

Article

Evaluation of User-Centred Design in the User Interface (UI) and User Experience (UX) of a Gamified Edutainment Application on Disaster Preparedness

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Abstract— Recent years have witnessed a rise in the frequency and intensity of natural disasters, disproportionately affecting vulnerable communities, as reported by the United Nations Office for Disaster Risk Reduction (UNDRR, 2022). Public preparedness, particularly among youth and rural populations, remains limited due to the absence of accessible and engaging educational tools. Conventional approaches often lack interactivity, reducing knowledge retention and behavioural change. To address these gaps, this study developed DisasterPrep, a user-centred mobile edutainment solution designed to enhance disaster awareness and preparedness. The research pursued three objectives: (i) to identify knowledge gaps among target users, (ii) to design a gamified mobile application tailored to their needs, and (iii) to evaluate its effectiveness in improving preparedness and resilience. A mixed-methods approach was adopted, including surveys, focus groups, and co-design workshops, followed by prototype testing with 30 participants in Malaysia. Quantitative data were collected through a structured survey measuring User Interface (UI) and User Experience (UX) using a 5-point Likert scale, with descriptive statistics computed for usability and engagement. Results revealed strong usability, with UI mean scores ranging from 4.04 to 4.60 and UX outcomes between 4.20 and 4.56. Tutorials, navigation flow, and progress tracking emerged as the most valued features, while simulation realism and quiz integration revealed more variable responses. Findings confirm alignment with Malaysia's MySTIE strategic goals and contributions to SDG 3 (Good Health) and SDG 4 (Quality Education). This research demonstrates that gamified, user-centred mobile tools can significantly enhance disaster preparedness education, offering a scalable, inclusive model to strengthen community resilience. The novelty lies in integrating edutainment with structured evaluation, establishing a replicable framework for disaster education that bridges gaps in interactivity, engagement, and scalability.

Keywords— Near-infrared spectroscopy; Chemometrics; Leather authentication, Halal authentication.

I. INTRODUCTION

Malaysia continues to experience recurrent and severe natural disasters, particularly floods, which cause extensive economic, social, and educational disruptions. The Department of Statistics Malaysia reported that the 2022 floods affected nearly all states, resulting in billions of ringgit in damages and widespread disruption to livelihoods and learning [1]. These recurring events underscore the need to address infrastructural recovery and enhance disaster literacy and preparedness, particularly among vulnerable populations such as students and rural communities.

Despite ongoing national campaigns and community drills, disaster education in Malaysia remains largely reactive, insufficiently engaging, and limited in its long-term effectiveness. While such initiatives can raise short-term awareness, they often fail to cultivate lasting competencies or behavioural change that translate into effective disaster response. At the global level, the Midterm Review of the Sendai Framework (2015-2030) reinforces this concern, identifying persistent gaps in disaster risk reduction (DRR) education and noting uneven preparedness levels across communities, particularly in developing contexts [2]. These disparities suggest that a significant portion of the population remains under-equipped to anticipate, absorb, and adapt to recurring hazards.

Conventional methods, including lectures, brochures, and drills, dominate the disaster education landscape, yet they struggle to sustain learner attention, promote interactivity, or encourage meaningful engagement. Consequently, knowledge retention is low, and the transition from awareness to preparedness behaviour remains weak. This shortfall highlights the urgent need for innovative, interactive, and user-centred approaches to bridge the knowledge-to-action gap.

Recent evidence suggests that gamified and edutainment-based platforms can increase motivation, knowledge retention, and active participation, particularly among younger, digitally native populations. However, empirical studies systematically examining the influence of user interface (UI) and user experience (UX) design on usability, inclusivity, and adoption in disaster education remain scarce. In Malaysia, although agencies such as the National Disaster Management Agency (NADMA) have encouraged integration of disaster education into community frameworks [3], the absence of robust evaluation frameworks limits the institutionalisation and scalability of such digital initiatives.

This gap is particularly significant as rapid digitalisation demands that resilience strategies incorporate inclusive, technology-driven approaches aligned with both national and global frameworks. This research, therefore, addresses these gaps by evaluating the DisasterPrep application as a user-centred, gamified platform, explicitly linking UI/UX design features to disaster education effectiveness and policy relevance.

To address these challenges, this study introduces and evaluates DisasterPrep, a mobile edutainment application designed to enhance disaster preparedness through interactive tutorials, clear navigation, progress tracking, simulations, and quizzes. Specifically, the study pursues two objectives: (i) to

assess UI/UX effectiveness through structured survey analysis focusing on clarity, usability, interactivity, and engagement, and (ii) to contextualise findings within Malaysia's 10-10 MySTIE framework and the Sustainable Development Goals (SDGs 3 and 4) [4]-[6]. By aligning empirical evaluation with both design principles and policy frameworks, this work contributes evidence-based insights into the role of gamified applications in strengthening disaster resilience.

The remainder of the paper is organised as follows: Section II reviews related work; Section III describes the methodology; Section IV presents the results and discusses the findings; and Section V concludes with implications for research, policy, and practice.

II. RELATED WORK

In recent years, serious games and gamification have emerged as promising alternatives to conventional disaster preparedness education. Prior studies consistently demonstrate that interactive simulations, reward mechanisms, and scenario-based learning enhance awareness, motivation, and knowledge retention compared to passive methods [7]-[9], [10]-[13], [14], [15]. However, the effectiveness of these approaches depends heavily on the quality of UI/UX design, with navigation clarity, feedback, and immersion playing a strong role in shaping learner engagement.

A. Serious Games in Disaster Education

Existing games have demonstrated potential in specific domains, such as seismic risk [9], [11], humanitarian training [12], and inclusive disaster risk reduction [13]. Yet, most remain highly context-specific, with limited transferability across hazard types or learner groups. Furthermore, their evaluations often focus on awareness outcomes, with little systematic assessment of usability or long-term adoption.

B. UI/UX in Educational Games

Established instruments, such as the System Usability Scale (SUS) [16] and User Experience Questionnaire (UEQ) [17], along with modular extensions such as UEQ+ [18], provide validated frameworks for evaluating usability and experience. These tools informed the design of the custom survey instrument for DisasterPrep, ensuring methodological rigour while tailoring metrics to disaster education. Unlike prior works that seldom apply structured UI/UX evaluation, DisasterPrep integrates both dimensions into its assessment, enabling a holistic understanding of usability, inclusivity, and engagement.

C. Learning Theory Foundations for UI/UX Design

The design of educational games must be grounded in robust learning theories to ensure that technology enhances, rather than hinders, knowledge acquisition. Mayer's Cognitive Theory of Multimedia Learning (CTML) emphasises the integration of verbal and visual channels, encouraging the use of concise text, meaningful graphics, and interactive elements to support dual coding and retention [19]. Similarly, Cognitive Load Theory (CLT) emphasises reducing

extraneous load, allowing learners to focus their cognitive resources on essential tasks [20].

Prior disaster education games have implicitly drawn on these theories, often through scenario-based learning or simplified simulations. However, few have explicitly connected CTML or CLT principles to UI/UX evaluation. In DisasterPrep, these frameworks informed the design of tutorials, navigation clarity, and progress tracking, which users identified as the most valued features. For instance, tutorials reduce intrinsic cognitive load by scaffolding learning, while progress indicators minimise uncertainty and help sustain motivation. By explicitly integrating CTML and CLT into UI/UX design, DisasterPrep bridges the gap between pedagogical theory and practical usability evaluation, ensuring that the application engages and optimises cognitive processing for disaster preparedness learning.

D. Policy and Global Development Alignment

Beyond theoretical grounding, disaster preparedness tools must align with national and international policy frameworks to ensure scalability and sustainability. In Malaysia, the 10-10 MySTIE Framework identifies Smart Technology Applications and Education for the Future Workforce as key drivers of innovation, promoting digital inclusiveness and human-centric solutions. At the global level, the Sendai Framework for Disaster Risk Reduction (2015-2030) calls for stronger integration of education and technology in building community resilience, while the Sustainable Development Goals (SDGs) emphasise inclusive quality education (SDG 4) and health resilience (SDG 3) [2], [4], [6], [21]-[23].

Many disaster education applications fail to effectively connect with relevant policy contexts, focusing primarily on engagement rather than broader societal impacts. DisasterPrep differentiates itself by linking its design evaluation to Malaysia's innovation agenda and global resilience goals. This policy integration enhances its relevance to Malaysia's disaster management, including NADMA initiatives, and positions it as a scalable model for other developing contexts. By aligning design, pedagogy, and policy, DisasterPrep demonstrates how digital edutainment tools can effectively build resilience in line with national and global priorities.

Although prior studies in disaster education have advanced gamification (A) and occasionally examined usability (B), they rarely integrate learning theory (C) with explicit policy alignment (D). DisasterPrep uniquely combines these four dimensions, offering a theoretically grounded, policy-aligned, and user-centred approach to scalable disaster preparedness education. This integrated positioning provides the methodological basis for a structured evaluation of the application's UI and UX, which is presented in the following section.

Table I synthesises representative examples of disaster education games and UI/UX frameworks, underscoring the fragmented nature of prior approaches. Serious games consistently demonstrate improvements in awareness and engagement. Yet, most remain context-specific, such as seismic, nursing, or humanitarian training, with limited generalizability. Similarly, established evaluation instruments such as the SUS, UEQ, and UEQ+ provide validated measures of usability and experience. However, they are

rarely prepared for disasters, leaving a critical gap in systematic evaluation.

DisasterPrep addresses this gap by combining gamified edutainment with structured UI/UX evaluation, situating its development within Malaysia's 10-10 MySTIE framework and aligning with the global agendas of SDG 3 and SDG 4. By bridging methodological rigour with policy relevance, it contributes both localised insights and a globally adaptable model for disaster education. The following section details the methodology adopted to design, implement, and evaluate this approach.

TABLE I. COMPARISON OF RELATED WORK IN DISASTER EDUCATION AND UX EVALUATION

Study / Year	Focus Area	Key Contribution / Limitation
Bai (2024) [1]	Gamification in disaster education	Broad review of gamified teaching benefits; limited empirical validation, nursing-focused.
Goretti & Musacchio (2024) [3]	Seismic risk education	Serious games improved school-level awareness, but it was context-specific and not generalizable.
Mukherjee & Guardiola (2024) [11]	Humanitarian training	Serious games for crisis decision-making; they lack outcome-based validation.
Buchanan (2023) [12]	Inclusive DRR education	Advocates play games for marginalised groups, largely through conceptual, limited, and large-scale trials.
Hyzy et al. (2022) [4]	Usability evaluation (SUS)	Benchmark usability scores; not disaster-specific.
Schrepp (2022, 2023) [5,6]	UX evaluation (UEQ, UEQ+)	Validated UX instruments; flexible but complex to apply.
Tsai et al. (2020) [21]	Flood education	Serious game for prevention; small-scale, older study.
Boothe et al. (2024) [22]	UX evaluation (UEQ-G)	Holistic multimodal UX tool; limited disaster-specific testing.
Ali Pitchay et al. (2024) [20]	DisasterPrep app	Strong usability focus; early-stage, limited deployment.

A review of the literature indicates that serious games for disaster education have successfully demonstrated gains in awareness, engagement, and knowledge retention [7]-[14]. However, most applications are context-specific, such as nursing education, seismic risk, or humanitarian training, and lack transferability across diverse hazard types or learner groups. Moreover, while they leverage interactivity and scenario realism, few incorporate systematic UI/UX evaluations, creating a gap between engagement design and actual usability. This fragmentation underscores the need for approaches that integrate both pedagogical depth and user-centred design principles to ensure that digital disaster education tools have a consistent impact at scale.

From a policy and global development perspective, bridging this gap significantly advances Sustainable

Development Goal 3 (Good Health and Well-Being) by enhancing community capacity to manage health and safety risks, and Sustainable Development Goal 4 (Quality Education) by offering inclusive, engaging, and technology-enabled learning opportunities. In the Malaysian context, such innovations resonate with the 10-10 MySTIE Framework, which particularly emphasizes the drivers of Smart Technology Applications and Education for Future Workforce, which focus on human-centric digital solutions and fostering resilience through knowledge. By integrating disaster preparedness applications within these frameworks, initiatives like DisasterPrep can exemplify how national policy and global development goals align to promote scalable, evidence-based digital resilience education.

III. METHODOLOGY

In software engineering and educational technology, user experience (UX) evaluation is increasingly recognised as an iterative, embedded process rather than a post-development task. Prior work (e.g., [15]) stressed the significance of explicitly defining UX goals, while frameworks such as FRAMUX-EV [16] illustrated how UX artefacts can be systematically embedded within Agile workflows. This perspective guided the iterative design of DisasterPrep, ensuring that usability and user satisfaction were continuously addressed (Figure 1).

The evaluation employed a structured survey methodology to capture both user interface (UI) and user experience (UX) dimensions. Items were measured on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). UI items addressed navigational clarity, icon comprehensibility, progress indicators, controller layout, colour palettes, animation smoothness, glow indicators, narration clarity, and automated certification. UX items focused on navigation flow, tutorial effectiveness, support availability, content informativeness, progress tracking, scenario realism, quiz integration, ease of configuration, and ergonomic layout. To ensure authentic evaluation, the survey was administered only after participants completed one full cycle of gameplay, defined as progressing through a complete disaster scenario, including tutorials, simulations, quizzes, and certification.

Participants primarily included university students aged 17 to 25, with smaller groups comprising secondary school learners and adults aged 26 and older. While this mix provided diversity in digital literacy, the sample was modest and student-heavy, limiting generalizability. The survey instrument was self-developed yet adapted from established frameworks, such as the System Usability Scale (SUS) [4] and the User Experience Questionnaire (UEQ/UEQ+) [5,6], to enhance methodological validity.

Data analysis involved descriptive statistics, including mean, standard deviation, minimum, and maximum values. The Likert mean was calculated using the standard formula (1):

$$\bar{x} = \frac{\sum_{i=1}^n x_i}{n}, \quad (1)$$

where x_i represents the score of respondent i and n is the number of respondents. This approach, which treats ordinal data as interval data, is widely accepted in usability research [29], allowing meaningful aggregation of central tendencies. Standard deviations quantified variability in perceptions, enabling the identification of features with higher response divergence (e.g., simulation realism and quiz integration). Results were presented in tabular form (Tables II–III) for precision and bar charts (Figure 2 & Figure 3) for clarity.

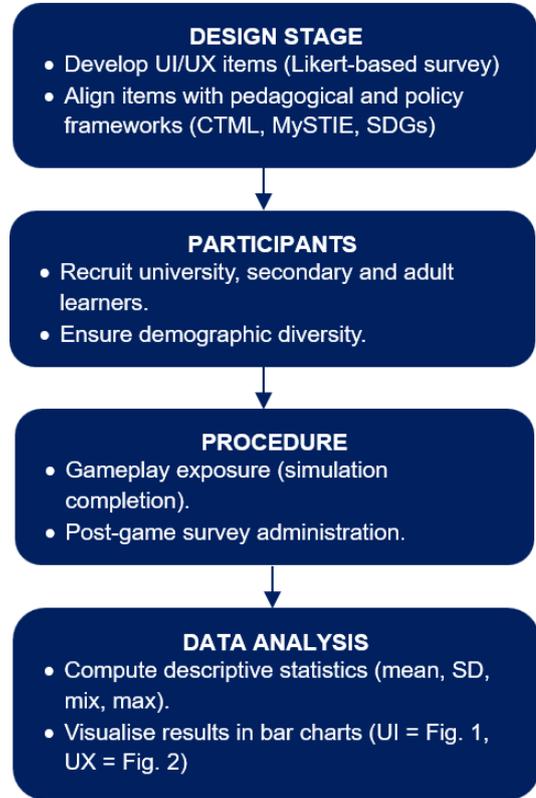


Figure 1. Methodology framework of the DisasterPrep evaluation.

The methodological process consisted of four sequential stages: (1) Design Stage – development of survey items aligned with CTML, CLT, MySTIE, and SDG frameworks; (2) Participants – recruitment of learners from different age groups; (3) Procedure – exposure to one full gameplay cycle followed by survey administration; and (4) Data Analysis – computation of descriptive statistics and interpretation of findings. This process is illustrated in Figure 3, ensuring that DisasterPrep was evaluated with both theoretical grounding and methodological rigour.

IV. FINDINGS AND DISCUSSION

The demographic analysis confirmed that most respondents were university-aged learners (17 to 25 years), with a smaller representation from secondary school students and adults aged 26 or older. The gender distribution slightly favoured female participants, consistent with trends in higher education cohorts. Meanwhile, the gaming experience varied from extensive to none. This demographic spread ensured the evaluation incorporated perspectives from both digitally

experienced and novice users, supporting inclusivity in assessing usability and learning outcomes.

Educational background was heavily concentrated among college/university students (particularly from USIM), with fewer participants from secondary schools and almost none from primary schools. When asked about prior gaming experience, responses varied: a significant subset reported “a lot” of experience (five or more games), while others indicated moderate or little exposure, and a small number had no prior gaming familiarity. This distribution demonstrates that while the tool was primarily assessed by digitally literate university students, it also captured perspectives from younger learners and individuals with varying levels of gaming exposure. This approach ensures a degree of representativeness for both experienced and novice users in evaluating UI and UX features.

A. User Interface (UI) Evaluation Results

UI features were rated positively overall, with mean scores ranging from 4.04 to 4.60 (Table II). The highest score was for automatic certificate generation ($M = 4.60$, $SD = 0.65$), highlighting the motivational value of achievement recognition. Menu clarity ($M = 4.40$, $SD = 0.76$) and pop-up accuracy ($M = 4.48$, $SD = 0.77$) also received strong endorsements, confirming that navigation and informational cues effectively enhanced the user experience.

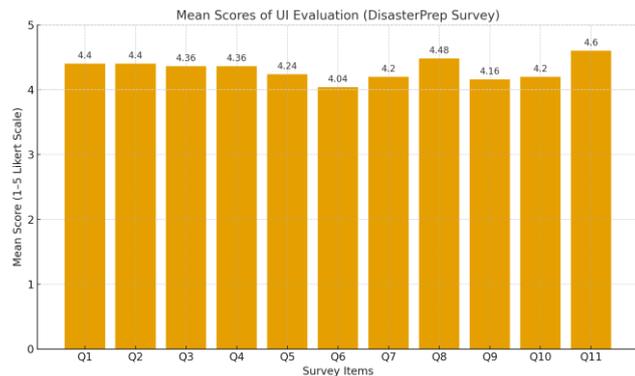


Figure 2. Mean scores of DisasterPrep UI evaluation survey items ($n =$ respondents). Ratings were based on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). The results reveal consistently high satisfaction across all interface elements, with the highest mean for certificate generation ($M = 4.60$) and the lowest for animations and transitions ($M = 4.04$).

As illustrated in Figure 2, the mean scores for UI elements reveal consistently high satisfaction, with most features scoring well above 4.0 on the 5-point scale. The certificate generation system ($M = 4.60$) stands out as the most highly valued feature, reinforcing the motivational role of achievement recognition. Other features, such as pop-up information ($M = 4.48$) and menu clarity ($M = 4.40$), underscore the importance of clear navigational cues and accurate information support in enhancing usability.

The relatively lowest-rated elements were animation smoothness ($M = 4.04$, $SD = 0.89$) and quiz interactivity ($M = 4.20$, $SD = 0.96$). While still above satisfactory thresholds, qualitative comments suggested that some animations distracted from gameplay focus, and quizzes required clearer

feedback cues. Compared to SUS benchmarks (average $\approx 68 - 70$) and UEQ dimensions such as “stimulation” and “novelty,” these results suggest room for refinement, particularly in reducing extraneous cognitive load and improving consistency of interactivity. Similarly, quiz interactivity ($M = 4.20$) presented greater variability, with participants suggesting that clearer feedback indicators (e.g., instant correctness cues) could enhance the learning value of the quiz experience.

Thus, Figure 2 visualises the quantitative distribution of UI evaluations and highlights critical areas for refinement, particularly balancing aesthetic design (animations) with functional clarity and reinforcing interactivity (quizzes) to sustain learner engagement.

Based on Table II, the highest-rated feature was the automatic certificate generation ($M = 4.60$, $SD = 0.65$), confirming its effectiveness in reinforcing user achievement. Conversely, the dimensions of animation smoothness and non-intrusiveness received the lowest mean rating ($M = 4.04$, $SD = 0.89$), suggesting a critical need for refinement in these areas. This indicates that enhancements are necessary to minimize potential distractions during gameplay, thereby improving the overall user experience.

TABLE II. DESCRIPTIVE STATISTICS OF DISASTERPREP UI EVALUATION SURVEY ITEMS

Item No.	UI Element Evaluated	Mean	SD	Min	Max
Q1	Menu button clarity	4.40	0.76	3.0	5.0
Q2	Settings icons comprehensibility	4.40	0.82	2.0	5.0
Q3	Disaster progress display	4.36	0.64	3.0	5.0
Q4	Controller arrangement	4.36	0.76	3.0	5.0
Q5	Color palette appropriateness	4.24	0.88	2.0	5.0
Q6	Animation smoothness & non-intrusiveness	4.04	0.89	2.0	5.0
Q7	Quiz interactivity (drag-and-drop)	4.20	0.96	2.0	5.0
Q8	Pop-up information accuracy	4.48	0.77	3.0	5.0
Q9	Narrator audio clarity	4.16	0.85	2.0	5.0
Q10	Glow indicators visibility	4.20	0.87	2.0	5.0
Q11	Automatic certificate generation	4.60	0.65	3.0	5.0

Overall, the results confirm that the DisasterPrep UI is highly usable and pedagogically effective, with its strongest elements being navigational clarity, informational feedback, and certification mechanisms. However, improvements in animation subtlety, visual highlights, and narration clarity could further optimise inclusivity and engagement across diverse learner groups.

B. User Experience Evaluation Results

UX scores also indicated high satisfaction, with means ranging from 4.20 to 4.56 (Table III, Figure 3). Tutorials ($M = 4.56$, $SD = 0.65$) and navigation flow ($M = 4.48$, $SD = 0.71$) were the strongest contributors, confirming the value of structured onboarding and intuitive progression. Progress tracking ($M = 4.44$, $SD = 0.71$) and multi-scenario coverage ($M = 4.44$, $SD = 0.71$) also reinforced the application’s pedagogical effectiveness.

The lowest scores appeared in realistic simulations ($M = 4.20$, $SD = 1.00$) and quiz integration ($M = 4.24$, $SD = 0.97$). Variability here indicates that while many found the features engaging, others noted a lack of immersion in simulation realism and a limited depth of interactivity. Benchmarking against UEQ's "perspicuity" and "stimulation" scores suggests these features may fall short of expectations for experiential learning, underscoring the need for greater realism, more diverse scenarios, and more dynamic quiz mechanics.

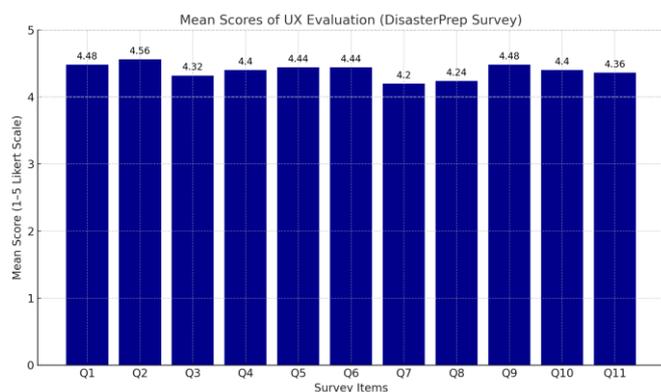


Figure 3. Mean scores of DisasterPrep UX evaluation survey items ($n =$ respondents). Ratings were based on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). The highest-rated item was the tutorial module ($M = 4.56$), while the lowest-rated item was the realistic simulations ($M = 4.20$); however, all items demonstrated overall positive user experience outcomes.

The analysis of UX-related items indicated consistently high user satisfaction across all measured features, as summarised in Table III. Mean scores ranged from 4.20 to 4.56, reflecting strong usability and engagement in the overall design of the DisasterPrep application. The most highly rated element was the training and tutorial module ($M = 4.56$, $SD = 0.65$), which participants valued for providing structured onboarding and easing the learning curve for gameplay. This was closely followed by page-to-page navigation clarity ($M = 4.48$, $SD = 0.71$) and the certificate reward system ($M = 4.48$, $SD = 0.82$), confirming the importance of intuitive flow and motivational reinforcement in sustaining user engagement. Similarly, progress-tracking features ($M = 4.44$, $SD = 0.71$) and multiple disaster-scenario representations ($M = 4.44$, $SD = 0.71$) were highly regarded, suggesting that the application successfully combined interactive design with pedagogical reinforcement.

Other aspects, such as informative content ($M = 4.40$, $SD = 0.76$), settings configuration ease ($M = 4.40$, $SD = 0.87$), and ergonomic joystick/button layout ($M = 4.36$, $SD = 0.86$), also received strong ratings, indicating that both informational and control-based features were accessible and user-friendly. The relatively lowest scores were observed in realistic simulations ($M = 4.20$, $SD = 1.00$) and quiz integration ($M = 4.24$, $SD = 0.97$), both of which demonstrated greater variability among respondents. While these elements were still positively evaluated, the higher standard deviations suggest that participants' experiences of immersion and interactivity were less uniform.

TABLE III. DESCRIPTIVE STATISTICS OF DISASTERPREP UX EVALUATION SURVEY ITEMS

Item No.	UX Element Evaluated	Mean	SD	Min	Max
Q1	Page-to-page navigation clarity	4.48	0.71	3.0	5.0
Q2	Training/tutorial effectiveness	4.56	0.65	3.0	5.0
Q3	Visual/auditory assistance adequacy	4.32	0.75	3.0	5.0
Q4	Informative content for preparedness	4.40	0.76	3.0	5.0
Q5	Progress tracking display	4.44	0.71	3.0	5.0
Q6	Multiple disaster scenarios representation	4.44	0.71	3.0	5.0
Q7	Realistic simulations for immersion	4.20	1.00	2.0	5.0
Q8	Quiz integration into simulations	4.24	0.97	2.0	5.0
Q9	Certificate reward for completing all difficulty levels	4.48	0.82	2.0	5.0
Q10	Ease of settings configuration	4.40	0.87	2.0	5.0
Q11	Ergonomic joystick/button layout	4.36	0.86	2.0	5.0

The findings from both the UI and UX evaluations demonstrate that DisasterPrep has achieved a high degree of usability, educational relevance, and engagement. The UI analysis confirmed the strength of navigational clarity, informational feedback, and automated certification, while the UX results highlighted the effectiveness of structured tutorials, intuitive navigation, and motivational reward systems. Together, these outcomes confirm that the application successfully met core usability standards and effectively embedded pedagogical and motivational strategies to enhance learning in disaster preparedness.

Importantly, these findings align with MySTIE strategic drivers, particularly Smart Technology Applications, Education for Future Workforce, and Medical & Healthcare Technology. By combining clear user interface design with interactive, simulation-based learning, DisasterPrep reflects the MySTIE emphasis on human-centric digital innovation and knowledge-driven solutions for societal resilience. The gamified elements and automated feedback systems also align with the MySTIE goal of building a digitally skilled future workforce. The inclusion of realistic disaster scenarios directly supports the mission of leveraging technology to enhance healthcare and safety outcomes.

Tables II and III highlight the consistently high ratings of DisasterPrep's UI and UX features, with mean scores largely above 4.0 on the 5-point scale. UI strengths (Table II), such as menu clarity, pop-up information, and certificate generation, confirm prior studies' findings that interactivity and reward systems drive engagement in gamified learning [7]-[13]. Similarly, UX strengths (Table III), particularly tutorials, navigation flow, and progress tracking, reflect principles from UEQ benchmarks [17], [18] that emphasise clarity and perspicuity as critical for sustaining engagement. Compared to the fragmented focus in prior disaster games, which are often domain-specific (e.g., seismic [9], humanitarian [12]) and rarely combine both UI and UX evaluations, DisasterPrep demonstrates a methodological advance by systematically integrating both dimensions.

The lower-rated features (animations, simulation realism, and quiz integration) echo gaps noted in the literature, where

studies reported limitations in immersion, scalability, or interactivity [8], [11], [13]. The higher variability ($SD \approx 0.9 - 1.0$) for these features suggests differing expectations among users with varied digital literacy levels, underscoring the importance of adaptive design. In benchmarking terms, while overall UI/UX scores compare favourably with SUS "good usability" thresholds, the variability highlights the need for refinements aligned with Cognitive Load Theory to minimise distractions and improve immersion.

Table IV enhances this discussion by mapping features to MySTIE drivers and SDG targets, demonstrating how design choices transcend mere usability to engage with policy relevance. For example, certificate generation enhances user motivation (which received high ratings in Tables II and III) and operationalizes MySTIE's "Education for Future Workforce" initiative through gamified pedagogy. In a similar vein, while immersive simulations may have received lower ratings for realism, they directly contribute to SDG 3 by promoting preventive health measures. Furthermore, clarity in the user interface (UI) aligns with MySTIE's aim of developing "human-centric digital systems" by minimizing barriers to learning. This synthesis underscores the distinctiveness of DisasterPrep: it effectively combines methodological rigor in UI/UX integration with critical global and national policy objectives, addressing a gap that has been largely overlooked in prior related work.

TABLE IV. MAPPING OF DISASTERPREP FEATURES TO MYSTIE DRIVERS AND SDG 3 & 4

DisasterPrep Feature	MySTIE Driver Alignment [15]	SDG 3: Good Health & Well-Being [25]	SDG 4: Quality Education [26]
Clear UI (menus, navigation, intuitive controls)	<i>Smart Technology Applications</i> (human-centric digital systems)	Enhances access to life-saving preparedness knowledge, reducing risk in crises	Supports inclusive access to digital learning environments
Immersive simulations (realistic animations, narration, scenarios)	<i>Cybersecurity & Encryption</i> (secure, reliable digital platforms)	Promotes health resilience by simulating safe responses in disasters	Provides experiential, scenario-based learning aligned with 21st-century skills
Gamified quizzes, drag-and-drop interactivity, automatic certificates	<i>Education for Future Workforce</i> (digital & gamified pedagogy)	Reinforces preparedness behaviors linked to reduced health vulnerabilities	Strengthens active learning, assessment, and motivation in education
Joystick & button ergonomics, smooth gameplay	<i>Smart Technology Applications</i> (design thinking, ergonomics)	Reduces stress in learning environments, supporting psychological well-being	Increases accessibility of digital education through usability principles
Color palette, glow indicators, feedback signals	<i>Arts, Culture & Creative Industries</i> (applied design for society)	Ensures clarity during time-critical disaster decision-making	Enhances cognitive load management for effective learning
Multiple disaster scenarios	<i>Medical & Healthcare Technology</i>	Promotes awareness of diverse health	Expands breadth of knowledge across contexts,

(floods, outbreaks, etc.)	(preparedness for public health crises)	and safety hazards	reinforcing equitable education
Knowledge-embedded pop-ups and progress tracking	<i>Education for Future Workforce</i> (knowledge-driven innovation)	Improves awareness of preventive health actions	Encourages continuous monitoring of learning outcomes
Scalability & localization potential	<i>National Missions: Social Inclusivity & Digital Society</i>	Extends preparedness to vulnerable and rural populations	Supports equitable and inclusive lifelong learning opportunities

V. CONCLUSION

The evaluation of DisasterPrep confirms its effectiveness in integrating user-centred interface design with pedagogically sound user experiences, yielding consistently high satisfaction across UI and UX features. Strengths such as intuitive navigation, structured tutorials, and automated certification align with Malaysia's MySTIE drivers and global frameworks, particularly SDG 3 (Good Health and Well-Being) and SDG 4 (Quality Education). This affirms the platform's dual value as both an educational innovation and a resilience-enhancing tool.

The research's novelty lies in systematically combining UI/UX evaluation with policy alignment, a gap rarely addressed in disaster education research. While improvements are needed in animation design, simulation realism, and quiz interactivity, these refinements will broaden inclusivity and scalability. Looking ahead, DisasterPrep can serve as a flagship model for digital disaster resilience education, scalable across Malaysia and adaptable globally, paving the way for stronger community preparedness and digitally literate, safety-conscious societies.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

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REFERENCES

- [1] Department of Statistics Malaysia, *Special Report on Impact of Floods in Malaysia 2022*. Putrajaya, Malaysia: Department of Statistics Malaysia, 2023. [Online]. Available: <https://www.dosm.gov.my>
- [2] United Nations Office for Disaster Risk Reduction, *Report of the Midterm Review of the Implementation of the Sendai Framework 2015–2030*, 2023. [Online]. Available: <https://sendaiframework-mtr.undrr.org/reports-midterm-review-implementation-sendai-framework-disaster-risk-reduction-2015-2030>
- [3] A. S. Zainal Azman, "Malaysia: National Disaster Management Agency (NADMA) and its philosophy," in *Proc. Asian Conf. Disaster Reduction (ACDR)*, 2017.

- [4] Academy of Sciences Malaysia, "10-10 MySTIE Framework," 2020. [Online]. Available: <https://www.akademisains.gov.my>
- [5] United Nations, "SDG 3: Good health and well-being." [Online]. Available: <https://sdgs.un.org/goals/goal3>
- [6] United Nations, "SDG 4: Quality education." [Online]. Available: <https://sdgs.un.org/goals/goal4>
- [7] S. Bai, H. Zeng, Q. Zhong, Y. Shen, L. Cao, and M. He, "Application of gamification teaching in disaster education: Scoping review," *JMIR Serious Games*, vol. 12, p. e64939, 2024.
- [8] L. Galbusera, M. Cardarilli, M. Gómez Lara, and G. Giannopoulos, "Game-based training in critical infrastructure protection and resilience," *Int. J. Disaster Risk Reduction*, vol. 78, p. 103109, 2022.
- [9] A. Goretti and G. Musacchio, "Serious games for seismic risk education: The case of the ENP-CP project," *GeoHazards*, vol. 5, no. 2, pp. 310–328, 2024.
- [10] D. Tzioutzios, S. Song, H. Bean, and A. M. Cruz, "Serious gaming for Natech risk awareness: Introducing EGNARIA," *Int. J. Disaster Risk Reduction*, vol. 115, p. 105080, 2024.
- [11] M. Giuffrè, V. Tomassoni, M.S. Benigni & C. Fontana, "Pathways to seismic risk awareness in urban areas," *Int. J. Disaster Risk Reduction*, 2025.
- [12] P. Mukherjee and E. Guardiola, "Serious games for education and training in the humanitarian sector: State of the art," in *Proc. 18th Eur. Conf. Games Based Learn.*, 2024, pp. 1155–1162.
- [13] P. Buchanan, "Serious games as an inclusive disaster risk reduction tool," Natural Hazards Center, Univ. of Colorado Boulder, 2023. [Online]. Available: <https://hazards.colorado.edu/uploads/freeform/buchanan-literature-review-web-v2.pdf>
- [14] S. Bai, H. Zeng, Q. Zhong, L. Cao, and M. He, "Effectiveness of gamified teaching in disaster nursing education for health care workers: Systematic review," *J. Med. Internet Res.*, vol. 27, p. e74955, 2025.
- [15] A. Hinderks, F. J. Domínguez Mayo, J. Thomaschewski, and M. J. Escalona, "Approaches to manage the user experience process in agile software development: A systematic literature review," *Inf. Softw. Technol.*, 2022.
- [16] M. Hyzy, R. Bond, M. Mulvenna, L. Bai, A. Dix, S. Leigh, and S. Hunt, "System usability scale benchmarking for digital health apps: Meta-analysis," *JMIR Mhealth Uhealth*, vol. 10, no. 8, p. e37290, 2022.
- [17] M. Schrepp, *User Experience Questionnaire (UEQ) Handbook*, 2022. [Online]. Available: <https://ueq-online.org>
- [18] M. Schrepp, *UEQ+ Handbook V5: Modular Extension of the UEQ*, 2023. [Online]. Available: <https://ueqplus.ueq-research.org>
- [19] R. E. Mayer and L. Fiorella, Eds., *The Cambridge Handbook of Multimedia Learning*, 3rd ed. Cambridge, U.K.: Cambridge Univ. Press, 2021.
- [20] R. E. Mayer, "Cognitive theory of multimedia learning," in *The Cambridge Handbook of Multimedia Learning*, 3rd ed., R. E. Mayer and L. Fiorella, Eds. Cambridge, U.K.: Cambridge Univ. Press, 2021, pp. 57–72.
- [21] Academy of Sciences Malaysia, "10-10 MySTIE Framework—Annual Report Update," 2021. [Online]. Available: <https://www.akademisains.gov.my/ar21/10-10-mystie-framework/>
- [22] World Health Organization, "SDG target 3.d—Early warning, risk reduction and management of global health risks." [Online]. Available: <https://www.who.int/data/gho/data/themes/topics/indicator-groups/indicator-group-details/GHO/sdg-target-3.d-national-and-global-health-risks>
- [23] M.-H. Tsai, Y.-L. Chang, J.-S. Shiau, and S.-M. Wang, "Exploring the effects of a serious game-based learning package for disaster prevention education: The case of Battle of Flooding Protection," *Int. J. Disaster Risk Reduction*, vol. 43, p. 101393, 2020.
- [24] C. S. Boothe, L. Strawderman, R. F. Burch V, B. K. Smith, C. L. Bethel, and K. Holmes, "Generalized user experience questionnaire (UEQ-G): Holistic measurement of multimodal UX," *J. User Experience*, vol. 19, no. 2, pp. 75–103, Feb. 2024.
- [25] S. Ali Pitchay, F. Ridzuan, A. H. A. Halim, and N. H. M. Alwi, "DISASTERPREP: Gamified mobile edutainment for future disaster preparedness and resilience," *Asian J. Teach. Learn. Higher Educ.*, vol. 16, no. 2, 2024.
- [26] L. F. Rojas, D. Quiñones, and C. Cubillos, "FRAMUX-EV: A framework for evaluating user experience in agile software development," *Appl. Sci.*, vol. 14, no. 19, p. 8991, 2024.
- [27] D. A. Norman, "Likert scales, levels of measurement and the 'laws' of statistics," *Adv. Health Sci. Educ.*, vol. 15, no. 5, pp. 625–632, Dec. 2010.
- [28] Y. S. N. Syed and R. Ibrahim, "Exploring user experience evaluation in mobile educational games: A systematic literature review," in *Proc. 2024 IEEE Int. Symp. Advances Comput. Intell. Eng. (ISCAIE)*, 2024, pp. 540–545.
- [29] M. Tian, L. Xie, W. Wei, Y. Chen, and J. Tang, "User experience and acceptability of a digital educational game for self-management health education among people living with HIV," *Patient Prefer. Adherence*, vol. 19, pp. 2593–2608, 2025.