



Research Article

# Integrating Artificial Intelligence and Local Wisdom in Disaster Comics to Strengthen Social Studies Learning in Coastal Cities

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**Abstract:** This study investigates the development of artificial intelligence (AI)-based disaster comics as an instructional medium for strengthening Social Studies learning in coastal urban settings. The study is motivated by the high vulnerability of Semarang City to floods and tidal flooding, along with the urgent need for disaster mitigation learning media that are contextual, visually engaging, and responsive to the learning characteristics of junior high school students. Adopting a Research and Development (R&D) design based on the Borg and Gall model, the study involved needs assessment, prototype design, product development, expert validation, and preliminary effectiveness testing using pre-test and post-test measures. The findings reveal that the digital comic, *Flood in the Urban Village*, is highly feasible and effective in enhancing students' understanding of disaster mitigation. For publication in an international Scopus-indexed journal, the concept of local wisdom can be more explicitly positioned as a pedagogical framework that connects disaster literacy with the sociocultural realities of coastal urban communities.

**Keywords:** Artificial Intelligence; Coastal Urban Communities; Disaster Comics; Disaster Mitigation; Social Studies Education.

## 1. Introduction

Semarang City is one of Indonesia's coastal urban areas with a high degree of vulnerability to hydrometeorological hazards, particularly flooding, urban waterlogging, and tidal flooding (Mulianingsih, Suharini, et al., 2023; Safitri & Nirwansyah, 2023; Tjahjono, 2019; Ujianti et al., 2023). Geographically, the city is located along the northern coast of Java, directly bordering the Java Sea, and is characterized by a coastline of approximately 13.6 km, a territorial area of 373.78 km<sup>2</sup>, and a dense population exceeding 1.7 million inhabitants. In the 2025–2029 Regional Medium-Term Development Plan, the Semarang City Government explicitly recognizes that this geographical configuration exposes the city to recurrent tidal flooding in coastal areas and landslide risks in the hilly zones (Sari & Prayoga, 2018; Setiawan, 2023). As a result, disaster impacts in Semarang extend beyond physical damage and significantly disrupt social activities, economic productivity, mobility, and public services, including education.

The urgency of this issue became increasingly visible throughout 2025. On 20 January 2025, (Berkat & Fitriana, 2021; Herbanu et al., 2024; Hermi et al., 2018; Imam Wahyudi et al., 2017; Marfai & King, 2008; Neise et al., 2021) Alert Status for floods, landslides, and extreme weather through 31 March 2025, following projections that the peak rainy season in February would intensify hydrometeorological risks. BMKG also warned that January to February 2025 would represent a critical rainfall period in Central Java, with moderate to very high precipitation and the possibility of tidal flooding along the northern coastline. These warnings were followed by repeated flood events, including a flood in April 2025 affecting 187 households or 728 people, and a major flood episode in late October to early November 2025 that affected at least 22,653 households or 40,452 residents across several subdistricts, including Pedurungan, Gayamsari, Genuk, and East Semarang. These data confirm that flood

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risk in Semarang is not episodic, but recurrent and structurally embedded in the city's environmental and urban conditions.

In this context, flood mitigation should not be treated solely as a technical issue of drainage, pumping systems, and river normalization. From the perspective of the social sciences and education, flooding directly affects people's everyday lives, patterns of social interaction, family mobility, environmental health, and the continuity of students' learning processes (Deri Saputra, Andarweni Astuti, 2024; Ferani Mulianingsih, 2022; Miandini & Mulianingsih, 2025; Mulianingsih & Usman, 2025; Purnomo & Mulianingsih, 2021; Setiawan, 2023; Shafira & Mulianingsih, 2025; Yap et al., 2023; Yuliastuti, 2023). Consequently, disaster mitigation needs to be integrated into contextual learning, particularly within Social Studies, which is intended to help students understand the relationships among people, space, the environment, and social dynamics. In a coastal city such as Semarang, Social Studies provides a particularly relevant platform for connecting disaster knowledge to students' lived experiences and local realities.

The urgency of more innovative disaster mitigation learning is also supported by the uploaded research report (Mulianingsih, Suharini, et al., 2025; Suharini & Baharsyah, 2020). The study found that 85% of Social Studies teachers experienced difficulties in teaching flood mitigation through conventional methods, while 78% of students expressed stronger interest in visual learning media such as comics and animation. These findings indicate a clear mismatch between the severity of disaster threats in Semarang and the instructional approaches commonly used in schools. They also suggest that the core challenge lies not only in the availability of disaster-related knowledge, but in the way such knowledge is communicated, contextualized, and internalized in classroom settings.

To respond to this challenge, the uploaded study developed a digital educational comic entitled *Flood in the Urban Village*, organized into five chapters covering the causes of flooding, flood impacts, individual mitigation measures, community roles, and government roles. The innovation of the study lies in the use of deep learning to generate visual illustrations based on Semarang-specific datasets, thereby producing a more contextual and realistic learning medium. Empirically, the product achieved an average expert-validation score of 86%, categorized as highly feasible, and preliminary testing with 30 students showed an increase in mean scores from 56.7 in the pre-test to 82.3 in the post-test, representing an improvement of approximately 45%. These findings demonstrate the strong potential of AI-assisted educational comics to strengthen disaster literacy in Social Studies learning in coastal urban contexts.

Based on the Semarang case and the uploaded research materials, three major gaps can be identified. First, official policy responses to flooding in Semarang remain largely oriented toward emergency response and structural mitigation, such as pump deployment, weather modification, river normalization, and drainage optimization. While these measures are essential, they do not sufficiently address the pedagogical dimension of disaster preparedness among school-aged populations living in flood-prone environments.

Second, the uploaded study reveals a practical gap between the learning needs of students and the instructional approaches commonly used in Social Studies classrooms. The dominance of conventional teaching methods contrasts with students' strong preference for contextual and visual media. This indicates that current school-based disaster education has not yet fully adapted to the cognitive and motivational characteristics of learners in disaster-prone coastal settings.

Third, although the developed comic already demonstrates the effectiveness of deep learning-assisted visual contextualization, the pedagogical integration of local wisdom remains more implicit than explicit. In other words, the available study provides strong evidence for the value of AI-based, locally grounded visual media, but it also opens further space for a more systematic incorporation of local sociocultural knowledge as a distinct educational framework within disaster mitigation learning. This is particularly important in coastal urban communities, where environmental risks are closely intertwined with everyday social practices and local meaning systems. This final point is an inference grounded in the uploaded study's contextual emphasis rather than a separately tested variable.

The novelty of this study lies in the development of an AI-assisted disaster comic that is contextually anchored in the environmental realities of Semarang as a flood-prone coastal city. Unlike generic disaster learning materials, the comic was produced using deep learning trained on Semarang-based visual datasets, allowing the instructional content to reflect local spaces, flood conditions, and social realities that are familiar to students. This contextual grounding enhances the relevance and pedagogical value of the learning medium.

A second dimension of novelty lies in the positioning of disaster comics not merely as supplementary teaching aids, but as a strategic medium for strengthening Social Studies learning in coastal urban communities. By integrating flood causes, impacts, mitigation actions, and social actors into a narrative and visual format, the study extends disaster education into a broader framework of social, environmental, and civic literacy. This makes

the learning model especially relevant for Social Studies, which seeks to connect spatial, social, and environmental understanding in meaningful ways.

A third and forward-looking novelty is the study's potential to incorporate local wisdom as a pedagogical lens for future refinement. While local wisdom was not empirically tested as an independent variable in the uploaded study, the model offers a strong foundation for linking AI-based visual learning with the sociocultural realities of coastal communities. In this sense, the study does not only propose a technological innovation, but also opens a pathway toward a culturally grounded model of disaster mitigation education for twenty-first-century Social Studies learning.

## 2. Methods

This study employed a mixed-methods approach within a Research and Development (R&D) framework adapted from the Borg and Gall model (Gall, M., Gall, Joyce, Borg, 2006; Meredith D. Gall, Walter R. Borg, 2003). The research stages comprised a preliminary study and initial information gathering, planning, initial product development, limited field testing, product revision, expert validation, and dissemination. To examine the effectiveness of the developed learning media, the study applied a quasi-experimental design using pre-test and post-test instruments, while the quantitative data were analyzed through (ANOVA) (Davies, 2014; Hirotsu, 2017; Zhang, 2013). In the qualitative phase, the informants consisted of Social Studies teachers at junior secondary schools in Semarang City as the key informants, seventh-grade students as the main informants, and the head of the Semarang City Social Studies Teachers' Working Group (MGMP IPS) as the supporting informant (Apik Budi Santoso, Pradika Adi Wijayanto, Ferani Mulianingsih, Iwan Saputra, 2024; Arif Purnomo, Ferani Mulianingsih, 2025; Lestari & Mulianingsih, 2025; McParker, 2023; Purnomo & Mulianingsih, 2021; Zong, 2022). The study was conducted in several junior secondary schools located in areas with high flood susceptibility in Semarang City, namely SMP Negeri 4, 6, 20, 25, 31, 36, 38, and 43 Semarang, while the preliminary trial was carried out with 30 students from SMP Negeri 6 Semarang.

The selection of Semarang City as the research setting was strongly grounded in empirical considerations, as the city experienced substantial hydrometeorological pressure throughout 2025. The Semarang City Government declared an Emergency Alert Status for Floods, Landslides, and Extreme Weather from 20 January to 31 March 2025, following projections that the peak rainy season in February 2025 would intensify the risk of hydrometeorological disasters. At the same time, the Meteorological, Climatological, and Geophysical Agency (BMKG) identified January–February 2025 as a critical phase of the rainy season in Central Java, with forecast rainfall ranging from moderate to very high levels, potentially exceeding 500 mm, and accompanied by the risk of tidal flooding along the northern coast. These risks were reflected in actual disaster events: the National Disaster Management Agency (BNPB) reported a flood in Semarang in April 2025 affecting 187 households (728 people), while an official update issued by the Semarang Regional Disaster Management Agency (BPBD) on 2 November 2025 recorded a major flood affecting at least 16 inundation points, with water depths ranging from approximately 10 to 40 cm, and impacting 22,653 households (40,452 people). Taken together, the disaster context of Semarang in 2025 underscores that selecting schools in flood-prone areas as the locus of this study was not only academically relevant, but also socially and educationally urgent.

## 3. Results and Discussion

The findings indicate that the need for more innovative disaster mitigation learning media in Semarang is not merely abstract, but rather emerges from a highly tangible and recurring disaster reality (Anwar et al., 2020; Astuti et al., 2025; Awalianti et al., 2025; Ferani Mulianingsih, Andarweni Astuti, Amin Pujiati, 2025; Lestari & Mulianingsih, 2025; Mulianingsih, Astuti, et al., 2025; Mulianingsih, Kintoko, et al., 2023; Mulianingsih, Santoso, et al., 2025; Purnomo et al., 2022, 2024; Riyani, Mulianingsih, & Rahman, 2025; Riyani, Mulianingsih, ., et al., 2025). Throughout 2025, Semarang experienced considerable hydrometeorological pressure. The Semarang City Government declared an Emergency Alert Status for Floods, Landslides, and Extreme Weather through Mayor's Decree No. 300.2/71 of 2025, effective from 20 January to 31 March 2025. The decree emphasized that the peak of the rainy season in February 2025 was projected to increase the likelihood of hydrometeorological disasters across the city. At the same time, the Meteorological, Climatological, and Geophysical Agency (BMKG) warned that the period from January to February 2025 represented a critical phase of the rainy season in Central Java, with rainfall ranging from moderate to very high intensity and, in some areas, potentially exceeding 500 mm, along with the risk of tidal flooding along the northern coast of Central Java on 31 January 2025. Accordingly, the context of this study is grounded in the factual situation that

Semarang is an area that, both ecologically and socially, requires disaster mitigation education that is more contextual, systematic, and accessible for students.

Within this context, the preliminary findings reveal a substantial gap between the level of disaster threat faced by the city and the mitigation learning models currently implemented in schools. The needs analysis showed that 85% of Social Studies teachers reported difficulties in explaining flood disaster mitigation content when relying solely on conventional instructional approaches. These difficulties were not caused merely by limited teaching materials, but also by forms of presentation that were insufficiently interactive, insufficiently visual, and not always closely related to students' everyday experiences. On the other hand, 78% of students stated that they were more interested in learning through visual media, such as comics or animation, than through text-based materials alone. These findings confirm that the central challenge in school-based disaster mitigation education lies not only in the availability of disaster-related knowledge, but also in how such knowledge is packaged in ways that are relevant to the learning preferences of younger generations and to the local conditions of disaster-prone areas such as Semarang.

In response to this need, the study developed a digital educational comic entitled *Flood in the Urban Village*. The product was organized into five main chapters, namely: the causes of flooding, the impacts of flooding, individual mitigation measures, the role of the community, and the role of government. This structure suggests that the developed comic was designed not merely as a reading aid, but as a pedagogical medium that introduces disasters in a comprehensive manner, ranging from the root causes of the problem to the social responsibilities involved in disaster response. The choice of comics as a format also has a strong academic basis, as comics enable complex material to be translated into a visual and narrative language that is more readily understood by junior secondary school students. Within the context of Social Studies education, such an approach is particularly important because flooding is not viewed solely as a natural phenomenon, but as a socio-environmental issue that affects human behavior, living space, social interaction, and community resilience.

The novelty of this product is further strengthened by the use of deep learning in the development of its illustrations. The deep learning model was trained using visual datasets derived from the Semarang environment, allowing the resulting illustrations to move beyond generic representations and instead portray settings, spaces, and disaster-related problems that are closely aligned with students' everyday realities. In this way, the comic functions not only as an engaging visual medium, but also as a contextual learning tool. The relationship between visual representation and students' lived experiences is particularly important in disaster mitigation education, because the closer the instructional material is to learners' real-world environment, the greater the possibility of fostering meaningful understanding and applicable preparedness. From the perspective of Social Studies pedagogy, this approach also reinforces the linkage between learning, local social space, and the development of civic awareness regarding disaster risk.

The urgency of developing this comic becomes even more evident when viewed in relation to the disaster dynamics that actually occurred in Semarang throughout 2025. Official weather information issued by the Semarang City Government, based on BMKG forecasts for 21–27 January 2025, stated that the influence of the Asian monsoon continued to generate a high probability of moderate to extreme rainfall, including in Central Java, thereby increasing the risk of floods, landslides, and falling trees. This means that, from the very beginning of 2025, the social environment in which students lived was already characterized by a heightened sense of alertness toward flood hazards. Under such circumstances, schools cannot rely solely on the theoretical delivery of disaster-related knowledge. Instead, they need to provide learning media capable of translating such threats into forms that are concrete, relatable, and easily internalized. It is precisely at this point that educational comics become highly relevant, as they serve as a bridge between academic knowledge and the disaster realities experienced by the community.

This need is further supported by empirical evidence from actual disaster events. In April 2025, the National Disaster Management Agency (BNPB) reported a flood event in Semarang affecting 187 households, or 728 individuals. These data indicate that the flood threat in Semarang did not remain at the level of early warning, but materialized into a real disruption to people's lives. Subsequently, on 23 May 2025, the Semarang City PPID also published information on a dyke failure caused by tidal flooding, which resulted in inundation affecting 35 households, or 70 individuals, including older adults, toddlers, and persons with disabilities. This sequence of events demonstrates that the risks of flooding and tidal flooding in Semarang are recurrent, layered, and directly affect vulnerable groups. Therefore, disaster mitigation education in schools should not be designed as an additional or peripheral topic, but rather as an essential part of learning that prepares students to understand environmental risks, recognize warning signs, and develop adaptive behavior.

In terms of product quality, the study produced highly convincing results. The validation process involved three disaster experts and two instructional media experts, meaning that the

assessment covered not only the visual appearance of the comic, but also the accuracy of its content, its pedagogical feasibility, and its suitability for use in Social Studies instruction. The validation results yielded an average feasibility score of 86%, placing the product in the “highly feasible” category. This achievement is important because it indicates that the developed comic met both academic and practical standards as an instructional medium. In other words, the product was not merely a creative experiment, but had undergone an initial evaluation demonstrating that it was content-valid and appropriate for use as a disaster mitigation learning instrument in flood-prone areas.

Furthermore, the effectiveness of the comic was also confirmed during the preliminary trial stage. The findings show that students’ mean comprehension scores increased from 56.7 on the pre-test to 82.3 on the post-test, representing a gain of 25.6 points, or approximately 45% in relative terms. This increase is substantial, indicating that contextual visual-narrative media can significantly improve students’ conceptual understanding of disaster mitigation. Before using the comic, students’ level of understanding remained below the minimum mastery criterion. After engaging with the deep learning-based educational comic, their understanding improved markedly. These results suggest that when disaster-related content is presented in a format aligned with students’ learning needs and closely connected to their spatial experiences, the process of knowledge internalization becomes more effective.

Substantively, this effectiveness can be explained in at least two ways. First, the comic simplifies complex information into a coherent and easily followed storyline. Issues such as the causes of flooding, its impacts on social life, individual mitigation measures, and the role of government often appear abstract when conveyed only through lectures or textbook explanations. However, when such content is presented through characters, dialogue, spatial illustrations, and everyday situations, students can more easily connect the concepts with real-life experience. Second, the principal strength of the comic lies in the visual contextualization enabled by deep learning. Because the illustrations were generated from environmental datasets specific to Semarang, students were not confronted with unfamiliar imagery, but rather with scenes and situations that closely resembled their own lived realities. This sense of familiarity strengthens association, facilitates understanding, and increases students’ sense of ownership over the mitigation messages being conveyed.

The significance of these findings becomes even more pronounced when compared with the scale of the major flood that struck Semarang in late October 2025. Official information from the Semarang City PPID recorded at least 16 inundation points, with water levels ranging from 10 to 40 cm, affecting areas such as Terboyo Wetan, Terboyo Kulon, Trimulyo, Tambakrejo, Kaligawe, Kemijen, Genuksari, and Kudu. During the same event, the total number of affected residents reached 22,653 households, or 40,452 individuals. The distribution of impacts also reflected a considerable scale, including Muktiharjo Kidul with 4,950 households or 10,049 people, Genuksari with 1,298 households or 2,588 people, Trimulyo with 486 households or 1,756 people, and Sawah Besar with 2,582 households or 6,881 people. In addition, 10 households, or 30 individuals, were still recorded as displaced. These facts indicate that flooding in Semarang in 2025 was not a minor or localized incident, but rather a large-scale urban disaster that placed substantial pressure on community social resilience. In this context, the results of the present study gain strong empirical justification: schools in flood-prone areas do indeed require disaster mitigation learning media that are effective, contextual, and accessible from an early stage.

More broadly, the contribution of this study extends beyond media development to the strengthening of the orientation of Social Studies learning in disaster-prone areas. Disaster mitigation learning has often been treated as marginal within the curriculum, whereas in a coastal city such as Semarang it directly touches the core concerns of Social Studies education: the relationships among humans, space, the environment, social change, and collective responsibility. The educational comic *Flood in the Urban Village* demonstrates that mitigation content can be taught in a more vivid and meaningful manner by connecting disaster knowledge, local realities, and social actions that can be undertaken by individuals and communities alike. In this way, students learn not only to recognize flooding as a natural event, but also to understand its implications for social life, the importance of community solidarity, and the role of the state and government in disaster management. It is this dimension of social education that makes the innovation relevant not only technically, but also curricularly.

#### 4. Conclusion

AI-based disaster comics have been shown to be highly feasible and effective as a Social Studies learning medium for enhancing students’ disaster literacy in coastal areas. The primary contribution of this medium lies in its capacity to deliver contextualized learning through the integration of deep learning-based visual technology with locally grounded disaster issues. In line with the orientation of an international journal article, this study may be positioned as a

Social Studies learning model that integrates artificial intelligence, disaster education, and local wisdom as the foundation for adaptive, contextual, and regionally relevant learning in coastal settings. Nevertheless, from a methodological perspective, it should be clarified that local wisdom remains at the level of conceptual reinforcement and future development at this stage, and therefore cannot yet be treated as an independently tested primary variable.

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