



DIGITAL INNOVATION IN INCLUSIVE DISASTER PREPAREDNESS EDUCATION: DISASTER RISK REDUCTION FOR DEAF STUDENTS THROUGH INTERACTIVE MULTIMEDIA LEARNING

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ABSTRACT

Children with hearing impairment are part of a vulnerable group that is often overlooked in disaster mitigation programs, largely because of limited access to emergency information and preparedness education. This study aims to evaluate the effectiveness of the Inclusive Disaster Risk Reduction learning intervention (IDRR), delivered through interactive learning media using Articulate Storyline, in improving disaster preparedness knowledge among students who are deaf. A quasi-experimental two-group pre-test and post-test design was conducted, involving 40 students with hearing impairments from special-education senior high schools in Surabaya, Indonesia. The study measured disaster preparedness using a modified preparedness questionnaire adapted from LIPI–UNESCO/ISDR. Paired-sample and independent-sample t-tests were used to analyze the data. The results showed a significant increase in disaster preparedness knowledge in both groups; however, the intervention group exhibited a greater increase ($p = 0,02$) than the control group ($p = 0,04$). A significant between-group difference was also observed (mean difference = 5,94; $p = 0,008$). These findings indicate that IDRR education based on Articulate Storyline is more effective than conventional instruction in improving disaster preparedness knowledge among students with hearing impairments. Interactive multimedia learning is an accessible strategy for strengthening inclusive disaster preparedness education for persons with disabilities in schools.

Keywords: inclusive disaster preparedness, deaf student, interactive multimedia learning

INTRODUCTION

People with disabilities are among the most vulnerable groups during disasters due to physical, sensory, cognitive, and communication barriers that limit their access to emergency information, warning systems, and evacuation procedures (Novalita and Widowati, 2018). This vulnerability has become increasingly significant as climate change intensifies the frequency and severity of disasters worldwide (Oxfam, 2021). Consequently, disaster risk reduction (DRR) policies have shifted toward more inclusive approaches that promote the participation and protection of persons with disabilities throughout disaster preparedness, response, and recovery processes (Stough and Kang, 2015).

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Indonesia is highly vulnerable to natural hazards, including earthquakes, floods, landslides, and volcanic eruptions. According to the National Disaster Management Agency (BNPB), more than 2,100 disaster events occurred in 2024, affecting approximately 4.8 million people nationwide (Bencana, 2025a, 2025b). However, disaster impacts are not experienced equally across populations. Persons with disabilities face higher risks of injury, mortality, and displacement during emergencies than the general population (Development, 2021). Children with disabilities are particularly vulnerable because they depend on caregivers and often have limited access to disaster preparedness education (Dyregrov, Yule and Olff, 2018). Previous studies in Indonesia have also highlighted the low level of emergency preparedness among children with special educational needs (Yulianti *et al.*, 2024).

Among disability groups, students with hearing impairments face unique challenges in disaster situations. Most disaster warnings and emergency communications rely heavily on auditory signals, limiting accessibility for deaf individuals (Savitri, Sya'ban and Fardiarman, 2024). In addition, disaster education programs are often not adapted to their communication needs, resulting in lower preparedness and disaster awareness (Rahmat *et al.*, 2020; Firdaus and Hayati, 2023). These challenges emphasize the need for accessible and inclusive disaster education that accommodates visual learning and alternative communication methods.

The concept of Inclusive Disaster Risk Reduction (IDRR), promoted through the Sendai Framework for Disaster Risk Reduction 2015–2030, emphasizes the active participation of persons with disabilities in disaster preparedness and resilience-building efforts (Stough and Kang, 2015). Within educational settings, IDRR aims to ensure that all students, regardless of disability status, acquire the knowledge and skills necessary to respond effectively to disasters. Previous studies have shown that disability-inclusive disaster education can significantly improve preparedness knowledge and awareness among students with special educational needs (Salmani *et al.*, 2020; Hussain, 2022). Nevertheless, affordable and accessible educational tools specifically designed for students with hearing impairments remain limited.

Recent advances in educational technology have introduced innovative approaches to disaster preparedness education. Interactive multimedia learning has been shown to improve learner engagement, motivation, and knowledge retention compared with conventional teaching methods (Mayer, 2021). Although technologies such as Virtual Reality (VR) and Augmented Reality (AR) offer immersive learning experiences, their implementation often requires expensive equipment and technical resources, making them less feasible for many special education schools (Savitri, Sya'ban and Fardiarman, 2024).

Grounded in the Cognitive Theory of Multimedia Learning, interactive learning environments that combine text, images, animations, and simulations can facilitate deeper understanding and long-term knowledge retention (Sorden, 2012). Articulate Storyline is an e-learning authoring platform that enables the development of interactive and visually rich learning materials tailored to learners' specific needs. Previous studies have reported its effectiveness in supporting learning among students with hearing impairments through accessible and engaging educational content (Rahayu and Khasanah, 2022).

Despite growing interest in disability-inclusive disaster education, limited research has examined the use of Articulate Storyline for disaster preparedness training



among deaf students. Therefore, this study aimed to develop and evaluate an Articulate Storyline-based disaster preparedness learning medium for students with hearing impairments. The findings are expected to contribute to the advancement of Inclusive Disaster Risk Reduction by providing an accessible, scalable, and cost-effective educational strategy to enhance disaster preparedness among vulnerable populations.

METHODS

This study employed a quantitative approach with a quasi-experimental, two-group pre-post test design. The research was conducted at SMALB-B Karya Mulia Surabaya, East Java, from May to November 2025. From a total population of 41 deaf students, 40 participants were selected using purposive sampling. The inclusion criteria comprised active deaf high school students without multiple disabilities who were proficient in sign language or text reading. Students who were absent or ill during the intervention were excluded. Participants were equally allocated into the intervention group ($n = 20$) and the control group ($n = 20$). Disaster preparedness knowledge was measured using a questionnaire adapted from the Indonesian Institute of Sciences (LIPI) and UNESCO/ISDR (2006). To accommodate deaf students, sentence structures were simplified, and administration was assisted by teachers using sign language. The instrument met the validity threshold with $r_{\text{count}} > r_{\text{table}}$ (0.444) and demonstrated high reliability with a coefficient of 0.83. The intervention spanned two weeks with one session per week. The intervention group received disaster preparedness training via Articulate Storyline media, while the control group received conventional learning. Data were analyzed using univariate and bivariate statistics. Univariate analysis summarized demographic characteristics using frequencies, percentages, means, medians, and standard deviations. Bivariate analysis evaluated the intervention's impact using Paired *T*-Tests and Independent *T*-Tests. This study obtained ethical clearance from the Health Evaluation Ethics Committee (Approval No. 011/UN38.10/EC.KEPK/HK.01.02/2025). Informed consent was obtained from all participants prior to data collection.

RESULT

Table 1. Frequency Distribution of Respondents Based on Respondent Characteristics

Respondent Characteristics	Frequency (n)	(%)
Gender		
Male	28	68,3
Female	13	31,7
Age		
Teenager	27	65,8
Adult	14	34,2
Education level		
Grade X	7	17
Grade XI	16	39
Grade XII	18	44

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Table 1 presents the demographic characteristics of the participants, including gender, age group, and educational level. Regarding gender distribution, the majority of respondents were male, accounting for 68.3% of the total sample.

Participants were categorized into two age groups: adolescents (<18 years) and adults (≥18 years). As shown in Table 1, most respondents belonged to the adolescent age group. This finding reflects the typical age distribution of students enrolled in special secondary education and highlights the importance of providing disaster preparedness education during adolescence, a critical period for developing knowledge, attitudes, and adaptive behaviors related to disaster risk reduction.

With respect to educational level, respondents consisted of 10th-grade students (17%), 11th-grade students (39%), and 12th-grade students (44%). The predominance of students in the upper grades indicates that most participants had greater exposure to formal educational content and learning experiences. This educational background is particularly relevant to disaster preparedness education, as students in higher grades are generally better equipped to understand more complex concepts related to disaster risk reduction and emergency preparedness.

Effect of Inclusive Disaster Risk Reduction Education on Disaster Preparedness Knowledge

Prior to hypothesis testing, data normality was assessed using the Shapiro–Wilk test. This test was selected because it provides reliable estimates of normality for small sample sizes ($n < 50$) within each study group. A p -value greater than 0.05 was considered indicative of a normal data distribution.

The results of the Shapiro–Wilk test showed that both pretest and posttest scores of disaster preparedness knowledge in the intervention and control groups had p -values greater than 0.05. These findings indicate that the data were normally distributed and met the assumptions required for parametric statistical analyses. Therefore, paired-samples t -tests and independent-samples t -tests were subsequently performed to evaluate within-group and between-group differences in disaster preparedness knowledge.

Table 2. Pretest–Posttest Comparison of Disaster Preparedness Knowledge in the Intervention Group

Variable	Mean	SD	p -value
Pretest	56,42	8,17	0,02
Posttest	79,37	6,83	

As shown in Table 2, the mean disaster preparedness knowledge score in the intervention group increased from 56.42 ($SD = 8.17$) at pretest to 79.37 ($SD = 6.83$) at posttest. The paired-samples t -test revealed a statistically significant difference between pretest and posttest scores ($p = 0.020$), indicating that the intervention had a significant positive effect on participants' disaster preparedness knowledge. These findings suggest that the Inclusive Disaster Risk Reduction (IDRR) learning intervention effectively improved students' understanding of disaster preparedness concepts. The substantial increase in mean knowledge scores following the intervention demonstrates the potential of the educational program to enhance disaster preparedness knowledge among students with hearing impairments.



Table 3. Pretest–Posttest Comparison of Disaster Preparedness Knowledge in the Control Group

Variable	Mean	SD	p-value
Pretest	56.79	6.53	0.040
Posttest	72.30	6.79	

As shown in Table 3, the mean disaster preparedness knowledge score in the control group increased from 56.79 (SD = 6.53) at pretest to 72.30 (SD = 6.79) at posttest. The paired-samples t-test indicated a statistically significant difference between pretest and posttest scores ($p = 0.040$), suggesting that participants in the control group also experienced an improvement in disaster preparedness knowledge following conventional instruction.

Although the control group demonstrated a significant increase in knowledge, the magnitude of improvement was lower than that observed in the intervention group. This finding indicates that conventional learning methods contributed to knowledge acquisition; however, their effectiveness may be less substantial than that of the Inclusive Disaster Risk Reduction (IDRR) intervention delivered through the interactive learning platform.

Comparison of Disaster Preparedness Knowledge Between the Intervention and Control Groups

Table 4. Between-Group Differences in Disaster Preparedness Knowledge Scores

Comparison	Mean Difference	95% CI	p-value
Intervention vs. Control	5.94	–10.22 to –1.65	0.008

To examine the effectiveness of the intervention relative to conventional instruction, an independent-samples t-test was conducted to compare disaster preparedness knowledge scores between the intervention and control groups. As presented in Table 4, a statistically significant difference was observed between the two groups ($p = 0.008$).

The intervention group achieved significantly higher knowledge scores than the control group, with a mean difference of 5.94 points (95% CI: –10.22 to –1.65). These findings indicate that the Inclusive Disaster Risk Reduction (IDRR) intervention delivered through the Articulate Storyline-based learning medium was more effective in improving disaster preparedness knowledge than conventional classroom instruction.

DISCUSSION

This study's findings indicate that the Inclusive Disaster Risk Reduction (IDRR) intervention delivered through interactive, Articulate Storyline-based instruction significantly improves disaster preparedness knowledge among students with hearing impairments. Although both the intervention and the control groups show similarly significant gains after the intervention, the intervention group achieves a substantially greater improvement. These results suggest that interactive multimedia learning provides additional educational benefits beyond conventional classroom instruction and can offer an effective approach to strengthening disaster preparedness among students with disabilities.

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The effectiveness of the intervention may also be explained by participants' characteristics. Most respondents are adolescents, who are in a developmental stage associated with curiosity, active exploration, and a preference for visually engaging learning experiences. Prior studies have shown that adolescents are more responsive to interactive digital environments that promote active participation and independent learning than to teacher-centered traditional approaches (Mutanda and Ngcamu, 2026). Using Articulate Storyline has increased students' engagement and motivation, thereby enabling a deeper understanding of disaster preparedness concepts.

The findings of this study also support the Cognitive Theory of Multimedia Learning (CTML), indicating that meaningful learning occurs when information is processed through both visual and verbal channels. According to Mayer's multimedia learning framework, instructional materials that combine text, images, animation, and interactive activities can improve understanding and retention by reducing cognitive load and promoting active knowledge construction (UNESCO, 2023). This principle is particularly well suited to students with hearing impairments, who rely heavily on visual information for communication and learning. The integration of illustrations, animations, quizzes, and scenario-based activities within the Articulate Storyline platform may strengthen students' ability to comprehend and recall disaster preparedness information.

The intervention in this study also helps address communication barriers that commonly constrain disaster preparedness among students with hearing impairments. Emergency alerts, evacuation instructions, and preparedness information are frequently communicated through the auditory channel, making them a significant challenge for individuals with hearing loss (Mayer, 2021). Limited access to disaster information is a key factor contributing to increased disaster vulnerability among people with disabilities (Yarosh, Schrier and Abowd, 2021). By presenting information in visual and interactive formats, the intervention enhances accessibility and participant engagement in disaster preparedness. These results corroborate earlier evidence showing that disability-responsive educational technologies can improve learning outcomes and educational participation among students with special educational needs (Sari *et al.*, 2026).

The findings of this study align with the most recent research on inclusive disaster education for persons with disabilities. Kang *et al.* reported that disability-tailored disaster risk reduction education significantly improves disaster knowledge, preparedness skills, and risk awareness (Kang *et al.*, 2025). Sheehy *et al.* also found that inclusive disaster education programs enhance disaster literacy among children in Indonesia when instructional content is adapted to the specific needs of learners (Sheehy *et al.*, 2024). School-based disaster education consistently indicates that preparedness programs contribute to greater disaster awareness and improved preparedness competence among students. This suggests that an easily accessible multimedia learning platform can effectively increase disaster preparedness knowledge among deaf students. This is in line with the findings of Calgaro *et al.* (2021), who emphasized that traditional emergency systems are not yet able to accommodate people with hearing impairments because they still use voice systems, requiring a transition to visually enriched digital communication tools (Calgaro *et al.*, 2021).



The Sendai Framework for Disaster Risk Reduction 2015–2030 emphasizes the importance of easily accessible information and the active participation of persons with disabilities (Salmani *et al.*, 2020). Inclusive disaster education for persons with disabilities remains limited in many low- and middle-income countries. The results of this study indicate that easily accessible digital learning technology can help implement the principles of the Sendai Framework by providing disaster preparedness education that accommodates students' communication and learning needs who have hearing impairments.

This research also supports several Sustainable Development Goals (SDGs). This intervention contributes to SDG 4 (Quality Education) by promoting inclusive and equitable learning opportunities through easily accessible digital education resources. The study also supports SDG 10 (Reduced Inequalities) by addressing gaps in access to disaster preparedness education among students with disabilities. It further contributes to SDG 13 (Climate Action), which highlights building resilience and adaptation to climate-related hazards (Reduction, 2015).

Articulate Storyline can be one possible solution for special education settings. Compared with advanced technologies such as virtual reality and augmented reality, which require substantial financial resources and specialized equipment, Articulate Storyline can be implemented using existing school infrastructure and commonly available digital devices (Sari *et al.*, 2026). This affordability is especially important in disaster-prone developing countries, where educational resources are often scarce. Effective Disability-Inclusive Disaster Risk Reduction (DiDRR) relies on a person-centered capabilities framework that can optimize existing tools to match the capacities of groups of people with disabilities (Villeneuve *et al.*, 2021).

The study provides evidence that an Articulate Storyline-based IDRR intervention can effectively improve disaster preparedness knowledge among deaf students. By reducing communication barriers, promoting inclusive learning, and supporting the global disaster resilience agenda, this approach constitutes a strategy that strengthens inclusive disaster preparedness education for persons with disabilities in schools. Some limitations of this study are that it was conducted only at a single special education school with a relatively small sample size, which may restrict the generalizability of the findings. In addition, this study focuses only on short-term knowledge outcomes and does not assess long-term retention, respondents' behavioral readiness, or disaster responses among the respondents.

CONCLUSION

The findings of this study indicate that the Inclusive Disaster Risk Reduction (IDRR) intervention using the interactive learning media Articulate Storyline effectively increases disaster preparedness knowledge among students with hearing impairments, to a greater extent than conventional instruction. By incorporating visual, interactive, and easily accessible learning features, this platform helps lessen—or even overcome—communication barriers and strengthens understanding of disaster preparedness concepts. Instruction that uses interactive multimedia as an inclusive, measurable, and cost-effective strategy supports disaster risk reduction education in special education settings while also aligning with the aims of the Sendai Framework and the Sustainable

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Development Goals related to quality education, reducing inequalities, and climate resilience.

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