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Research Article

Stop Disasters Game as a Tool for Teaching Resilience within Geography Education in Uncertain Times

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Abstract: As climate extremes intensify and disaster risks escalate, geography education faces critical imperatives to equip students with capacities for navigating uncertainty. This study examines the pedagogical potential and limitations of digital serious games for teaching disaster risk reduction, focusing on preservice geography teachers' perceptions of the *Stop Disasters* game, a browser-based simulation developed by the United Nations Office for Disaster Risk Reduction. Employing an exploratory mixed-methods design, the study analysed game experience reports from preservice geography teachers in Germany who engaged with five hazard scenarios (tsunami, hurricane, earthquake, wildfire, flood). The study involved 14 preservice teachers (n = 14). Quantitative findings indicate moderate to high engagement (M = 3.79) and strong recognition of the game's value for teaching preparedness concepts (M = 4.00). However, participants expressed substantial concerns regarding realism (M = 2.57), capacity to challenge assumptions (M = 2.36), and relevance to regional contexts (M = 2.43). Qualitative thematic analysis identified four key dimensions: learning outcomes emphasising preparedness imperatives but limited hazard mechanism understanding; pedagogical affordances including experiential engagement and systems thinking opportunities; implementation challenges encompassing oversimplification, technology barriers, and curriculum constraints; and recommendations for enhanced realism, instructional scaffolding, and contextual adaptation. Findings position serious games as valuable adjunct tools within broader pedagogical approaches rather than comprehensive solutions, and they require substantial scaffolding to support powerful geographical knowledge development. The study contributes to digitalisation debates in geography education by empirically demonstrating how preservice teachers critically evaluate educational technologies against standards of powerful knowledge necessary for teaching resilience in uncertain times.

Keywords: geography education; serious games; resilience; digital pedagogy; powerful knowledge; pre-service teachers

Highlights:

- Preservice teachers view the *Stop Disasters* game as engaging but epistemically limited.
- *Stop Disasters* teaches preparedness but lacks depth in geographical thinking.
- *Stop Disasters'* low realism ratings highlight epistemic problems of oversimplification.
- Effective game use for powerful geographical knowledge depends on teacher scaffolding and guided reflection.

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1. Introduction

The education of future geographers currently takes place against the backdrop of the Anthropocene, which is the current geological epoch defined by the unprecedented scale of human influence on Earth's systems (Waters et al., 2016). Currently, accelerating environmental disruption, escalating geopolitical tensions, and the rapid reorganisation of spatial knowledge through digital technologies are fundamentally reshaping the conditions under which geographical understanding is produced and applied. Amid this confluence of pressures and uncertainties, geography has been relocated as a subject that might provide what Young (2008, 2013) and Lambert (2014) go so far as to frame 'powerful knowledge', which is discipline-based knowledge that will enable young people to move beyond their experiences to the development of explanatory frameworks for making sense of complex socio-environmental situations.

However, a critical pedagogical question emerges: How can geography educators cultivate competencies enabling students to navigate an increasingly uncertain world? Disaster risk reduction offers one compelling avenue for addressing this challenge. As extreme weather events, seismic disturbances, and related natural phenomena intensify, preparedness education becomes increasingly vital. Selby and Kagawa (2012) argue that school curricula provide sustained opportunities for developing disaster risk reduction competencies that minimise disaster impacts across communities.

Previous studies, such as Occhipinti (2019), have shown that traditional approaches to hazard awareness education in school geography have tended to emphasise factual knowledge concerning the nature of hazards, their origins, and their effects. However, modern disaster risk reduction frameworks increasingly stress the need to comprehend vulnerability and preparedness planning, as well as the social-spatial dimensions of disaster resilience (Wisner et al., 2004; Mitchell et al., 2008). Hence, pedagogical approaches that engage students actively in learning-by-doing are required, especially on the topic of disasters, to stimulate preparedness actions rather than simple knowledge transfer.

Serious games, that is, games designed for educational rather than purely entertainment purposes, have emerged as powerful pedagogical tools for advancing climate sustainability and disaster preparedness. They enable experiential learning by immersing participants in realistic simulations of environmental crises and disaster events that would otherwise be too costly, risky, or impractical to reproduce in real life (Madani et al., 2017; Strada et al., 2023). Through game-integrated learning experiences, learners develop essential soft skills, including critical thinking, creative problem-solving, teamwork, and adaptive decision-making, which are vital for navigating contemporary complex sustainability challenges. The interactive and immersive nature of serious games sustains learners' attention and motivation, making abstract or technical topics more engaging, and in turn, enhancing retention and conceptual understanding.

Moreover, empirical studies demonstrate that these games significantly improve knowledge, awareness, and pro-environmental attitudes, often leading to behavioural intentions aligned with sustainability and resilience goals (Strada et al., 2023; Haryanto et al., 2023; Alarcon et al., 2025). From a practical standpoint, serious games offer safe, scalable, and cost-effective training environments, providing viable alternatives to live disaster drills that can be resource-intensive and logistically demanding; however, the study of Yang et al. (2025) reinforces the need to contextualise gameplay to local hazards to contribute to community resilience and disaster readiness, particularly in vulnerable regions. Collectively, these studies highlight serious games as versatile, evidence-based instruments for experiential, affective, and cognitive learning that promote both individual competence and community resilience in the face of environmental and disaster risks.

An example of a serious game for teaching about disasters is *Stop Disasters* (https://www.stopdisastersgame.org/), a web-based simulation produced by the United Nations Office for Disaster Risk Reduction (UNDRR). *Stop Disasters* aims to engage players in building community disaster resilience through a scenario-based approach of selecting game choices on infrastructure development and land use planning with emerging threats that typically face cities. As of the date of writing this paper, the game is currently available in different languages, including Chinese, Croatian, English, French, German, Italian, Japanese, Portuguese, Russian, and Spanish.

Despite the growing interest in serious games for geography education, we lack empirical evidence on their usability and effectiveness, especially in European geography educational spaces (Solinska-Nowak et al., 2018; Mossoux et al., 2016). More specifically, very few studies, if any, have tested *Stop Disasters* among preservice teachers in Germany. These gaps are especially relevant in teacher education, where pre-service geography educators need to develop content and pedagogical knowledge for the application of new digital tools in their future teaching. Moreover, there are also still significant questions about whether serious games can actually help develop powerful geographical knowledge or merely perpetuate naive realities through reductionism.

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The research question that structures this study is: How do geography preservice teachers perceive *Stop Disasters* as a pedagogical resource for teaching hazard preparedness and resilience in times of uncertainty? Using guided reflections of fourteen prospective teachers in Germany who played the game for different hazards, this study explores (i) their experiences playing the hazard-specific games, (ii) their perceptions regarding learning opportunities that digital games afford, and (iii) challenges they foresee in integrating such digital tools in schools. In answering these questions, this study has two primary contributions to the literature. First, the study contributes to evidence of the perceived pedagogical potentials and pitfalls of serious games for disaster risk reduction education in a German geography education context, which could be scaled to other contexts. Second, practical knowledge is herein provided to geography educators and curriculum designers who are interested in incorporating digital pedagogies into resilience-oriented teaching under conditions of uncertainty.

Together, these debates reveal a critical pedagogical tension. While geography education is increasingly tasked with preparing learners for uncertainty through powerful disciplinary knowledge, the growing use of digital tools, particularly serious games, raises unresolved questions about whether such tools deepen geographical thinking or merely simulate decision-making through simplified representations of risk. This study addresses this tension by empirically examining how preservice geography teachers interpret the pedagogical value and limitations of a widely used disaster-focused serious game in relation to resilience education.

2. Literature Review

2.1. Powerful Geographical Knowledge for Navigating Uncertain Futures

The concept of powerful knowledge, introduced by sociologist Young (2008, 2013), refers to specialised disciplinary knowledge that enables learners to 'understand and think beyond the limits of their own experience' and provides them with the intellectual power to predict, explain, and envisage alternatives. Subsequent work, specifically Young and Muller's (2010) 'Future 3' curriculum framework, distinguishes powerful disciplinary knowledge from both fact-based transmission (Future 1) and skills-focused constructivism (Future 2). Future 3 curricula engage students actively with dynamic disciplinary knowledge through which teachers function as 'curriculum makers' rather than content deliverers (Lambert et al., 2015).

Within geography education, the concept of powerful knowledge has gained substantial traction as scholars argue that geographical knowledge becomes powerful when it equips students with conceptual frameworks to think geographically, while enabling them to analyse spatial patterns, understand place-based complexities, and grasp interconnections across scales (Lambert, 2014; Maude, 2016; Roberts, 2014). Moreover, five geography-specific dimensions are described in Maude (2016): new ways of thinking about the world; analytical and explanatory frameworks; knowledge acquisition and evaluation skills; capacity to engage in societal debates; and knowledge of global diversity beyond personal experience.

In the context of this study, disciplinary knowledge refers to the specialised body of geographical and DRR understanding that learners are expected to develop, including: conceptual knowledge of hazard processes (e.g., causes, mechanisms, and spatial dimensions of tsunamis, hurricanes, floods, wildfires, and seismic events); analytical frameworks for understanding vulnerability as a socially produced, unevenly distributed condition shaped by exposure, sensitivity, and adaptive capacity (Wisner et al., 2004); and systems-level thinking that connects land-use decisions, infrastructure, governance, and community characteristics to disaster outcomes. The disciplinary competencies central to this study's learning objectives encompass: (i) critical evaluation of risk and preparedness information; (ii) spatial reasoning about hazard exposure and vulnerability at local and regional scales; (iii) decision-making under conditions of uncertainty; and (iv) the capacity to analyse the social, political, and ethical dimensions of disaster risk management. These competencies align directly with the theoretical framework of powerful geographical knowledge (Young, 2008, 2013; Maude, 2016), which demands that learning move beyond procedural know-how toward conceptual understanding that enables learners to explain, evaluate, and imagine alternatives to existing conditions.

Hence, the relevance of powerful geographical knowledge intensifies in contexts of mounting uncertainty. As climate extremes proliferate and socio-environmental risks escalate, geography education must cultivate students' capabilities to imagine alternative futures and adapt to complexity (Davidson et al., 2023; de Miguel González, 2024). Recent scholarship, such as Biddulph et al. (2020) and Kriewaldt et al. (2025), emphasises that powerful geographical knowledge, especially the understanding of place, space, scale, and human-environment interactions, provides essential

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cognitive tools for developing resilience and navigating an uncertain Anthropocene. However, whether digital pedagogies, such as serious games, can effectively transmit this powerful knowledge remains underexplored, particularly within disaster risk reduction education.

2.2 Disaster Risk Reduction and Geography Education

Disaster Risk Reduction (DRR) has evolved from reactive emergency response toward proactive, education-centred approaches that build community resilience. The Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015) explicitly positions education as a cross-cutting priority, emphasising the integration of hazard knowledge, preparedness planning, and risk awareness into school curricula to prevent new risks and reduce existing vulnerabilities. This paradigm shift, from a culture of reaction to one of prevention, recognises that what people know is often more decisive than what they possess when confronting hazards. Within the school system, geography occupies a strategic position to equip learners with the knowledge, skills, and dispositions needed for preparedness and adaptive response.

As used throughout this study, 'resilience' refers specifically to the capacity of individuals, communities, and systems to anticipate, withstand, respond to, and recover from the adverse impacts of hazard events (Manyena, 2006; UNDRR, 2015). This understanding encompasses several interrelated dimensions including: (a) hazard preparedness (i.e., the proactive acquisition of knowledge, skills, and resources to reduce exposure and vulnerability before a disaster occurs); (b) community resilience (i.e., the collective ability of social systems to absorb disturbances while maintaining essential functions, drawing on local resources and adaptive capacities, Norris et al., 2008); and (c) resilience education (i.e., pedagogical approaches that cultivate the knowledge, critical thinking, and dispositions required to participate meaningfully in disaster risk reduction and adaptive decision-making, Selby & Kagawa, 2012). Taken together, these dimensions frame resilience as a dynamic, learnable, and contextually embedded (never fixed) set of competencies that geography education is uniquely positioned to develop.

Geography education is thus central to DRR frameworks because of its focus on human–environment interactions, spatial patterns, and place-based vulnerabilities. Comparative studies from Malaysia, Singapore, China, and the United States (Gong et al., 2021; Gouramanis & Morales-Ramirez, 2021; Hawa et al., 2023; Sun et al., 2024) reveal varying levels of DRR integration in curricula and textbooks. Yet, as Occhipinti (2019) argues, the persistence of traditional knowledge-transmission models in geography classrooms limits students' capacity to develop adaptive reasoning. Beyond the factual understanding of hazards, contemporary DRR pedagogy calls for active, competence-oriented learning that enables learners to analyse vulnerability, evaluate preparedness strategies, and participate in disaster-mitigation planning (Kamil et al., 2020).

Although countries such as Greece (Passadelli et al., 2024) and India (Goswami & Ahmad, 2025) report increasing inclusion of DRR competencies within geography curricula, empirical studies across Germany and other European contexts remain scarce. Moreover, geography educators continue to face curriculum constraints, limited professional development in DRR teaching, and tensions between content coverage and experiential learning (Goswami & Ahmad, 2025; Hawa et al., 2023; Sun et al., 2024). These persistent challenges raise the question of how to move students beyond theoretical understanding toward embodied preparedness behaviours, a pedagogical gap that digital serious games may help bridge by transforming abstract risk concepts into lived, interactive learning experiences.

2.3. Digital Serious Games as Pedagogical Tools for Resilience Education

Serious games, which are digital games designed for educational rather than purely entertainment purposes, have garnered increasing attention as pedagogical tools in geography education, particularly for teaching complex systems thinking and spatial decision-making (Arnab et al., 2015). Unlike traditional instructional materials, serious games provide interactive simulated environments that enable learners to experiment with decisions and observe their consequences through guided play. This experiential, constructivist approach aligns with contemporary pedagogical theories emphasising active learning and inquiry-based education (Minnery & Searle, 2014).

Several theoretical foundations support the pedagogical potential of serious games. Cognitively, games engage learners through multiple representational systems, provide immediate feedback, and scaffold progressively complex problem-solving (Chen et al., 2023). From a sociocultural perspective, games create shared experiences and collaborative reference points for collective discussion (Gee, 2003). Motivationally, Gautier (2025) suggests that game-based

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learning can enhance engagement through challenge structures and goal-oriented designs, particularly for digitally fluent generations.

Within disaster risk reduction education specifically, serious games offer distinct pedagogical advantages (Fleming et al., 2020; Gampell et al., 2020). They enable simulation of hazard scenarios and disaster impacts within risk-free environments, facilitating exploration of counterfactual *"what if"* questions. Games can render abstract concepts, such as hazard processes, vulnerability factors, and preparedness measures, more concrete through visual and interactive representations. They promote systems thinking by revealing interconnections between decisions and their cascading consequences. Furthermore, games cultivate decision-making competencies by requiring players to optimise limited and competing resources under conditions of uncertainty.

Stop Disasters exemplifies this pedagogical approach. Developed by the United Nations Office for Disaster Risk Reduction in partnership with Playerthree, this browser-based simulation engages players across five hazard scenarios: tsunami, earthquake, hurricane, wildfire, and flood. Players assume the role of local Disaster Risk Management planners tasked with building community resilience within constrained budgets and time limits. Balancing competing objectives such as minimising loss of life, reducing disaster impacts, and sustaining development, the game requires strategic decisions regarding land-use planning, infrastructure placement, early warning systems, and emergency response capacity.

However, serious games face significant implementation challenges. Gundersen and Lampropoulos' (2025) systematic review of 78 studies on serious and digital games in K-12 education reported that, although outcomes were predominantly positive, a subset of studies documented increased cognitive strain, students' need for assistance to complete learning tasks, technical difficulties, and negative affective responses such as boredom or lack of freedom within the game.. These limitations underscore that pedagogical effectiveness depends critically on thoughtful design, adequate scaffolding, and alignment with learners' capacities.

2.4. Framing Serious Games for Powerful Teaching in Uncertain Times

This study synthesises the aforementioned theoretical perspectives into a guiding framework, positioning serious games as potentially transformative tools for developing powerful geographical knowledge toward disaster resilience in uncertain times. First, effective disaster risk reduction (DRR) education demands pedagogical approaches that foster active learner engagement, autonomous decision-making, systems analysis, and critical reflection. Specifically, Aghaei et al. (2018) identified eight core strategies for effective DRR education: raising knowledge, conducting educational needs assessments, educational planning, employing appropriate pedagogical approaches, developing contextually relevant content, utilising diverse educational tools, and addressing learning barriers and challenges. Many of these serious games and similar interactive simulations can facilitate most of these strategies. Moreover, rather than passively transmitting knowledge, games position learners as active agents navigating complex scenarios, thereby developing adaptive reasoning skills essential for uncertain futures.

In addition, beyond standalone interventions, serious games function most effectively as integrated components within broader pedagogical sequences (Clark et al., 2016). Therefore, optimal implementation encompasses pre-game contextual framing, facilitated post-game reflection (ideally collaborative), and explicit connections to disciplinary knowledge and real-world applications. Without such scaffolding, gameplay risks remaining disconnected from meaningful geographical learning.

Furthermore, evaluating the pedagogical value of serious games is important, especially their capacity to engage learners and sustain motivation, contribute to conceptual understanding aligned with learning objectives; the compatibility of these games with curriculum frameworks and educational contexts; and the feasibility of classroom implementation given practical constraints of time, technological infrastructure, and teacher preparedness.

Hence, the core framing aspects described above guide the present study's examination of how geography preservice teachers perceive *Stop Disasters* regarding both its pedagogical promises and constraints for teaching resilience education amid contemporary uncertainties. By investigating preservice teachers' experiences and reflections, this research seeks to illuminate whether and how serious games can bridge the gap between theoretical knowledge of disaster risk and the development of powerful geographical thinking necessary for navigating an uncertain world.

2.5. Aims and Research Questions

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Against the backdrop of mounting climate extremes and escalating disaster risks, geography education faces a critical imperative to equip students with the adaptive capacities for navigating uncertainty. While digital serious games hold promise as innovative pedagogical tools for fostering disaster resilience, empirical evidence regarding their effectiveness within European geography education contexts remains limited.

This study presents an initial step toward addressing this gap by examining how preservice geography teachers perceive and evaluate *Stop Disasters* as a pedagogical resource for teaching hazard preparedness and resilience. Rather than evaluating *Stop Disasters* per se, this research empirically investigates whether and how digital serious games can support the development of powerful geographical knowledge for resilience in uncertain times. This study does not assess serious games as instructional tools in general, but rather to interrogate their epistemic compatibility with the aims of powerful geographical knowledge. Specifically, it examines whether engagement-driven digital simulations can support or undermine the development of conceptually grounded, explanatory geographical thinking required for resilience in uncertain times.

The study is guided by the following overarching research question: How do geography preservice teachers in Germany perceive *Stop Disasters* as a pedagogical resource for teaching hazard preparedness and resilience? This overarching question is operationalised through four specific research questions (RQs) aligned with distinct dimensions of game-based learning assessment:

- **RQ1:** How do preservice geography teachers assess *Stop Disasters* as a learning experience, in terms of usability, learning outcomes, realism, and learner engagement?
- **RQ2:** To what extent do preservice teachers perceive *Stop Disasters* as pedagogically relevant for German geography classrooms, in terms of its capacity to challenge assumptions, prompt regional reflection, and enhance teaching confidence?
- **RQ3:** What are preservice teachers' intentions regarding future use of *Stop Disasters* Game or similar digital serious games in their own teaching practise?
- **RQ4:** What learning outcomes, pedagogical affordances, implementation challenges, and improvement recommendations do preservice teachers identify through reflective analysis of their gameplay experiences?

By investigating these dimensions through combining quantitative assessment of game perceptions with qualitative analysis of reflective narratives, this study provides empirical evidence regarding both the promises and limitations of serious games for cultivating disaster resilience within geography education. Furthermore, the findings offer practical guidance to teacher educators, curriculum developers, and practising teachers seeking to integrate digital pedagogies into resilience-oriented teaching amid contemporary uncertainties.

3. Materials and Methods

3.1. Research Design

This study employed an exploratory mixed-methods design combining quantitative survey data with qualitative reflective narratives to examine geography preservice teachers' perceptions of *Stop Disasters* as a pedagogical tool. The mixed-methods approach enabled both systematic measurement of preservice teachers' assessments across key dimensions (usability, learning outcomes, pedagogical relevance) and rich exploration of their experiential insights, anticipated challenges, and improvement recommendations (Creswell & Plano Clark, 2018). This methodological integration provided complementary perspectives. Here, quantitative data established patterns of perception across the participant group, while qualitative data illuminated the nuanced reasoning, contextual considerations, and pedagogical judgments underlying these perceptions.

3.2. Participants and Context

Participants comprised 14 preservice geography teachers enrolled in a Master of Education programme at the University of Münster, Germany, during the summer semester 2025. Participants were recruited through convenience sampling from an intact geography education seminar class (of 21 students) focused on innovative pedagogies for teaching physical geography and disaster risk reduction. Most participants were completing their disciplinary and pedagogical coursework in preparation for the German teacher training practicum.

Participant ages ranged from 22 to 37 years, and only two of the participants had played *Stop Disasters* before this study, ensuring that most gameplay experiences were novel. At the time of data collection, two participants (14.3%)

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were already working as school teachers, while the remaining twelve (85.7%) had not yet begun formal teaching positions. Given the exploratory and theory-informed nature of this study, the aim is not statistical generalization but analytical insight into how preservice teachers interpret and evaluate digital tools in relation to disciplinary knowledge expectations. The findings reported in subsequent sections are therefore to be interpreted as indicative patterns rather than population-wide.

The selection of preservice teachers as the research population was purposive. While experienced teacher educators or geography experts could offer authoritative evaluations of the game's content quality, the epistemic and pedagogical questions at the heart of this study concern how future teachers perceive, critically evaluate, and intend to use digital tools in their own professional practise. Preservice teachers occupy a distinctive position as simultaneous learners of geography education pedagogy and prospective practitioners, and their perceptions of educational technologies are shaped by both disciplinary understanding and anticipatory professional concerns. As such, their evaluations in this study are intended to both reveal the game's affordances as experienced by near-peer users, and also to illuminate the pedagogical preparation needs and curricular reasoning that teacher education programmes could address. The added value of engaging preservice teachers specifically, therefore, is in generating evidence that is directly actionable for teacher education curricula, informing how geography teacher educators prepare future teachers to critically select, scaffold, and integrate digital tools for resilience education.

Participants played different hazard scenarios within *Stop Disasters* to ensure representation across the five available disaster types. The distribution was as follows: tsunami (n = 6), earthquake (n = 2), hurricane (n = 3), wildfire (n = 2), and flood (n = 1). This deliberate variation enabled assessment of whether perceptions differed across hazard contexts. However, as participation was voluntary, representation across hazard scenarios was uneven, reflecting differential student participation rather than study design constraints. The distribution across hazard scenarios was not intended to support systematic comparison between hazards, but to ensure exposure to the full range of game contexts when analysing overarching pedagogical perceptions.

3.3. The Stop Disasters game

Stop Disasters (https://www.stopdisastersgame.org/) is a browser-based educational simulation developed by the United Nations Office for Disaster Risk Reduction (UNDRR) in partnership with Playerthree. The game positions players as disaster risk management planners tasked with building community resilience within constrained budgets and time limits across five hazard scenarios: tsunami, earthquake, hurricane, wildfire, and flood.

Gameplay requires strategic decision-making regarding infrastructure placement (e.g., evacuation shelters, hospitals, fire stations), early warning systems, land-use planning, and protective measures (e.g., seawalls, firebreaks, building reinforcement). Within the game, players balance competing objectives, such as minimising casualties, reducing property damage, and maintaining economic development, under resource constraints. The game then provides immediate visual feedback showing disaster impacts based on players' preparedness decisions, thereby creating an experiential learning environment for exploring disaster risk reduction principles. At the time of this study, the game was available in ten languages, including German, making it accessible for German-speaking learners.

3.4. Data Collection Procedure

Data collection occurred during a 90-minute seminar session on June 25, 2025. The procedure comprised three phases:

- **Phase 1: Introduction and Contextualisation**

The researcher provided background on disaster risk reduction education, serious games as pedagogical tools, and *Stop Disasters* specifically. Participants received an overview of the game's objectives, mechanics, and educational rationale. Ethical considerations were explained, including voluntary participation, anonymity, and the use of data solely for research purposes. Participants provided informed consent, and completing the reflection form implied further consent.

- **Phase 2: Gameplay**

Participants individually accessed the game via personal devices. Each participant was assigned one of the five hazard scenarios to ensure coverage across disaster types. Participants played their assigned scenario at their own pace, with most completing at least one full game cycle (typically 30–40 minutes), while faster players engaged in multiple

attempts or explored different strategies. The researcher remained available to address technical issues but did not intervene in gameplay decisions to preserve authentic experiences.

- **Phase 3: Survey Completion**

Immediately following gameplay, participants completed an anonymous online questionnaire via Google Forms. The survey comprised four sections: (1) demographic and background information, (2) quantitative ratings of game experience, (3) quantitative ratings of pedagogical relevance, and (4) open-ended reflective questions. The immediate post-gameplay administration ensured that responses captured fresh impressions and detailed recollections of gameplay experiences. Seven students (33%) chose not to participate in the study.

3.5. Instrument for data collection

The study employed a researcher-designed questionnaire comprising four sections (see Appendix for complete instrument). Section 1 collected demographic and background information, including age, prior game experience, teaching status, and hazard scenario played. Section 2 assessed game experience across four dimensions (i.e., usability, learning outcomes, realism, and engagement), using 5-point Likert scales. Section 3 evaluated pedagogical relevance through four Likert-scale items measuring perceived classroom effectiveness, capacity to challenge assumptions, regional reflection prompts, and impact on teaching confidence, plus one categorical item assessing future teaching intentions (Yes/Maybe/No). Section 4 comprised five open-ended questions inviting reflective narratives on learning outcomes, pedagogical affordances, implementation challenges, improvement recommendations, and additional comments. This mixed-methods instrument enabled both systematic quantitative assessment and rich qualitative exploration of participants' perceptions and pedagogical reasoning.

3.6. Data Analysis

From the instrument used for data collection, both quantitative and qualitative data were generated and analysed. The methods of analysis are described.

3.7. Quantitative Analysis

Quantitative data from Likert-scale items were analysed using descriptive statistics in SPSS Version 28. For each item, the following were calculated: mean (M), standard deviation (SD), and response frequency distributions across the five-point scale. Given the small sample size (n = 14), inferential statistical tests were not conducted; instead, descriptive patterns were interpreted to identify trends in participant perceptions. Categorical data from the future teaching intentions item were analysed through frequency counts and percentages.

3.8. Qualitative Analysis

Qualitative data from open-ended responses were analysed using reflexive thematic analysis following Braun and Clarke's (2006, 2019) six-phase framework: familiarisation, initial coding, theme development, theme review, theme definition, and reporting. Given the manageable dataset size and the exploratory nature of the study, the analysis was conducted manually without dedicated qualitative software packages to maintain close engagement with participant narratives.

The analytical process proceeded in two stages. In the initial stage, the researchers familiarised themselves with the data through multiple readings of all responses. Initial familiarisation and pattern organisation were facilitated by Google Forms' AI-powered response summary function, which generated descriptive summaries and identified recurrent patterns across responses. This computational assistance provided a systematic starting point for organising the data and identifying salient patterns, particularly useful given the structured nature of the open-ended questions, in which participants responded to identical prompts.

The subsequent stage involved rigorous human-led interpretation and refinement. The researcher critically reviewed AI-generated summaries against the original response data to verify accuracy, identify nuances overlooked by algorithmic processing, and ensure themes authentically represented participant meanings. Candidate themes were systematically reviewed against both coded extracts and the entire dataset to ensure internal coherence and external

distinctiveness. Themes were then refined with clear conceptual boundaries and descriptive names capturing their analytical essence. Throughout the reporting phase, themes were illustrated with representative participant quotations to demonstrate patterns while preserving authentic participant voice and interpretive context.

In this study, AI-generated summaries were used solely as organisational aids to support initial familiarisation with the dataset and to identify surface-level response patterns. All coding decisions, theme development, refinement, and interpretation were conducted exclusively by the researcher in accordance with the principles of reflexive thematic analysis (Braun & Clarke, 2019). AI outputs were systematically cross-checked against raw data and were neither treated as analytic codes nor as substitutes for interpretive judgement.

3.9. Ethical Considerations

The study adhered to ethical guidelines established by the University of Münster research ethics framework and received clearance from the Institute of Geography Education. Prior to data collection, participants received both verbal and written information detailing the study's purpose, procedures, voluntary participation, anonymity provisions, and intended use of data. Written informed consent was obtained from all participants.

Participation was entirely voluntary with explicit assurance that non-participation would have no academic consequences. Of the 21 students enrolled in the seminar, 14 (67%) consented to participate and completed the survey, while seven students (33%) chose not to participate, and this decision was respected without inquiry. All survey responses were collected anonymously through Google Forms with no personally identifying information requested or recorded. To further protect anonymity, participants were assigned numerical codes for data management purposes, with no linkage to individual identities maintained.

Data were stored securely in password-protected digital files accessible only to the lead researcher. Participant quotations presented in research outputs were reviewed to ensure no identifying details were inadvertently disclosed. Participants were informed of their right to withdraw consent and have their data removed from the study at any time prior to publication, though no withdrawal requests were received.

4. Results

Findings addressing the four research questions guiding this study are presented in this section. Quantitative data from Likert-scale items are reported through descriptive statistics, while qualitative open-ended responses provide deeper contextualisation of participants' experiences and perspectives.

4.1. Participant Overview

Fourteen preservice geography teachers participated in this study (M = 26.64, SD = 4.88, range = 22–37 years). The majority were not currently teaching (n = 12, 85.7%), with only two participants (14.3%) holding current teaching positions. Most participants (n = 12, 85.7%) had no prior experience with *Stop Disasters*, ensuring predominantly novel gameplay experiences. Participant distribution across hazard scenarios is already documented in earlier sections of this paper.

4.2. Game Experience and Learning Affordances (RQ1)

RQ1 examined how preservice teachers assessed *Stop Disasters* across four dimensions: (a) usability and clarity, (b) learning outcomes, (c) realism and real-world relevance, and (d) capacity to sustain learner engagement.

4.2.1. Usability and Clarity

Participants generally rated the game's usability positively (Table 1). Navigation and interface comprehension received strong endorsement (M = 4.07, SD = 0.83), with the overwhelming majority finding the game technically accessible. Goal clarity was similarly well-rated (M = 4.00, SD = 1.11), though with slightly greater variability, suggesting that while most participants readily understood game objectives, a small subset experienced difficulties with comprehending game mechanics or challenge structures. These findings indicate minimal technical barriers to game access for most participants.

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Table 1. Preservice teachers' assessments of game usability, learning affordances, realism, and engagement.

Dimension	Items	Mean	% Agree	Neutral	% Disagree
Usability and Clarity	The game was easy to understand and navigate	4.07	85.7	7.1	7.1
	The goals and challenges of the game were clear	4.00	71.4	14.3	14.3
Learning Outcomes	The game helped me understand the causes and impacts of the hazard	3.14	28.6	42.9	28.6
	The game showed the importance of preparedness and planning	4.00	71.4	14.3	14.3
	I had to think critically about trade-offs during the game	2.79	35.7	28.6	35.7
Real-World Relevance	The game felt realistic and relevant to real-world disasters	2.57	14.3	42.9	42.9
Learner Engagement	I was engaged while playing the game	3.79	71.4	14.3	14.3

All items rated on 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).
% Agree = combined percentage of "Agree" and "Strongly Agree" responses (scores 4–5).
% Disagree = combined percentage of "Disagree" and "Strongly Disagree" responses (scores 1–2).

4.2.2. Learning Outcomes

Assessments of the game's learning contributions revealed notable variation across three dimensions (Table 1). The game's capacity to demonstrate the importance of preparedness and planning received the strongest endorsement (M = 4.00, SD = 1.11), aligning with its core design objective of fostering disaster preparedness awareness.

In contrast, the game's effectiveness in deepening understanding of hazard causes and impacts received more moderate ratings (M = 3.14, SD = 1.03), with responses distributed across agreement, neutrality, and disagreement. This pattern suggests limitations in the game's explanatory depth regarding underlying hazard mechanisms, with many participants finding the treatment of causal processes insufficiently robust.

The dimension showing greatest scepticism concerned critical thinking about trade-offs (M = 2.79, SD = 1.19). Responses were nearly evenly distributed across agreement, neutrality, and disagreement, indicating sharply divergent experiences. While some participants engaged substantively with decision-making complexities, others found the choices insufficiently nuanced to require genuine critical analysis, suggesting the game's challenge structure varied in intellectual demand depending on individual play strategies or prior knowledge.

4.2.3. Realism and Real-World Relevance

Realism emerged as a significant concern. The game's perceived alignment with real-world disasters received the lowest mean rating among all assessed dimensions (M = 2.57, SD = 0.94), with disagreement outweighing agreement. This below-midpoint rating, coupled with the predominance of neutral and negative assessments (Table 1), indicates substantial scepticism about the game's fidelity to authentic disaster preparedness scenarios.

4.2.4. Learner Engagement

Engagement levels were moderately high, with most participants reporting sustained attention during gameplay (M = 3.79, SD = 1.19). The game's interactive format successfully captured interest for the majority of users. However, the relatively high standard deviation reflects notable variability, as a small subset reported disengagement, suggesting the game's motivational appeal was not universal.

4.3. Pedagogical Relevance and Implementation Potential

RQ2 examined perceptions of the game's (a) classroom effectiveness, (b) capacity to challenge assumptions, (c) ability to prompt regional reflection, and (d) impact on teaching confidence.

4.3.1. Classroom Effectiveness

Participants expressed cautious optimism regarding the game's classroom implementability (*M* = 3.29, *SD* = 1.14). While a majority viewed the game as potentially effective for German geography classrooms, a substantial minority expressed scepticism, and others remained neutral (Table 2). This mixed response pattern suggests recognition of pedagogical potential tempered by significant concerns about practical feasibility. The relatively high standard deviation reflects considerable disagreement among participants regarding whether the game's affordances outweigh its limitations in classroom contexts.

Table 2. Preservice teachers' perceptions of classroom applicability, reflective potential, and teaching confidence.

Items	Mean	% Agree	Neutral	% Disagree
I believe this game can be effectively used in Geography classrooms in Germany	3.29	57.1	14.3	28.6
The game challenged my prior assumptions about disaster preparedness	2.36	14.3	28.6	57.1
The game made me reflect on real-world vulnerabilities in my region	2.43	28.6	21.4	50.0
Playing this game increased my confidence in teaching about hazards and preparedness	3.14	35.7	35.7	28.6

All items rated on 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).
% Agree = combined percentage of "Agree" and "Strongly Agree" responses (scores 4–5).
% Disagree = combined percentage of "Disagree" and "Strongly Disagree" responses (scores 1–2).

4.3.2. Challenging Assumptions and Promoting Reflection

The game demonstrated limited capacity to disrupt existing conceptual frameworks or prompt contextual reflection (Table 2). Regarding the challenge to prior assumptions about disaster preparedness, ratings were notably low (*M* = 2.36, *SD* = 1.22), with disagreement substantially outweighing agreement. This pattern suggests that for most participants, the game reinforced rather than disrupted existing knowledge structures, offering little that extended beyond their current understanding of disaster risk management.

Similarly, the game showed modest effectiveness in prompting reflection on regional vulnerabilities (*M* = 2.43, *SD* = 1.28). Half of participants disagreed that the game stimulated thinking about local disaster risks, indicating limited success in connecting game scenarios to participants' own geographical contexts. This disconnect likely reflects the mismatch between the game's hazard scenarios (tsunamis, hurricanes, earthquakes, wildfires, floods) and the disaster risk profile of Germany, where such extreme events are relatively uncommon.

4.3.3. Teaching Confidence

The game's impact on participants' professional confidence in teaching about hazards revealed considerable variability (*M* = 3.14, *SD* = 0.95). Responses were distributed relatively evenly across agreement, neutrality, and disagreement (Table 2), indicating divergent effects on pedagogical self-efficacy. While approximately one-third experienced gains in confidence, another third experienced no change, and the remaining third expressed doubt about the game's contribution to their professional preparation. This heterogeneity suggests that confidence enhancement may depend on individual factors such as prior disaster risk knowledge, teaching experience, or game engagement levels.

4.4. Future Teaching Intentions

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RQ3 examined participants' intentions regarding future use of *Stop Disasters* or similar digital serious games in their teaching practise. Adoption intentions were predominantly tentative rather than enthusiastic. The majority (n = 8, 57.1%) expressed conditional willingness *("Maybe"*), indicating recognition of potential value tempered by reservations requiring resolution before confident implementation. Approximately one-third (n = 5, 35.7%) expressed definite intentions to adopt the game *("Yes"*), while only one participant (7.1%) definitively rejected future use *("No"*).

Combining affirmative and tentative responses, nearly all participants (n = 13, 92.9%) expressed at least qualified openness to future use. However, the predominance of conditional commitments suggests that successful classroom integration would depend critically on addressing identified implementation concerns or enhancing game features to better align with classroom realities and pedagogical objectives. The pattern of hesitant rather than enthusiastic endorsement aligns with the mixed assessments of pedagogical relevance documented in RQ2, particularly concerns about classroom effectiveness (M = 3.29) and teaching confidence (M = 3.14).

4.5. Pedagogical Insights from Reflective Analysis

RQ4 examined specific (a) learning outcomes, (b) pedagogical affordances, (c) implementation challenges, and (d) improvement recommendations identified through participants' reflective analysis of their gameplay experiences. These qualitative findings (Table 3), derived from open-ended responses, provide rich contextualisation of the quantitative patterns documented in earlier sections. We note that thematic analysis allows themes to reflect participants' meanings, which may not always correspond to distinct theoretical categories.

4.5.1. Learning Outcomes Identified

When asked what the game taught them about hazards, participants' responses clustered around four primary themes, with notable variation in perceived learning depth. The most frequently articulated learning outcome emphasised **preparedness imperatives**. Approximately half of respondents highlighted lessons about proactive risk management, with representative comments including *"Being prepared is necessary," "The damage caused by natural hazards can be greatly reduced through smart planning and preparedness,"* and *"Protective measures are essential as people live in risk areas for various reasons."* These responses suggest the game successfully conveyed its core educational message about disaster preparedness.

A second prominent theme concerned **impact magnitude and vulnerability**. Several participants noted that the game revealed hazards' consequences to be more severe than anticipated: *"The impact is higher than I thought" and "Tsunamis have strong effects."* Others recognised exposure dynamics, observing that *"disasters become catastrophic when people and communities are exposed and vulnerable."* One participant noted unexpectedly broad spatial impacts: *"Some areas are vulnerable to disaster which you didn't think of before, e.g., not only the coastal areas are affected by a hurricane."*

However, a notable subset expressed scepticism about **learning depth**, indicating the game offered limited new knowledge. Two participants explicitly stated the game taught them *"nothing I didn't already know"* or *"nothing new,"* suggesting the content may have been insufficiently challenging for individuals with prior knowledge of disaster risk. This pattern aligns with the quantitative finding that understanding of hazard causes and impacts received only moderate ratings (M = 3.14).

4.5.2. Pedagogical Affordances for Student Understanding

Participants identified multiple mechanisms through which the game could enhance student learning, with **interactive and experiential engagement** emerging as the most frequently cited affordance. Approximately one-third emphasised the value of active, visual learning: *"Students like visual and interactive learning, so I think this game is ideal for that," "It's vivid and activating,"* and the game provides *"a first impression of these catastrophes and possible precautions"* in areas where *"natural hazards are not that present,"* such as Münster, Germany. This perceived strength directly addresses the challenge of teaching students about geographically distant hazards with limited experiential reference points.

Critical thinking and systems understanding constituted a second major affordance theme. Multiple participants noted the game's capacity to develop decision-making competencies: *"They have to think about what's most important*

to reduce risk, as you can't save everything at once," "Students must make decisions, weigh trade-offs, and see the consequences of their choices," encouraging "critical thinking, systems thinking, and reflection on the balance between human needs (like tourism or agriculture) and safety." The role-playing dimension was specifically valued: *"By taking the role of a city planner, students... become aware of dangers"* and must prioritise actions strategically.

However, several participants proposed **pedagogical enhancements** to maximise learning effectiveness. One suggested incorporating *"additional reflection questions to evaluate the game on a meta-level,"* recognising that gameplay alone may be insufficient without structured debriefing to consolidate learning.

Table 3. Summary of Qualitative Themes Identified from Preservice Teachers' Reflective Analysis.

Dimension	Theme	Description of Theme
Learning outcomes identified	Preparedness and proactive risk management	Participants emphasised preparedness, planning, and mitigation as central lessons, recognising that disaster impacts can be reduced through anticipatory actions rather than prevented entirely.
	Impact magnitude and vulnerability	Several participants reported increased awareness of the severity of hazard impacts and the role of exposure and vulnerability in shaping disaster outcomes.
	Limited novelty of content	A subset of participants perceived the game as offering little new knowledge, particularly for those with prior understanding of disaster risk concepts.
Pedagogical affordances for student understanding	Experiential and visual learning	The game was valued for its interactive, visual, and experiential nature, particularly for introducing hazards unfamiliar to students in low-risk regions.
	Systems thinking and decision-making	Participants highlighted opportunities for developing systems thinking through prioritisation, trade-offs, and observing consequences of planning decisions.
	Need for structured reflection	Several participants noted that learning would be enhanced through guided reflection or meta-level discussion accompanying gameplay.
Implementation challenges	Oversimplification and lack of realism	Many participants criticised unrealistic mechanics and the omission of social, cultural, political, and sustainability dimensions of disaster risk management.
	Risk of superficial engagement	Participants expressed concern that students might focus on gameplay rather than learning, reducing educational depth.
	Technical and accessibility barriers	Barriers included device availability, internet reliability, and navigation difficulties within the game interface.
	Insufficient instructional scaffolding	Participants noted the absence of clear tutorials and guidance, potentially leading to trial-and-error play rather than deliberate learning.
	Time and curricular constraints	Time demands and age appropriateness were identified as limiting factors for classroom integration.
Improvement recommendations	Increased realism and complexity	Participants recommended enhancing realism by incorporating social consequences, sustainability perspectives, and greater scenario variability.
	Pedagogical scaffolding and materials	Calls were made for teacher guides, tutorials, worksheets, and built-in reflection prompts to support classroom use.
	Interface and visual improvements	Suggestions included clearer icons, improved map readability, zoom functions, and clearer explanations of game elements.
	Greater customisation	Participants expressed interest in adaptable features to suit diverse classroom contexts and learner needs.

4.5.3. Implementation Challenges

Participants identified substantial barriers to classroom integration, with concerns clustering around six primary dimensions. **Realism and oversimplification** emerged as the most frequently cited challenge, mentioned by nearly half

of the respondents. Multiple participants criticised specific game mechanics as undermining educational authenticity: *"Sometimes the game is unrealistic, since you can just build hotels and remove buildings, people are safe in a hotel but they don't live there usually," "The solutions are very simple and don't observe any negative aspects,"* and the game *"completely disregards sustainability, cultural, or sentimental factors in city planning."* One participant noted the absence of social dimensions: *"Social consequences if you move residents and destroy their homes"* are ignored. These critiques suggest that the game's simplified simulation model may detract from, rather than support, learning about the complexity of disaster preparedness.

Student engagement quality constituted a second concern. Several participants worried that *"students might view it primarily as a game and not take it seriously enough,"* potentially *"limiting the learning takeaway."* This tension between game mechanics and learning objectives reflects broader debates about the educational efficacy of serious games.

Technical and accessibility barriers were identified by approximately one-third of participants. Challenges included device availability *("Not every student has a digital device to play the game"*), unreliable connectivity *("access to enough computers or reliable internet can be a barrier"*), and usability issues *("sometimes the game stopped, some things are difficult to navigate"*).

Instructional scaffolding deficits emerged as a fourth theme. Multiple participants noted *"the lack of a clear tutorial or guided instructions, which means students might feel lost at first and rely on trial and error instead of deliberate planning."* The non-intuitive user interface compounded this issue: *"The UI is not intuitive at all times, so sometimes you discover new functions... 15 minutes into the game, so you probably would have used a different strategy if you knew the function from the beginning."* One participant emphasised prerequisite knowledge requirements: *"Students need to know what does what in the game. It needs a proper introduction and understanding of the disaster."*

Time demands presented practical constraints. Participants noted the game is *"time-consuming"* and *"only suitable for older students,"* with one explaining that *"one scenario takes about 20 minutes, but real learning happens through repetition, discussion, and reflection, which need more lesson time."*

Finally, several participants identified **weak theoretical grounding**: *"The theoretical background is a bit weak,"* and the game omits *"ethnic and political questions,"* failing to address *"possible conflict potentials"* inherent in disaster risk management decisions.

4.5.4. Improvement Recommendations

Participants offered specific, actionable suggestions for enhancing classroom utility, organised around four improvement domains. **Enhanced realism and complexity** were the most frequent recommendations. Multiple participants called for eliminating unrealistic mechanics *("More realistic and no hotel building"*), incorporating social and environmental dimensions *("It has to focus on more perspectives like sustainability and the interests of the people," "social consequences if you move residents"*), and introducing scenario variability (*"variations where disasters do not always occur, to make risk assessment and real-life uncertainty more realistic"*).

Pedagogical scaffolding and support materials constituted the second major cluster of recommendations. Participants requested *"a clear, step-by-step tutorial or teacher guide to help students understand goals, tools, and best practises before they start," "additional teaching materials like worksheets or scenario guides to support teachers in integrating the game effectively into lessons," and "built-in reflection or discussion prompts after each scenario to help students connect their decisions to DRR concepts and lessons learned."* One participant called generally for *"more explanations"* to support comprehension.

Visual and interface improvements were widely recommended. Suggestions included *"better visual clarity for building elements and protective measures (e.g., clearer icons or labels for walls, shelters, or warning systems)," "the maps should be smaller with a zoom function for better viewing of smaller elements,"* and *"make clear/easier which object does what in the game."* Finally, participants requested **increased customization options** to adapt the game to diverse learning contexts and students' needs, though specific customization desires were not elaborated.

5. Discussion

5.1. Core Findings

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Findings from this study demonstrate that preservice geography teachers perceive serious games, such as *Stop Disasters,* as pedagogically promising yet epistemically limited tools for resilience education. Participants recognised the game's capacity to engage learners and convey foundational preparedness concepts, aligning with claims that serious games render abstract concepts concrete through interactive simulation (Fleming et al., 2020; Gampell et al., 2020). The game's strong usability ratings and moderately high engagement scores confirm minimal technical barriers for most users, while its effectiveness in conveying preparedness concepts demonstrates successful knowledge transmission at the foundational level.

However, the same participants expressed substantial scepticism regarding the game's realism, capacity to challenge assumptions, ability to prompt regional reflection, or its ability to promote critical thinking about trade-offs. Rather than representing contradictory assessments, this pattern reveals a productive tension, showing that the participating preservice teachers valued what the game accomplishes (i.e., initial engagement and preparedness awareness) while recognising what it cannot accomplish, including the analytical depth, contextual specificity, and conceptual complexity that constitute powerful geographical knowledge (Lambert, 2014; Maude, 2016). Such duality, therefore, positions serious games such as *Stop Disasters* as valuable entry points requiring substantial pedagogical scaffolding to support transformative learning.

5.2. Procedural Knowledge is not Powerful Geographical Knowledge

Essentially, the study's findings unveil a critical distinction between procedural preparedness understanding and powerful geographical knowledge as theorised by Young (2008, 2013) and operationalised for geography education by Maude (2016). Participants' qualitative critiques revealed that *Stop Disasters* successfully conveys *that* preparedness matters and *what* protective measures exist, but struggles to develop an understanding of *why* disasters occur, *how* vulnerability is socially produced, *who* bears differential risks, and *where* spatial injustices concentrate disaster impacts. Therefore, while the game strongly supported awareness of preparedness (a key dimension of resilience), it showed limited capacity to develop deeper resilience competencies such as understanding vulnerability as a socially constructed condition or engaging in context-specific risk reasoning.

Thus, the game treats disaster preparedness as a technical problem-solving exercise, which entails optimising infrastructure placement within budget constraints, thereby obscuring the social, political, economic, and ethical dimensions that actually determine disaster outcomes. Specifically, participating preservice teachers explicitly documented these omissions, stating that the game: "*disregards sustainability, cultural, or sentimental factors,*" "*simple solutions that don't observe any negative aspects,*" and excludes *"ethnic and political questions"* and *"possible conflict potentials."* Such pedagogical reductionism directly contradicts contemporary DRR frameworks that emphasise vulnerability analysis, social-spatial dimensions of resilience, and the contested, value-laden nature of risk management (Kamil et al., 2020; Mitchell et al., 2008; Wisner et al., 2004).

Consequently, these preservice teachers' responses do not imply or indicate resistance to game-based learning, but disciplinary awareness of what constitutes powerful geographical knowledge. In particular, their recognition that the game reinforced rather than challenged existing understanding, such that some participants learned *"nothing new,"* reflects sophisticated evaluation against standards of analytical depth and explanatory sophistication that powerful knowledge demands.

5.3. Epistemic Case for Realism

The study's most significant finding is that participants disagreed with all items related to the game's realism, which should not be interpreted merely as a game design critique. Realism for serious games used in geographic education is essential because low realism signals fundamental epistemic tensions between simulation mechanics and geographical understanding.

For example, participants identified further specific authenticity deficits in their qualitative reflections, pointing to unrealistic mechanics (the *"hotel building"* problem), the absence of social dimensions, oversimplified decision structures, and disconnection from German geographical contexts. These critiques (excluding the contextual point) illuminate how simplification becomes pedagogically problematic when it obscures rather than foregrounds the uncertainty, complexity, and contestation inherent in disaster risk management. The game's rule-based simulation encourages the

discovery of optimal strategies for *"winning,"* fundamentally misrepresenting disaster preparedness as a technical optimisation problem with deterministic solutions rather than a wicked problem characterised by competing values, incomplete information, and irreducible uncertainty (Kasdan, 2024).

This epistemological limitation becomes especially salient given the current focus on teaching geography for a world in transition amid uncertain times. Powerful geography education's contribution to navigating uncertainty depends on cultivating capacities to analyse complexity, evaluate competing claims, and make reasoned judgments despite incomplete knowledge (Maude, 2016). These capacities are precisely what the game's oversimplified, mechanistic framework undermines, according to participating preservice teachers.

Moreover, *Stop Disasters* for hazards such as tsunamis and hurricanes was ill-suited for German risk profiles. Whereas the game was developed for global use, participants' responses to the mismatch further illustrate how decontextualisation prevents the development of a place-based, locally grounded understanding, which Maude (2023) describes as central to geographical thinking.

5.4. Positioning Serious Games as Pedagogical Adjuncts

Findings empirically justify positioning serious games as adjunct tools within broader pedagogical approaches rather than standalone solutions. Clark et al.'s (2016) argument that serious games function most effectively as integrated components within comprehensive sequences finds support in participants' emphatic calls for scaffolding and their recognition that the game provides entry points requiring substantial pedagogical work to translate into powerful knowledge.

From participants' responses, specific adjunct functions the game could serve could be identified, such as introducing hazards unfamiliar to students in low-risk regions, visualizing disaster impacts, providing safe spaces for decision-making experimentation, and motivating engagement with distant phenomena too impractical or costly to reproduce in real life (Madani et al., 2017; Strada et al., 2023). However, actualizing these affordances depends on teachers' positioning games as boundary objects that catalyze rather than replace geographical analysis. For example, teachers could use gameplay to trigger discussions about what the simulation reveals and what it obscures, what it represents and what it distorts, how simplification serves and how it misleads.

Hence, such adjunct positioning avoids the trap of treating digital tools as inherently transformative while recognising genuine pedagogical contributions games can make when thoughtfully integrated. Lastly, the finding that nearly all participants expressed at least conditional openness to using the game suggests receptivity to game-based learning, but the qualifications attached to this openness underscore that pedagogical value depends critically on implementation quality.

5.5. Implications for Geography (Teacher) Education

The findings suggest a critical tension in digital geography education. Notably, although serious games could effectively simulate decision-making environments, they risk reducing complex socio-spatial processes to procedural choices, thereby limiting the development of powerful geographical knowledge. In this sense, engagement does not necessarily translate into epistemic depth, and without structured pedagogical mediation, such tools may reinforce rather than challenge simplified understandings of disaster risk.

Furthermore, for teacher educators, findings suggest that preparing preservice teachers to use serious games requires developing several core competencies. First, preservice teachers need frameworks for critically evaluating the epistemological assumptions, representational choices, and alignment with powerful knowledge objectives of serious games. From this study, the significant variation in participants' assessments indicates that not all preservice teachers recognised the game's conceptual limitations, which suggests that teacher education must explicitly model critical analysis of educational technologies.

Moreover, participants' calls for scaffolding materials, which reflect recognition that game integration requires substantial pedagogical effort, make pedagogical integration competencies essential in designing lesson sequences. Specifically, geography teachers should be able to position games within broader learning progressions, crafting pre-game activities that establish conceptual foundations, facilitating post-game discussions that surface and critique simulation assumptions, and connecting gameplay to disciplinary concepts and real-world cases that reveal complexities games could necessarily omit.

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In addition, given concerns about regional relevance, preservice teachers need skills to adapt or supplement serious games to connect with learners' geographical contexts, potentially developing complementary materials focused on locally relevant hazards or using game limitations themselves as learning opportunities to analyse how hazard geographies vary across contexts.

5.6. Limitations

Several limitations contextualise the findings of this study. First, the small sample (n = 14) limits generalizability. The study's exploratory purpose to surface pedagogical perceptions rather than measuring learning outcomes makes a modest sample size appropriate for generating rich qualitative insights. Similarly, the focus on preservice teachers in a German university context means findings may not transfer to other educational settings, student populations, or cultural contexts. Also, single-session gameplay precludes assessment of sustained engagement or repeated-use effects.

These limitations are inherent to exploratory research, which establishes a foundational understanding in underexplored domains. The study contributes empirical evidence on serious games for DRR education within European geographic contexts where such evidence remains scarce (Mossoux et al., 2016; Solinska-Nowak et al., 2018), provides a theoretically grounded analysis that connects serious games to powerful knowledge frameworks, and generates actionable insights for teacher education and game design. Future research can build on this foundation through comparative studies and investigations of games integrated within comprehensive pedagogical sequences.

6. Conclusions

As geography education confronts escalating disaster risks amid increasing uncertainty, this study examined whether digital serious games can support the development of powerful geographical knowledge for resilience. Findings reveal that preservice geography teachers perceive serious games as pedagogically promising yet epistemically limited. While *Stop Disasters* effectively engaged learners and conveyed preparedness concepts, participants critiqued its oversimplification, unrealistic mechanics, and omission of social-political complexities that define disaster risk management.

These findings, therefore, position serious games as adjunct tools within broader pedagogical approaches rather than standalone solutions. The value of serious games such as *Stop Disasters* lies in complementing traditional instruction, not in displacing it. Such tools would practically offer experiential entry points that require substantial scaffolding, critical analysis, and explicit connections to disciplinary knowledge. For geography education seeking to prepare students for uncertain futures, the challenge is to harness the motivational affordances of serious games while ensuring they serve rather than substitute for rigorous geographical thinking. Consequently, thoughtful integration, critical evaluation, and pedagogical scaffolding could transform serious games into genuine tools for powerful geography teaching in uncertain times. In practise, integrating serious games into geography education should shift the focus of tool adoption toward pedagogical orchestration, in which teachers actively transform gameplay into opportunities for disciplinary reasoning rather than treating games as self-sufficient learning environments.

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May 2026. The collection brings together research on geography education and geographical inquiry, with a focus on powerful geographical knowledge, spatial thinking, and critical, future-oriented pedagogies. Contributions address key transformations shaping contemporary geography, including deglobalisation, multipolar world orders, postcolonial critique, contested knowledge and places, and the integration of artificial intelligence in educational practise and research. The Special Issue is edited by **Dr Neli Heidari**, University of Bremen, Germany, **Dr Uwe Krause**, Fontys University of Applied Sciences, The Netherlands & Ege University Izmir, Türkiye, **Dr Susan Caldis**, Macquarie University, Australia, **Prof. Tine Beneker**, Utrecht University, The Netherlands, and **Dr Alexandros Bartzokas-Tsiompras**, National Technical University of Athens, Greece, & Associate Editor of the European Journal of Geography. **2.** The author gratefully acknowledges the preservice geography teachers at the Institute for Didactics of Geography, University of Münster, who participated in this study during the summer semester of 2025. Sincere appreciation is also extended to colleagues and peer reviewers for their constructive feedback and scholarly input during the development of the manuscript.

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