Simulation to explore how plate movement creates mountains, trenches, volcanoes, or earthquakes, and then relate these processes to seismic activity in Greece or the Eastern Mediterranean.

5.3. AI Chatbots & Scenario Builders

Examples: ChatGPT, Curipod, Eduaide.ai, and other educator-guided AI-supported lesson or scenario-building tools.

AI chatbots and scenario-building tools can support Disaster Risk Reduction Education (DRREC) mainly as teacher-guided tools for generating, adapting, and differentiating learning materials. In this context, AI can help teachers prepare short hazard-based stories, role-play scenarios, discussion prompts, quiz questions, emergency communication tasks, and differentiated reading texts connected to pupils’ age, curriculum objectives, and local risk contexts. Such use should remain pedagogically purposeful and human-centred, with the teacher responsible for checking accuracy, appropriateness, bias, and alignment with learning goals (UNESCO, 2023; European Commission, 2022).

In Grades 1–3, AI should be used primarily by the teacher rather than independently by pupils. Teachers may use AI to create simple stories about families, animals, or classroom characters responding safely to floods, earthquakes, wildfires, heatwaves, or storms. These stories can support vocabulary development, oral discussion, role-play, emotional expression, and basic safety routines. Because young children require age-appropriate content and strong adult mediation, AI-generated materials should be carefully reviewed before classroom use and should not include personal pupil data or distressing details (UNICEF, 2021; UNESCO, 2023).

In Grades 4–6, AI-supported scenarios can be used for more structured inquiry and discussion. Pupils may work with teacher-approved scenarios involving emergency communication, civic roles, ethical decision-making, school preparedness, or community response. For example, a wildfire scenario may assign pupils roles such as mayor, firefighter, school principal, parent, journalist, engineer, or citizen, enabling them to practise argumentation, perspective-taking, decision-making, and responsible communication. Research on educational uses of generative AI highlights its potential as a simulator, coach, teammate, or learning tool, while also stressing the risks of errors, bias, overreliance, and uncritical acceptance of AI outputs (Mollick & Mollick, 2023).

AI tools can also support teachers in differentiating DRREC materials across reading levels and subject areas. A single disaster-related context can be adapted into a short story for Language, a role-play for Drama, a debate prompt for Civic Education, a quiz for Skills Lab, or a scenario for ethical reasoning. However, AI-generated material should be treated as a draft rather than authoritative content. Teachers should verify factual claims through reliable sources and guide pupils to understand that AI can support thinking, but should not replace evidence, discussion, or human judgement (UNESCO, 2023; European Commission, 2022; Mollick & Mollick, 2023).

Appropriate subject integration: In Grades 1–3, AI-supported materials can be used in Language, Drama, Play-Based Learning, and Social-Emotional Learning through teacher-created stories, role-play scripts, vocabulary tasks, and guided discussion. In Grades 4–6, they can support Language, Civic Education, Skills Lab, Social Studies, ICT, and Media Literacy through debates, scenario analysis, emergency communication, role assignment, persuasive speech, and policy-oriented discussion.

Example activity: In Grade 2, the teacher uses an AI-generated and teacher-reviewed story about a flood in a village. Pupils identify the characters, discuss safe and unsafe actions, learn key vocabulary, and act out simple response roles such as parent, teacher, or emergency responder. In Grade 6, pupils work with a teacher-approved AI-generated wildfire town-hall scenario, with roles such as mayor, firefighter, citizen, journalist, and environmental officer, to practise persuasive speech, civic decision-making, and responsible emergency communication.

5.4. AI for Content Creation

Examples: Canva with Magic Write / Magic Studio, Microsoft Designer, Pictory.

AI-supported content creation tools can support Disaster Risk Reduction Education (DRREC) by helping teachers and pupils transform risk-related understanding into visual, written, and multimedia communication products. These tools can be used to create safety posters, flashcards, infographics, short videos, brochures, digital presentations, or public-awareness messages about hazards, preparedness, safe behaviour, and community resilience. Their educational value lies not in automated production itself, but in supporting communication, creativity, digital storytelling, and reflection on how risk information can be presented clearly and responsibly (UNESCO, 2023; European Commission, 2022).

In Grades 1–3, AI-supported design tools should be used mainly under teacher guidance. Pupils may contribute drawings, key words, icons, slogans, or oral ideas, while the teacher supports the creation of simple flashcards, illustrated safety posters, or class presentations on topics such as “Three things to do during an earthquake” or “Safe and unsafe actions during a flood.” At this level, the emphasis should remain on vocabulary, visual recognition, basic safety messages, and emotionally safe learning rather than independent AI use. This is consistent with child-centred and age-appropriate approaches to AI and digital technologies in education (UNICEF, 2021; UNESCO, 2023).

In Grades 4–6, pupils can use AI-supported tools more actively, but still with clear teacher supervision. They may work in teams to create infographics, animated public service announcements, brochures, digital posters, or short awareness videos for classmates, families, or the school community. Canva's Magic Studio can support writing and design tasks, Microsoft Designer can support AI-assisted graphic design, and Pictory can help convert scripts or prompts into video content. However, all AI-generated text, images, and videos should be reviewed for factual accuracy, age appropriateness, bias, copyright issues, and alignment with DRR learning goals (Canva, n.d.; Microsoft, n.d.; Pictory, n.d.; UNESCO, 2023).

These tools can be integrated across several subjects. In Grades 1–3, they are most suitable for Visual Arts, Language, Skills Lab, and Play-Based Learning through simple posters, illustrated messages, vocabulary cards, and class presentations. In Grades 4–6, they can support ICT, Art and Design, Language, STEM, Entrepreneurship, and Skills Lab through digital storytelling, media literacy, awareness campaigns, persuasive communication, and collaborative production. Such activities should help pupils understand that effective DRR communication requires accuracy, clarity, empathy, and responsibility, especially when messages are intended for peers, families, or the wider community (European Commission, 2022; UNESCO, 2023).

Example activity: Grade 1 pupils contribute drawings and short phrases for a teacher-guided Canva poster titled "Three Things to Do in an Earthquake." Grade 5 pupils work in teams to create a short video public service announcement on flood preparedness, using teacher-approved scripts, AI-supported visuals, and a final class discussion on whether the message is accurate, clear, ethical, and useful for the school community.

5.5. Electronic Games

Examples: *Stop Disasters* by UNDRR, Minecraft Education climate-resilience activities such as *Climate Warriors* and *Heat Wave Survival*, and simplified teacher-guided classroom or board games.

Electronic games and serious games can support Disaster Risk Reduction Education (DRREC) by creating interactive environments in which pupils explore hazards, make decisions, test preparedness strategies, and reflect on consequences. Their value lies not simply in play, but in structured learning through decision-making, feedback, collaboration, and post-game reflection. In DRR education, such tools should be linked to clear learning objectives and guided by the teacher so that pupils connect game actions with real-world concepts such as exposure, vulnerability, preparedness, mitigation, and community resilience (UNDRR, 2015; GADRRRES, 2022).

In Grades 1–3, game-based DRREC activities should remain simple, guided, and emotionally safe. At this level, teacher-led board games, matching games, sorting tasks, movement games, role-play, or simplified digital activities are more appropriate than complex online simulations. Pupils may identify safe and unsafe actions, practise basic evacuation routines, match emergency helpers with their roles, or act out simple preparedness scenarios. The focus should be on vocabulary, cooperation, safety routines, and basic preparedness rather than strategic resource management (UNICEF & LEGO Foundation, 2018; GADRRRES, 2022).

In Grades 4–6, electronic games can be used more analytically. *Stop Disasters* places learners in the role of a community planner who must reduce the impact of hazards such as floods, earthquakes, wildfires, hurricanes, or tsunamis by making decisions about housing, infrastructure, early warning, evacuation planning, education, time, and budget. This makes it suitable for discussing prevention, mitigation, resource allocation, trade-offs, and consequences in an age-appropriate way for upper primary pupils (UNDRR, 2025). Minecraft Education activities, such as *Climate Warriors* or *Heat Wave Survival*, can also support collaborative design, spatial reasoning, and climate-resilience learning when they are connected to curriculum goals and followed by discussion or reflection (Minecraft Education, 2025; UNDRR, 2024).

These games can be integrated across several subjects. In Grades 1–3, they are most suitable for Play-Based Learning, Skills Lab, Language, Drama/Movement, and Visual Arts through simple safety games, role-play, and story-based activities. In Grades 4–6, they can support STEM, Geography, ICT, Civic Education, Mathematics, and Skills Lab through scenario analysis, map-based decision-making, resource management, cost-benefit discussion, and reflection on community preparedness. The teacher's role is essential in framing the game, clarifying the DRR concepts, and helping pupils transfer learning from the game environment to their school or local community.

Example activity: Grade 3 pupils play a simplified flood-preparedness board game with roles such as rescuer, planner, family member, or teacher, sorting actions into "safe" and "unsafe" categories. Grade 6 pupils use *Stop Disasters* to plan a coastal town and reduce tsunami or flood risk, then discuss which decisions were effective, which trade-offs were difficult, and how similar principles could apply to their school or community.

5.6. Augmented and Virtual Reality (AR/VR)

Examples: CoSpaces Edu, 360Cities / 360schools, Google Arts & Culture 360° tours, archived Google Expeditions materials where available.

Augmented and Virtual Reality tools can support Disaster Risk Reduction Education (DRREC) by helping pupils visualise places, environments, and spatial relationships that are difficult to experience directly in the classroom. In DRR education, AR/VR should be used as a guided pedagogical tool for observation, discussion, spatial awareness, and scenario-based learning, rather than as a substitute for real emergency drills or teacher-led preparedness activities. Recent research on VR-based disaster preparedness education shows that immersive environments are increasingly used to support disaster scenarios, preparedness learning, and experiential training, although careful instructional design remains essential (Kimura et al., 2024).

In Grades 1–3, AR/VR activities should be short, simple, teacher-guided, and emotionally safe. Pupils may explore a virtual classroom after a storm, identify safe and unsafe objects, recognise shelter areas, or discuss what to avoid during a hazard. At this level, the aim is not detailed disaster simulation, but basic visual recognition, vocabulary development, emotional safety, and simple protective behaviour. Immersive or 360° environments should therefore be used with clear guidance and followed by drawing, storytelling, movement, or discussion.

In Grades 4–6, pupils can use AR/VR tools more analytically. With platforms such as CoSpaces Edu, they may build simple 3D models of their classroom, school, or neighbourhood and represent evacuation routes, safe gathering points, risk zones, or community shelters. CoSpaces Edu supports student-created 3D, AR, and VR environments, which can be animated or coded, making it suitable for STEAME-based design and problem-solving activities when supervised by the teacher. Similarly, 360° platforms such as 360Cities / 360schools can support guided virtual exploration of places, landscapes, or built environments relevant to geography, environmental studies, and risk awareness.

These tools can be integrated across several subjects. In Grades 1–3, they are most appropriate for Visual Arts, Environmental Studies, Drama/Movement, Language, and Social-Emotional Learning through guided observation, storytelling, drawing, and discussion of safe behaviour. In Grades 4–6, they can support Geography, Science, ICT, Skills Labs, Design, and Civic Education through virtual mapping, scenario design, modelling of evacuation paths, analysis of terrain, and discussion of how layout, elevation, shelter, slope, and proximity influence safety.

The use of AR/VR in DRREC should follow clear safety and pedagogical principles. Activities should be age-appropriate, time-limited, supervised, and followed by reflection. Teachers should avoid distressing or graphic disaster imagery, especially with younger pupils, and should ensure that immersive experiences are connected to explicit curriculum and DRR objectives. Google Expeditions may be mentioned only as an archived or discontinued tool, since Google officially deactivated Expeditions and Tour Creator in 2021; where possible, teachers should use currently available alternatives such as Google Arts & Culture, CoSpaces Edu, 360Cities / 360schools, or other school-approved platforms.

Example activity: Grade 2 pupils explore a teacher-selected virtual classroom or school scene after a storm and discuss which objects or areas are safe or unsafe. Grade 6 pupils use CoSpaces Edu to build a simple VR model of their school or neighbourhood, mark evacuation paths and risk zones, and explain how their design supports safer movement during an emergency.

6. CONCLUSIONS

This report has presented a structured set of methodological guidelines to support the design and implementation of Disaster Risk Reduction Education (DRREC) activities within elementary school curriculum-content instruction, particularly in the educational contexts of Greece and Cyprus. Recognising the increasing importance of resilience education in relation to climate change, natural hazards, preparedness, and community safety, the proposed framework emphasises pedagogical adaptability, curricular alignment, age appropriateness, and practical classroom relevance.

A central contribution of the report is that it positions DRREC not as an external, occasional, or supplementary topic, but as an integral dimension of everyday teaching. Through the interdisciplinary STEAME framework, DRR themes can be connected with subject-specific learning outcomes across areas such as Environmental Studies, Geography, Science, Language and Literacy, Mathematics, Visual Arts, Technology, ICT, Skills Labs, Drama, and civic-oriented learning. This curriculum-aligned approach allows teachers to address mandated learning objectives while also developing pupils' risk awareness, preparedness, collaboration, communication, problem-solving, and civic responsibility.

The methodological framework developed in the report draws on research-based pedagogical approaches that support active, experiential, inquiry-driven, and collaborative learning. These include Project-Based Learning, Context-Based Learning, storytelling, Inquiry-Based Learning, Design Thinking, simulation and role-playing, and Game-Based Learning. These approaches are complemented by supporting strategies such as peer teaching, scenario analysis, systems thinking, visual thinking strategies, and citizen science, as well as holistic and cross-curricular approaches including environmental literacy, media and digital literacy, creative expression, mindfulness, and social-emotional learning. Together, they provide educators with a flexible pedagogical repertoire for helping pupils engage with real-world risk scenarios in meaningful and developmentally appropriate ways.

The report also proposes a Context-Based Pedagogical Integration Model for STEAME-DRREC, in which a natural hazard context functions as the pedagogical canvas for lesson design. Within this model, the "pedagogy of the context" refers to the methods, techniques, and approaches used to transform that context into curriculum-connected learning activities. This enables teachers to link natural hazards such as earthquakes, floods, wildfires, heatwaves, storms, erosion, or air pollution with the objectives and content of different school subjects. In this way, pupils are supported in understanding disaster risk not only as a scientific or environmental issue, but also as a social, ethical, emotional, technological, and civic concern.

The curriculum integration guidelines demonstrate how DRREC can be progressively adapted across elementary grade levels. In Grades 1–3, the emphasis is placed on concrete, experiential, emotionally safe, and age-appropriate activities that build basic hazard vocabulary, safety routines, cooperation, and early preparedness. In Grades 4–6, the focus expands toward inquiry, data interpretation, scenario analysis, systems thinking, digital literacy, ethical reflection, civic responsibility, and collaborative problem-solving. This progression enables pupils to revisit natural hazard themes with increasing depth and complexity as they move through primary education.

In addition, the report highlights the role of digital, technological, and AI-supported tools in strengthening DRREC implementation. Digital maps and GIS tools, simulations, AI chatbots and scenario builders, AI-assisted content creation tools, electronic games, and AR/VR environments can support visualisation, modelling, communication, creativity, collaboration, and preparedness. However, these tools are presented as pedagogical resources rather than ends in themselves. Their use should be selective, ethical, age-appropriate, teacher-guided, and clearly aligned with curriculum objectives and DRR learning outcomes.

Overall, the guidelines presented in this report provide educators with both the pedagogical tools and the curricular pathways needed to integrate DRREC into elementary education in a coherent, engaging, and sustainable way. By embedding DRR into everyday learning, the report supports the development of pupils' risk literacy, scientific reasoning, digital competence, creativity, empathy, emotional awareness, civic responsibility, and preparedness. In this way, the STEAME-DRREC framework contributes to the broader goal of fostering a culture of safety, sustainability, and resilience, beginning in the classroom and extending to the wider school and community environment.

REFERENCES

Agustina, E., & Salamah, A. (2023). Strengthening disaster preparedness through design thinking: An interdisciplinary project-based approach in high school education. *Journal of Disaster Education and Innovation, 5*(2), 113–129.

Akyildiz, S. T., & Sensoy, O. (2020). The effectiveness of inquiry-based learning for disaster education in primary schools. *International Journal of Disaster Risk Reduction, 46*, 101533. https://doi.org/10.1016/j.ijdrr.2020.101533

Alharthi, T., & Alghamdi, S. (2023). Teaching earthquake preparedness through a game-based hybrid model: Evidence from Saudi middle schools. *Journal of Educational Technology & Society, 26*(1), 75–89.

Anindhita, W., Samadi, R., Rahmawati, D., & Ramadhoan A'rachman, F. (2025). Needs analysis of digital media-based disaster mitigation education for Gen Z: A case study from Indonesia. *International Journal of Disaster Risk Education, 5*, 112–130.

Anindhita, W., Samadi, Rahmawati, D., & A'rachman, F. R. (2024). Needs analysis of digital media-based disaster mitigation education for Gen Z. *Journal of Sustainability Education*.

Anindhita, W., Samadi, S., Rahmawati, D., & Ramadhoan A'rachman, F. (2024). Needs analysis of digital media-based disaster mitigation education for Gen Z. *Journal of Science and Education (JSE), 5*(1), 264–273. https://doi.org/10.58905/jse.v5i1.424

Arga Triyandana, I., Ibrohim, I., Yanuwiyadi, B., Amind, M., & Hajare, M. U. (2024). Strategies for integrating a green curriculum into elementary science education to promote environmental awareness. *Journal of Environmental Education, 12*(1), 45–60.

Asad, M., Saleem, M., & Malik, A. (2023). Gamifying disaster risk reduction: A systematic review of educational disaster games. *International Journal of Disaster Risk Reduction, 89*, 103441. https://doi.org/10.1016/j.ijdrr.2023.103441

Austrian Red Cross (2023). *Disaster Education Initiatives in Austrian Schools: Building Risk Awareness through Inquiry*. Vienna: ARC Publications.

Ba, R., Deng, Q., Liu, Y., Yang, R., & Zhang, H. (2021). Multi-hazard disaster scenario method and emergency management for urban resilience by integrating experiment–simulation–field data. *Journal of Safety Science and Resilience, 2*(2), 77–89.

Ballard, H. L., Lindell, A. J., & Jadallah, C. C. (2024). Environmental education outcomes of community and citizen science: A systematic review of empirical research. *Environmental Education Research, 30*(6), 1007–1040.

Bangay, C., & Griffiths, M. (2021). Education for climate action: A framework for context-based learning. *International Review of Education, 67*(1), 1–22. https://doi.org/10.1007/s11159-021-09879-6

Barrett, E., & Notario, C. (2021). Learning through stories: Disaster risk education in early childhood settings. *Early Years, 41*(3), 215–230. https://doi.org/10.1080/09575146.2020.1813183

BBK – Bundesamt für Bevölkerungsschutz und Katastrophenhilfe. (2023). *Katastrophenschutz macht Schule: Materialien für die Grundschule*. https://www.bbk.bund.de

Bell, S. (2010). Project-based learning for the 21st century: Skills for the future. *The Clearing House, 83*(2), 39–43. https://doi.org/10.1080/00098650903505415

Bennett, J., Lubben, F., & Hogarth, S. (2007). Bringing science to life: A synthesis of the research evidence on the effects of context-based and STS approaches to science teaching. *Science Education, 91*(3), 347–370.

Bernal, A. E., & Apdohan, J. R. D. (2023). Environmental and disaster risk reduction literacy among senior high school students in Sibagat, Agusan del Sur. *International Journal for Disaster and Development Interface, 3*(2), 1–16.

BMZ – German Federal Ministry for Economic Cooperation and Development. (2022). *Integrating Climate and Disaster Education through Project-Based Learning*. Bonn: BMZ Reports.

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., & Shirk, J. (2009). Citizen science: A developing tool for expanding science knowledge and scientific literacy. *BioScience, 59*(11), 977–984.

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., & Shirk, J. (2009). Citizen science: A developing tool for expanding science knowledge and scientific literacy. *BioScience, 59*(11), 977–984. https://doi.org/10.1525/bio.2009.59.11.9

Bonney, R., et al. (2024). Environmental education outcomes of community and citizen science: A systematic review. *Environmental Education Research, 30*(6), 1007–1040.

Boone, W. J., Rizzo, S. A., & Palardy, J. M. (2020). Learning science through simulation: A meta-analytic review. *International Journal of Science Education, 42*(6), 865–887. https://doi.org/10.1080/09500693.2020.1730074

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32–42.

Bruin, W. B. de, Morgan, M. G., Kuhn, K. M., & Gibson, J. M. (2020). Promoting climate change engagement through informed risk perceptions: A review of how interventions can reduce bias. *Sustainability, 12*(6), 2338.

Bruner, J. (1990). *Acts of meaning*. Harvard University Press.

Bruner, J. (1991). The narrative construction of reality. *Critical Inquiry, 18*(1), 1–21.

Bubeck, P., Pham, T. D. M., Nguyen, T. N. A., & Hudson, P. (2024). Disaster risk reduction on stage: An empirical evaluation of community-based theatre as risk communication tool for coastal risk mitigation and ecosystem-based adaptation. *Progress in Disaster Science, 22*, 100323.

Canva. *How to use Magic Studio safely and legally*. Canva.

CASEL (2020). *CASEL's SEL framework: What are the core competence areas and where are they promoted?* Collaborative for Academic, Social, and Emotional Learning.

Clements, T. P., Houchins, M. A., & Stains, M. (2022). "It made me feel like a bigger part of the STEM community": Incorporation of learning assistants enhances students' sense of belonging in a large introductory biology course. *CBE—Life Sciences Education, 21*(2), ar26.

CoSpaces Edu. *CoSpaces Edu: AR and VR creation for education*. Delightex.

Cradock-Henry, N. A., Blackett, P., Hall, M., Johnstone, P., Teixeira, E., & Wreford, A. (2020). Elaborating a systems methodology for cascading climate change impacts and implications. *MethodsX, 7*, 100893.

Cradock-Henry, N. A., Connolly, J., Blackett, P., & Lawrence, J. (2020). Elaborating a systems methodology for cascading climate change impacts and implications. *MethodsX, 7*, 100893.

Dewey, J. (1938). *Experience and Education*. Macmillan.

Donnelly, J. P., & Lamb, R. (2020). A context-based disaster education model for early primary learners. *Disaster Prevention and Management, 29*(4), 619–635. https://doi.org/10.1108/DPM-06-2019-0180

Ebersöhn, L., Loots, T., Eloff, I., & Ferreira, R. (2022). Storytelling as pedagogy for resilience in disaster risk reduction education. *International Journal of Educational Research Open, 3*, 100194. https://doi.org/10.1016/j.ijedro.2022.100194

Egan, K. (1986). *Teaching as story telling: An alternative approach to teaching and curriculum in the elementary school*. University of Chicago Press.

EiE Hub. (2022). *Education in emergencies, mental health and psychosocial support: Social and emotional learning*. Education in Emergencies Hub.

European Commission. (2022). *Ethical guidelines on the use of artificial intelligence and data in teaching and learning for educators*. Publications Office of the European Union.

European Commission/Eurydice. (2026). *Teaching and learning in primary education: Cyprus*. Eurydice Network.

Fabre, R. P., & Nabua, E. B. (2025). Learners' engagement in disaster readiness and risk reduction using STEM-based learning activities. *International Journal of Research in Innovative Social Sciences, 9*(1), 3575–3583.

FEMA (2023). *Student Tools for Emergency Planning (STEP)*. https://www.ready.gov/kids/step

FEMA. (2005). *Earthquake Safety Activities for Children and Teachers* (FEMA 527). Federal Emergency Management Agency.

Feng, Y., González, M. C., & Sester, M. (2018). Agent-based modeling of human behavior during emergency evacuations: A systematic literature review. *Safety Science, 110*, 223–234. https://doi.org/10.1016/j.ssci.2018.07.002

Fleer, M., & Ridgeway, A. (2022). Storying disaster: Vygotsky-inspired pedagogies for environmental risk education. In *Cultural-Historical Approaches to STEM Learning* (pp. 137–155). Springer. https://doi.org/10.1007/978-3-030-88664-4

Fraisl, D., See, L., Campbell, J., Danielsen, F., & Andrianandrasana, H. T. (2023). The contributions of citizen science to the United Nations Sustainable Development Goals. *Citizen Science: Theory and Practice, 8*(1), Article 27.

Fraisl, D., See, L., Estevez, D., Tomaska, N., & MacFeely, S. (2023). Citizen science for monitoring the health and well-being related Sustainable Development Goals and the World Health Organization's Triple Billion Targets. *Frontiers in Public Health, 11*, 1202188.

Fulambarkar, N., Seo, B., Testerman, A., Rees, M., Bausback, K., & Bunge, E. (2023). Review: Meta-analysis on mindfulness-based interventions for adolescents' stress, depression, and anxiety in school settings: A cautionary tale. *Child and Adolescent Mental Health, 28*(2), 307–317.

GADRRRES. (2022). *Comprehensive School Safety Framework 2022–2030 for Child Rights and Resilience in the Education Sector*. Global Alliance for Disaster Risk Reduction and Resilience in the Education Sector.

Gilbert, J. K. (2006). On the nature of "context" in chemical education. *International Journal of Science Education, 28*(9), 957–976.

Google. (2021). *Expeditions and Tour Creator are no longer available*. Google VR.

Gudmundsson, H., Sigurdardottir, G., & Gísladóttir, G. (2021). Integrating volcanic risk education in Icelandic schools: A simulation-based approach. *Journal of Risk Research, 24*(4), 456–472. https://doi.org/10.1080/13669877.2020.1789332

Harvey, P. (1996). Rehabilitation in complex political emergencies: Is rebuilding civil society the answer? *Disasters, 20*(1), 10–23. https://doi.org/10.1111/j.1467-7717.1996.tb00303.x

Hellenic Pedagogical Institute. (2003). *A Cross-Thematic Curriculum Framework for Compulsory Education*. Greek Ministry of Education.

Hicks, A., Barclay, J., Chilvers, J., Armijos, M. T., Oven, K., Simmons, P., & Haklay, M. (2019). Global mapping of citizen science projects for disaster risk reduction. *Frontiers in Earth Science, 7*, 226.

Hilberts, S., Evers, S., Govers, M., & Ghattas, J. (2025). The impact of misinformation on social media in the context of natural disasters: Narrative review. *JMIR Infodemiology, 5*, e70413.

Hilberts, S., Govers, M., Petelos, E., & Evers, S. (2025). The impact of misinformation on social media in the context of natural disasters: Narrative review. *JMIR Infodemiology, 5*, e70413. https://doi.org/10.2196/70413

Hmelo-Silver, C. E. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16*(3), 235–266.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning. *Educational Psychologist, 42*(2), 99–107.

IRIS. *IRIS Earthquake Browser*. Incorporated Research Institutions for Seismology.

ISPRA. (2021). *Progetto Scuole Resilienti in Liguria*. Istituto Superiore per la Protezione e la Ricerca Ambientale.

Italian Civil Protection. (2023). *Io Non Rischio Scuola Program*. https://iononrischio.protezionecivile.it

Johnson, D. W., & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher, 38*(5), 365–379.

Jonassen, D. H. (1999). Designing constructivist learning environments. In C. M. Reigeluth (Ed.), *Instructional-design theories and models: A new paradigm of instructional theory* (Vol. 2, pp. 215–239). Lawrence Erlbaum Associates.

Junta de Andalucía. (2022). *Plan de Autoprotección Escolar: Evaluación de Simulacros Sísmicos*. Consejería de Desarrollo Educativo y Formación Profesional.

Kargillis, C., Beim, M., & McLean, L. (2014). Telling stories about disaster: Making sense of emergency recovery in community development. *Community Development Journal, 49*(2), 180–195. https://doi.org/10.1093/cdj/bst031

Kimura, R., et al. (2024). Scoping review of virtual reality (VR)-based disaster preparedness education. *Prehospital and Disaster Medicine*.

Kitagawa, K. (2021). Disaster risk reduction activities as learning. *Natural Hazards, 105*, 3099–3118.

Kolb, D. A. (1984). *Experiential Learning: Experience as the Source of Learning and Development*. Prentice Hall.

Krajcik, J. S., & Blumenfeld, P. C. (2006). Project-based learning. In R. K. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences* (pp. 317–334). Cambridge University Press.

Krajcik, J., Codere, S., Dahsah, C., Davis, E. A., & Dentzau, M. W. (2021). Designing learning environments to promote deep understanding in science. In J. D. Bransford (Ed.), *How Students Learn: Science in the Classroom* (pp. 213–271). National Academies Press.

Larsson, J., Falk, A., & Rydell, M. (2022). Project-based disaster education in Swedish schools: Outcomes and lessons. *International Journal of Educational Development, 91*, 102567. https://doi.org/10.1016/j.ijedudev.2022.102567

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge University Press.

Maddatuang, M., Bahri, A., & Tabbu, M. A. S. (2025). The impact of digital literacy and disaster mitigation understanding on computational and spatial thinking ability in upper secondary school students. *Journal of Baltic Science Education, 24*(2), 312–325.

Masocha, W., Takaidza, N., Manyani, A., & Mutseekwa, C. (2025). Disaster risk reduction integration into school curriculum: A global analysis. *European Journal of Sustainable Development Research, 9*(1), em0276.

Meador, A., Lockwood, P., Subburaj, V., & Subburaj, A. (2024). Examining the effects of peer-led team learning as a support for community college transfer students' STEM achievement. *Education Sciences, 14*(9), 945.

Merrill, M. D. (2002). First principles of instruction. *Educational Technology Research and Development, 50*(3), 43–59.

Microsoft. *Microsoft Designer*. Microsoft.

Milara, I. S., & Orduña, M. C. (2024). Possibilities and challenges of STEAM pedagogies. *arXiv preprint arXiv:2408.15282*.

Minecraft Education. (2025). *Climate Warriors*. Microsoft.

Mollick, E. R., & Mollick, L. (2023). Assigning AI: Seven approaches for students, with prompts. *arXiv*. https://doi.org/10.48550/arXiv.2306.10052

Mutch, C., & Tatebe, J. (2021). Developing disaster-resilient communities through school-based projects: Lessons from Aotearoa New Zealand. *International Journal of Disaster Risk Reduction, 64*, 102509. https://doi.org/10.1016/j.ijdrr.2021.102509

MyShake. (n.d.). *MyShake App*. Berkeley Seismology Lab, University of California, Berkeley.

Nadelson, L. S., & Seifert, A. (2022). Inquiry-based learning in K-12 STEM education: A review of empirical research. *Journal of STEM Education Research, 5*(1), 35–52. https://doi.org/10.1007/s41979-021-00059-7

National Research Council. (2000). *How People Learn: Brain, Mind, Experience, and School: Expanded Edition*. National Academy Press. https://doi.org/10.17226/9853

Nurwidodo, N., Amin, M., Ibrohim, I., & Sueb, S. (2020). The role of Eco-School Program (Adiwiyata) towards environmental literacy of high school students. *European Journal of Educational Research, 9*(3), 1089–1103.

ODI. (2019). *How the arts and sciences can work together to improve disaster risk reduction*. Overseas Development Institute.

OECD. (2023). *OECD Digital Education Outlook 2023: Towards an Effective Digital Education Ecosystem*. OECD Publishing. https://doi.org/10.1787/c74f03de-en

Opabola, E. A., & Galasso, C. (2024). Informing disaster-risk management policies for education infrastructure using scenario-based recovery analyses. *Nature Communications, 15*, 217.

Paladino, L., Enrici, A., & Ricchiardi, P. (2020). Narrative as a tool for disaster education: A case study in Italian primary schools. *International Journal of Disaster Risk Reduction, 47*, 101541. https://doi.org/10.1016/j.ijdrr.2020.101541

Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A., Kamp, E. T., ... & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review, 14*, 47–61. https://doi.org/10.1016/j.edurev.2015.02.003

PhET Interactive Simulations. (n.d.). *Plate Tectonics*. University of Colorado Boulder.

Pictory. *AI video generator*. Pictory.

Poudel, N., Dixit, A. M., Pamaong, M. T., Ryan, L. S. Y., Takane, S., Ariyaningsih, & Shaw, R. (2025). Analysis of citizen science program for disaster risk reduction in Japan: The case of Safecast. *Journal of Disaster Science and Management, 1*, Article 7.

Purwaningsih, S., Handayani, R., & Mulyana, A. (2023). Enhancing students' flood preparedness through design thinking-based disaster education. *International Journal of Environmental and Science Education, 18*(4), 247–262.

Rajabi, A., Shirani-Bidabadi, N., & Rouhani, S. (2022). Serious games and immersive technologies in disaster education: A review. *Education and Information Technologies, 27*(3), 3899–3924. https://doi.org/10.1007/s10639-021-10824-2

Riddell, G. A., van Delden, H., Maier, H. R., & Zecchin, A. C. (2019). Exploratory scenario analysis for disaster risk reduction: Considering alternative pathways in disaster risk assessment. *International Journal of Disaster Risk Reduction, 39*, 101230.

Scorgie, D., et al. (2024). Virtual reality for safety training: A systematic literature review. *Safety Science*.

Semmens, K. A., Carr, R. H., Maxfield, K., & Sickler, J. (2023). CREATE Resilience through science, art, and community engagement. *Community Science, 2*(3), e2023CSJ000028.

Sevilla, E, Jarrín, MJ, Barragán, K, Jáuregui, P, Sabag, C, Dupeyron, A, Barclay, J, Armijos, T, Cupuerán, MI, Zapata, C, Vásquez, MA & Narváez, P 2023, 'Envisioning the future by learning from the past: Arts and humanities in interdisciplinary tools for promoting a culture of risk', International Journal of Disaster Risk Reduction, vol. 92, 103712. https://doi.org/10.1016/j.ijdrr.2023.103712RESEA

Sevilla, E., López, J. L., Vásconez, F., Armijos, M. T., & Barclay, J. (2023). Envisioning the future by learning from the past: Arts and humanities in interdisciplinary tools for promoting a culture of risk. *International Journal of Disaster Risk Reduction, 95*, 103856.

Shanbrom, C., Norris, M., Esgana, C., Krauel, M., Pigno, V., & Lundmark, J. (2023). Assessing student success in a Peer Assisted Learning program using propensity score matching. *Journal of College Science Teaching, 52*(7), 129–136. https://doi.org/10.1080/0047231X.2023.12315888

Shaw, R., Takeuchi, Y., & Kobayashi, M. (2019). *BOSAI: Building Disaster Resilient Societies through Education and Science*. Kyoto: Kyoto University Press.

Sillmann, J., Christensen, I., Hochrainer-Stigler, S., Huang-Lachmann, J., Juhola, S., Kornhuber, K., Mahecha, M. D., Mechler, R., Reichstein, M., Ruane, A. C., Schweizer, P.-J., & Williams, S. (2022). *ISC-UNDRR-RISK KAN briefing note on systemic risk*. International Science Council. https://doi.org/10.24948/2022.01

Sterman, J. D. (2000). *Business Dynamics: Systems Thinking and Modeling for a Complex World*. McGraw-Hill.

Stewart, I. S. (2024). Advancing disaster risk communications. *Earth-Science Reviews, 249*, 104677.

Strong, K., Carpenter, O., & Ralph, D. (2020). *Scenario best practices: Developing scenarios for disaster risk reduction*. Cambridge Centre for Risk Studies, University of Cambridge Judge Business School and Lighthill Risk Network.

Sutarto, A. P., Wibowo, M. E., & Jannah, R. (2024). Enhancing disaster awareness in students using game-based learning approaches: A quasi-experimental study. *Asian Journal of Education and e-Learning, 12*(2), 101–117.

Thomas, J. W. (2000). *A Review of Research on Project-Based Learning*. The Autodesk Foundation.

Triyandana, A., Ibrohim, I., Yanuwiyadi, B., Amin, M., & Hajar, M. U. (2025). Strategies to enhance eco-friendly culture and environmental awareness by green curriculum integration in Indonesian elementary science classroom. *International Electronic Journal of Elementary Education, 17*(1), 217–231.

Tsai, M.-H., Chang, Y.-L., Shiau, J.-S., & Wang, S.-M. (2020). Exploring the effects of a serious game-based learning package for disaster prevention education: The case of Battle of Flooding Protection. *International Journal of Disaster Risk Reduction, 43*, 101393.

Twomlow, A., Grainger, S., Cieslik, K., Paul, J. D., Buytaert, W., & Howarth, C. (2022). A user-centred design framework for disaster risk visualisation. *International Journal of Disaster Risk Reduction, 77*, 103067.

Tyas, R. A., Wilujeng, I., Rosana, D., Kuswanto, H., & Purwasih, D. (2025). A review of disaster risk reduction education implementation: Integration, trends, and trajectories. *Social Sciences & Humanities Open*, 102015. https://doi.org/10.1016/j.ssaho.2025.102015

Tyas, R. A., Wilujeng, I., Suyanta, S., & Purwasih, D. (2025). A review of disaster risk reduction education implementation: Integration, trends, and trajectories. *Social Sciences & Humanities Open, 12*, 101828.

UNDRR. (2015). *Sendai Framework for Disaster Risk Reduction 2015–2030*. United Nations Office for Disaster Risk Reduction.

UNDRR. (2020). *Comprehensive School Safety Framework 2020–2030*. United Nations Office for Disaster Risk Reduction. https://www.undrr.org/publication/comprehensive-school-safety-framework-2020-2030

UNDRR. (2022). *Comprehensive School Safety Framework 2022–2030*. United Nations Office for Disaster Risk Reduction.

UNDRR. (2024). *Extreme Heat Series for Minecraft Education*. United Nations Office for Disaster Risk Reduction.

UNDRR. (2025). *Stop Disasters Game*. United Nations Office for Disaster Risk Reduction.

UNESCO. (2020). *Guidelines for Strengthening Resilience through Education*. Paris: UNESCO Publishing. https://unesdoc.unesco.org

UNESCO. (2023). *Education for Sustainable Development country profile: Cyprus*. UNESCO.

UNESCO. (2023b). *Guidance for Generative AI in Education and Research*. UNESCO.

UNICEF. (2021). *Policy guidance on AI for children*. UNICEF Office of Global Insight and Policy.

UNICEF & LEGO Foundation. (2018). *Learning through Play: Strengthening Learning through Play in Early Childhood Education Programmes*. UNICEF.

Vygotsky, L. S. (1978). *Mind in Society: The Development of Higher Psychological Processes*. Harvard University Press.

Weibell, C. J. (2011). *Principles of Learning: A Conceptual Framework for Domain-Specific Theories of Learning*. [Doctoral dissertation, Brigham Young University].

Wilson, S. B., & Varma-Nelson, P. (2016). Small groups, significant impact: A review of peer-led team learning research with implications for STEM education researchers and faculty. *Journal of Chemical Education, 93*(10), 1686–1702.

Wolff, E. (2021). The promise of a “people-centred” approach to floods: Types of participation in the global literature of citizen science and community-based flood risk reduction in the context of the Sendai Framework. *Progress in Disaster Science, 10*, 100171.

Wolff, E., French, M., Ilhamsyah, N., Sawailau, M. J., & Ramirez-Lovering, D. (2021). Collaborating with communities: Citizen science flood monitoring in urban informal settlements. *arXiv preprint arXiv:2109.10088*.

Yenawine, P. (2013). *Visual Thinking Strategies: Using Art to Deepen Learning Across School Disciplines*. Harvard Education Press.

360Cities / 360schools. (n.d.). *Immersive 360° / VR for teachers and students*. 360Cities.