

How to Safety Education Through Interactive Technology: Fire Safety Awareness and Preparedness

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Abstract

Despite widespread recognition of fire hazards, conventional fire safety education in schools — including brochures, instructional videos, and traditional classroom lessons — consistently fails to engage young learners or produce lasting behavioral changes. This study addresses a critical gap in educational practice by developing and evaluating an interactive, game-based learning tool designed to teach fire safety awareness and emergency preparedness to elementary, junior, and high school students in Japan. Grounded in gamification theory and design-based research, the game integrates interactive storytelling, rewards, and scenario-based decision-making to create an engaging and pedagogically effective learning experience. A pre- and post-implementation survey methodology was employed to assess changes in students' knowledge, attitudes, and preparedness. Initial findings from a pilot cohort indicate significant improvements in students' ability to identify fire hazards, recall emergency procedures, and respond appropriately in simulated scenarios. These results suggest that gamified educational tools represent a promising and scalable approach to disaster preparedness education, with implications for curriculum design, instructional technology, and community resilience at the K–12 level.

Keywords: gamification, game-based learning, disaster preparedness education, instructional technology, K-12 education

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Introduction

Effective disaster preparedness education remains one of the persistent challenges in K–12 schooling. Despite the well-documented risks of fire incidents — Japan’s Fire and Disaster Management Agency recorded over 36,000 fire incidents and more than 1,400 fatalities in 2022 alone — the educational response has remained largely unchanged, relying on passive transmission methods that fail to build genuine competence or sustained awareness in young learners. These incidents not only cause immediate destruction but also leave long-term economic and psychological impacts on affected communities, underscoring the urgency of preparing for the next generation through more effective educational approaches.

The educational challenges are compounded by societal trends that intensify fire risks while simultaneously making traditional instructional methods less effective. Urbanization has produced densely populated environments where fire hazards can escalate rapidly, yet school curricula have not kept pace with the complexity of these contexts. Climate change contributes to more extreme weather conditions — prolonged heatwaves and droughts — that heighten wildfire risks, demanding more sophisticated and adaptive approaches to safety education. Industrialization further introduces unfamiliar hazards through flammable materials and complex machinery, creating new knowledge gaps that passive instruction is ill-equipped to address.

Our study addresses this need by integrating advanced technologies and public education to enhance community resilience against fire disasters. Technology alone cannot solve the problem; education plays a crucial role in preparing individuals and communities to respond effectively to fire emergencies. Our approach focuses on creating an engaging and educational tool that bridges the gap between knowledge and action, empowering users to make informed decisions during fire incidents.

A critical gap in current practice is the absence of engaging, learner-centered educational tools for fire safety. Existing resources — brochures, instructional videos, and traditional classroom lessons — consistently fail to capture the sustained attention of younger audiences. These methods are frequently perceived as disconnected from lived experience, resulting in poor retention and limited transfer of safety knowledge to real-world behaviors. Children in primary and secondary school are particularly vulnerable, given their limited prior experience and the procedural complexity of fire emergency protocols. Bridging this pedagogical gap requires innovative approaches that align with how young learners engage: through play, interactivity, and narrative.

This study responds to these challenges by applying a design-based research approach to develop a gamified educational tool for fire safety. Drawing on established principles of game-based learning — including intrinsic motivation, immediate feedback, graduated challenge, and scenario-based problem-solving — the game situates fire safety knowledge within engaging, interactive narratives. This hands-on approach not only reinforces declarative knowledge but also supports the development of procedural competence and confidence in responding to emergencies, making it particularly appropriate for K–12 educational settings.

Our hypothesis is that well-prepared instruments and trained awareness can reduce the risk and injuries in fire accidents. The independent variable in this hypothesis is the presence of well-prepared instruments and trained awareness, while the dependent variable is the risk and

injuries in fire accidents. By focusing on these variables, we aim to demonstrate that proactive education and preparedness can significantly mitigate the impact of fire disasters.

To test this hypothesis, we conducted a survey (see Table 1) and gathered feedback from users of our fire safety educational game. The data collected will allow us to assess the effectiveness of the educational content in improving fire safety awareness and preparedness.

We have developed the main ideas for our fire educational game, structuring its sections to engage users effectively. This foundation is crucial for attracting users and delivering impactful fire safety education. Our fire game is designed to address various aspects of fire safety, including prevention, emergency response, and post-incident recovery. Each section of the game is tailored to different learning styles, ensuring that all users can benefit from the content. For example, visual learners benefit from interactive simulations and animations, while auditory learners can engage with narrated scenarios and instructions (see Figure 1).

Our study will involve elementary, junior, and high school students in Japan, who will play the educational game and complete a questionnaire to provide feedback. This demographic was chosen because early education on fire safety can instill lifelong habits and awareness, significantly reducing the likelihood of fire-related injuries and fatalities. By targeting young students, we aim to create a generation that is better equipped to handle fire emergencies and contribute to overall community resilience.

The data analysis plan involves analyzing the questionnaire responses to identify areas for improving the educational game and evaluating users' game scores to determine which sections need enhancement and to identify gaps in students' fire safety knowledge. This comprehensive approach ensures that our educational tool is both engaging and effective in conveying crucial fire safety information. The analysis will involve both quantitative and qualitative methods, providing a holistic understanding of the game's impact. Quantitative data from the surveys will be statistically analyzed to measure improvements in knowledge and preparedness, while qualitative feedback will offer insights into user experiences and suggestions for further development.

Ultimately, our goal is to reduce the risk and impact of fire disasters on communities by equipping individuals with the knowledge and skills necessary to respond effectively to fire emergencies. By combining advanced technology with engaging educational content, we aim to create a tool that not only educates but also empowers users to take proactive steps in ensuring their safety and the safety of those around them. This study represents a significant step forward in fire safety education, leveraging modern technology to address an age-old problem in a way that is both innovative and impactful.

Method

The methodology for this study is designed to ensure a comprehensive assessment of the educational game's effectiveness in enhancing fire safety awareness and preparedness among elementary, junior, and high school students in Japan. The study involves multiple phases, including participant selection, game development, implementation, and data analysis.

Participants for this study are elementary, junior, and high school students from various schools across Japan. These students were selected based on their willingness to participate and their ability to access the educational game. Parental consent was obtained for all participants,

ensuring ethical compliance and safeguarding the well-being of the children involved in the study. The primary tool for this study is an educational game designed to teach fire safety.

The fire game features interactive sections that engage users and provide crucial information about fire prevention, emergency response, and safety protocols (see Figure 1). The game is accessible on various digital platforms, including tablets and computers, making it widely available to students. The fire game has been designed to cater to the cognitive and attention spans of elementary, junior, and high school students, incorporating elements of gamification to enhance user engagement. Before implementation of the game, a pre-implementation survey was conducted to assess participants' baseline fire safety knowledge and preparedness.

The survey included questions about basic fire safety concepts, emergency response procedures, and students' perceived confidence in handling fire emergencies (see Table 1). The survey served as a benchmark for measuring the impact of the educational game and will be used to evaluate changes in fire safety knowledge and preparedness following gameplay.

After the game has been used by the students, a follow-up survey will be conducted to assess changes in their fire safety knowledge and preparedness. This survey will mirror the initial survey, allowing for a direct comparison of pre- and post-implementation results. Alongside the post-implementation survey, feedback will be collected from participants regarding their experience with the game, including what they enjoyed, what they found challenging, and suggestions for improvement. Teachers and facilitators will also provide feedback on the implementation process and the students' engagement levels.

The data collected from the pre- and post-implementation surveys will be analyzed to measure changes in fire safety knowledge and preparedness. Statistical methods will be used to determine the significance of any observed changes, providing a robust evaluation of the educational game's impact. Survey responses will be quantified and analyzed using descriptive and inferential statistics, such as mean scores, standard deviations, and t-tests, while qualitative feedback will be coded and categorized to identify recurring themes, providing insight into the game's strengths and areas for enhancement and guiding future iterations of the educational tool. By combining quantitative and qualitative data, we will gain a comprehensive understanding of the educational game's effectiveness and identify opportunities for further development. This methodological approach ensures that our educational tool is both engaging and impactful, ultimately contributing to the reduction of fire-related risks and injuries in communities.

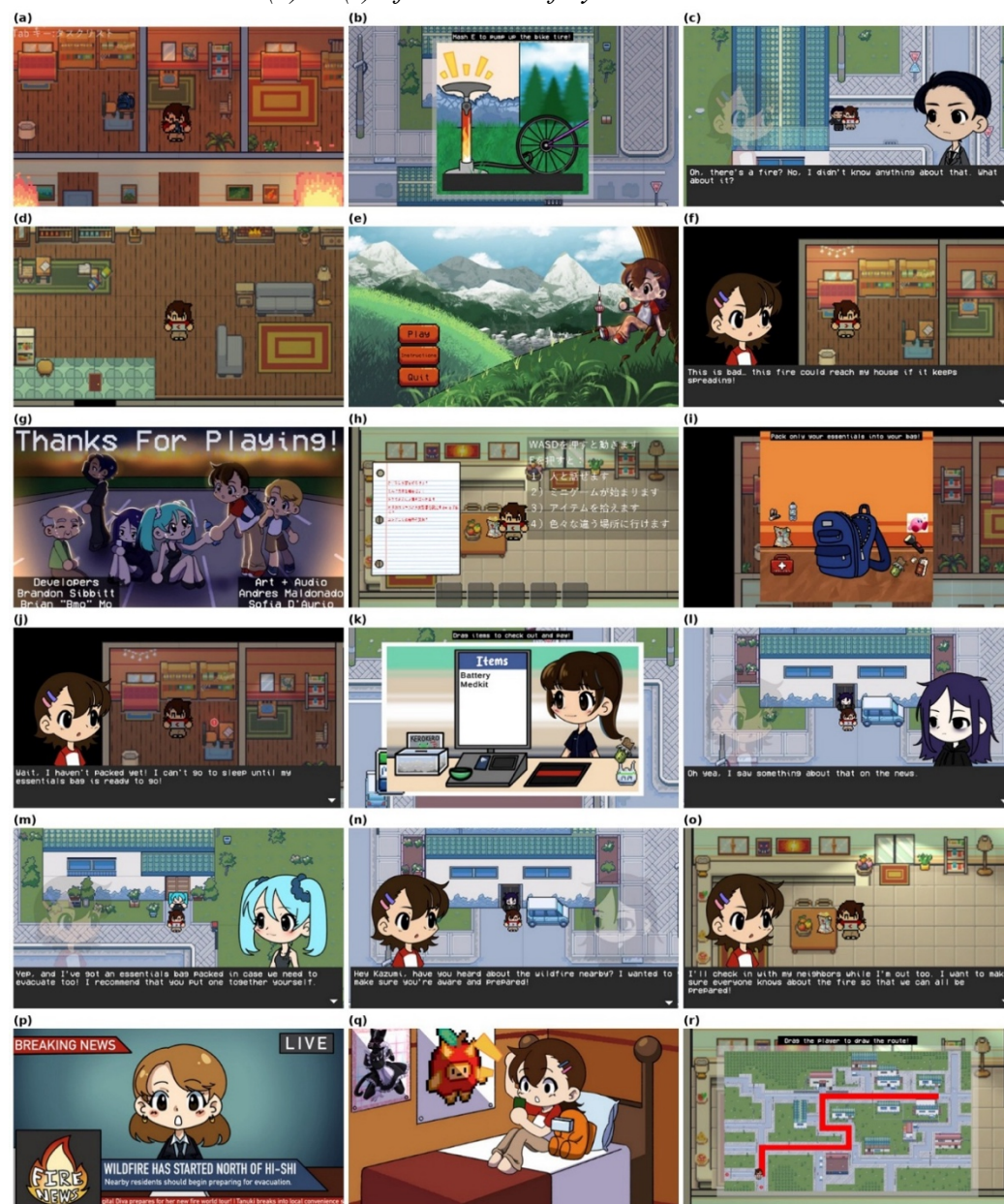
Table 1
Before Playing Fire Safety Game Questionnaire

No.	Question	Response Options
Section 1: Personal Information		
1	What school do you attend?	A. Elementary School Student B. Junior School Student C. High School Student
2	How old are you?	(open response)
3	What is your gender?	A. Male B. Female C. Other
4	Have you ever played a disaster-prevention game before?	Yes / No / I don't remember
5	Have you ever participated in a fire drill at school?	Yes / No / I don't remember
6	Have you ever experienced a fire in your home or its surroundings?	Yes / No / I don't remember

Section 2: Fire Safety Knowledge (Before the Game)		
1	Should you alert others by shouting “Kajida!” or “There’s a fire!”?	A. True B. False C. Maybe
2	Matches or lighters should not be placed where children can reach them.	A. True B. False C. Other
3	What should you do when a fire happens?	A. Hide under a desk B. Shout at others to run C. Stay calm, do nothing D. Inform neighbors, prepare to evacuate
4	What should you put in an emergency bag? (select all)	Drinking water; food (e.g., biscuits); comic books; flashlight; stuffed animals
5	What should you do escaping smoke from a fire? (select all)	Use elevator; wet towel over mouth/nose; open windows; stay low, cover mouth; run upstairs
6	Do you know where the emergency exits are in your home?	I know very well / I know a little / Not really / I have no idea

Note. n = 10.

Figure 1
Interactive Features (a) to (r) of the Fire Safety Game



Results

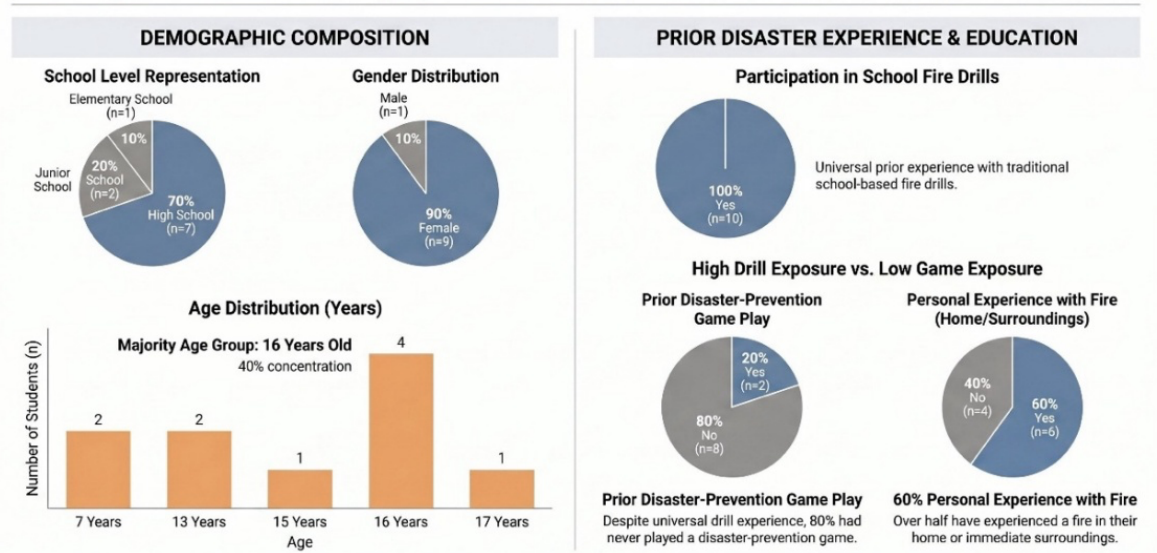
Figure 2 shows the questionnaire results for the personal information of the children before they played the fire safety game. Seven high schools, two junior high schools, and one elementary school students, respectively, participated in the survey. The youngest respondent to complete the questionnaire was seven years old and the oldest was seventeen; most respondents were sixteen years old. The proportion of female respondents was greater than that of male respondents.

In this survey, twenty percent of respondents had played a fire-safety game before, while more than half of the respondents had no prior experience playing such games. All respondents had received prior fire training, and more than half of the respondents had experienced a fire at home or in their neighborhood.

Figure 2

Section 1: Personal Information of Before Playing Fire Safety Game Questionnaire (English Version) Results

Participant Profile: Demographic and Experiential Baseline (n=10)



Source: Pilot Study Questionnaire (n=10 participants). 2024 Academic Research Data.

NotebookLM

Note. n = 10

Figure 3

Questionnaire Results (i) to (vi) for Fire Safety Knowledge Before the Game

Baseline Fire Safety Knowledge: Pre-Intervention Assessment of Japanese K-12 Students

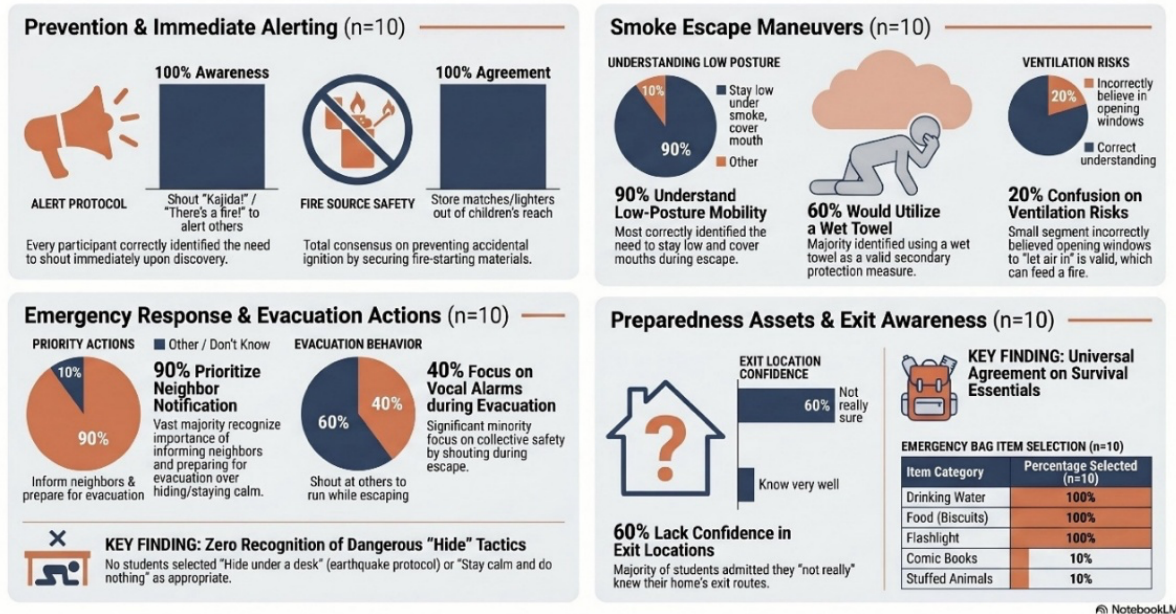


Figure 3 shows the questionnaire results for fire safety knowledge before students played the game. Figure 3(i) and (ii) show that all ten respondents agreed that they should shout "Fire!" to alert people nearby if they find a fire, and that matches and lighters should be kept out of the reach of children.

Figure 3(iii) shows that ninety percent of respondents agreed they should inform their neighbors and prepare to evacuate, while forty percent indicated they would shout at others to run from the fire.

Drinking water, biscuits, and a flashlight were the three items that all respondents chose to pack in their emergency bag (see Figure 3(iv)). Only ten percent would include comic books or stuffed animals in the emergency bag.

Figure 3(v) shows that ninety percent of respondents would stay low under the smoke and cover their mouth, and sixty percent would use a wet towel to cover their mouth and nose when escaping through smoke from a fire. Only twenty percent of respondents indicated they would open windows to let in more air, and no respondents selected using the elevator or running upstairs to find a safer place.

Figure 3(vi) shows that sixty percent of respondents did not know, and thirty percent knew only a little, where the emergency exits are in their home.

Our future is to increase the number of questionnaire responses by region in Japan, inviting elementary, junior, and high school students to play the game so that data obtained through the score system can serve as reference data for their baseline fire awareness.

Conclusion and Future Plan

In summary, as playing time increases, children can gather more of the items they need in a fire emergency and are better able to find an evacuation route to escape the site. This suggests that children's fire awareness and behaviors improve both in simulated fire scenarios and within the game itself, indicating that the game has a positive effect on fire education for elementary students. By integrating a well-structured methodology, control groups, realistic fire simulations, and long-term assessments, this project will contribute to safer school environments and enhanced community resilience against fire disasters.

Our future plan includes conducting further data analysis of questionnaire responses to identify areas for improving the educational game and evaluating users' game scores to determine which sections need enhancement and where gaps remain in students' fire safety knowledge. In addition, we plan to increase the number of questionnaire responses by region in Japan, inviting more elementary, junior, and high school students to play the game so that data obtained through the score system can serve as reference data for their baseline fire awareness. This score will be the average score per student, used to evaluate statistical tendencies across students. We also plan to develop a scenario in which a fire disaster is simulated within a building complex, using red ribbons moved by machines to represent fire and varying light brightness to represent smoke and lighting conditions during a fire.

Declaration of Generative AI and AI-Assisted Technologies in the Writing Process

The authors declare that NotebookLM, an AI-assisted tool, was used to assist in creating the graphics and visual materials presented in this manuscript, including figures illustrating the questionnaire results and the interactive game interface. The use of AI was limited to the generation and formatting of visual content and did not extend to the writing, analysis, or interpretation of the research. The ideas, design, procedures, findings, analyses, and discussion are originally written and derived from careful and systematic conduct of the research.

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