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INARISK PERSONAL FOR CRITICAL THINKING AND DISASTER RESILIENCE IN SOCIAL STUDIES EDUCATION

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Abstract

This research investigated the contribution of InaRisk Personal, a location-sensitive disaster-risk application, to senior high school students' critical thinking in social studies-oriented disaster education. The study employed a quasi-experimental nonequivalent control-group design involving 72 Grade XI students at State Senior High School 11 Semarang. Primary data were gathered through observation, testing, and interviews, complemented by secondary document analysis. Participants were selected using purposive sampling. This study examined the effect of the InaRisk Personal application on students' Higher Order Thinking Skills (HOTS)—specifically analyzing (C4), evaluating (C5), and creating (C6)—by testing the hypothesis of a significant difference in critical-thinking performance between the InaRisk Personal-supported class and the conventional instruction class (H_0 vs H_1). Descriptive statistics, normalized gain. Both groups showed a significant increase in critical thinking scores, with the experimental group improving from 66.53 to 84.58 and the control group from 57.92 to 66.67. However, after controlling for pretest differences, the treatment effect proved to be statistically significant (B – 13.69, p = < .001). Both groups also demonstrated low normalized gains (0.539 and 0.208, respectively). The InaRisk Personal application contributes to enhancing students' critical thinking skills after controlling for baseline differences. Its location-based data helps students analyze risk patterns, evaluate disaster conditions, and formulate local mitigation strategies contextually. Nevertheless, learning effectiveness ultimately relies on structured intellectual activities, such as questioning data, verifying sources, and examining the social impacts of mitigation choices.

Keywords Critical thinking; Disaster resilience; InaRisk Personal; Social studies education; Sustainable development.

INTRODUCTION

A hazard does not become a disaster solely because a physical event occurs; its consequences emerge from the interaction of environmental processes with exposure, vulnerability, institutional capacity, and community decisions. Therefore, disaster education should move beyond identifying hazards and memorizing evacuation procedures toward interpreting risk evidence, evaluating alternatives, and making socially responsible decisions. This orientation places disaster learning within social studies education, where environmental change is examined alongside settlement, public policy, technology, inequality, culture, and collective action. Recent research in disaster education emphasizes the importance of engaging students with multiple forms of data, analysis, interpretation, and judgment to develop critical thinking about disasters as complex social and environmental problems (Srigyan & Fortun, 2025). Furthermore, the integration of digital technology into disaster education has been shown to strengthen students' disaster literacy and resilience, supporting the use of technology as a means of connecting risk information with meaningful learning experiences (Haryati et al., 2025). This orientation is consistent with the Sendai Framework, the Comprehensive School Safety Framework, and the SDGs, particularly Targets 4.7, 11.b, and 13.3, which emphasize risk understanding, resilience, sustainable development, and education for disaster-risk reduction (Aksha & Emrich, 2024; Albareda-Tiana et al., 2024 ; Kintoko & Mulianingsih, 2022; Lei et al., 2017; Mulianingsih Ferani et al., 2023; Pal et al., 2022; Suharini & Baharsyah, 2020).

Based on preliminary data, specifically the results of students’ learning evaluations in Grade 11 at State Senior High School 11 Semarang on the topic of disaster mitigation during the previous academic year, it was found that the students’ average daily assessment score remained below the Minimum Mastery Criterion (KKM), which is 75. Of the 144 students, only approximately 30% were able to achieve scores above the KKM. This low achievement was particularly evident in question indicators requiring Higher-Order Thinking Skills (HOTS), particularly those involving the analysis of disaster risk maps or the formulation of mitigation strategies based on specific regional conditions. The low academic achievement is strongly presumed to stem from a learning process that remains conventional and heavily text-based. Based on interviews, students reported difficulties in visualizing abstract disaster risk data when learning primarily through textbooks. Consequently, when confronted with real-world problems, such as flooding in the southern area of Semarang, students struggled to connect theoretical concepts with actual conditions. This gap between theoretical knowledge and real-world contexts ultimately hindered the development of their critical thinking skills.

Digital geospatial resources may help address this gap by making spatial relationships visible and locally meaningful. Previous studies have demonstrated the potential of Google Earth, WebGIS InaRisk, GIS-based learning media, and digital modules to support spatial thinking, disaster literacy, and critical thinking (Indarti, 2023; Ma'dika & Rahman, 2024; Suharini et al., 2020; Von Schwerin et al., 2016), and multimedia GIS e-modules can facilitate e-learning. Studies published in scaffolding have also documented the role of digital media in supporting critical thinking and the importance of integrating disaster risk reduction into educational curricula (Anwar et al., 2020; Purnomo et al., 2025; Baytiyeh, 2018; Lunga et al., 2025; Mulianingsih et al., 2025). InaRisk Personal is particularly relevant because it provides location-based disaster-risk information, mitigation recommendations, and preparedness assessments that students can connect with familiar places. Although previous studies have examined its readability, acceptance, spatial-thinking potential, and learning outcomes (Marlina & Suharini, 2019; Meliana et al., 2020; Qatrunnada & Suharini, 2023), further research is needed to determine whether integrating InaRisk Personal into instruction can strengthen students' critical judgment rather than merely improve access to digital disaster information.

State Senior High School 11 Semarang was selected as the research site because its geographical context provides a relevant setting for developing students' critical thinking and disaster risk awareness in geography education. Semarang is a coastal city characterized by considerable spatial variation in elevation. According to (Badan Pusat Statistik Kota Semarang, 2026), the southern districts generally have higher elevations, such as Gunungpati (334.75 m a.s.l), Mijen (258.79 m a.s.l), and Banyumanik (215.33 m a.s.l), whereas several northern and coastal districts have much lower elevations, including North Semarang (2.16 m a.s.l), Genuk (2.37 m a.s.l), and East Semarang (5.22 m a.s.l). This geographical variation is associated with differences in exposure and vulnerability to hydrometeorogical hazards, including flooding and tidal inundation (Suhelmi & Triwibowo, 2018). Flash floods and tidal floods threaten approximately 40% of the lowland areas in Semarang City due to sea level rise (Suharini & Kurniawan, 2021). Recent spatial analysis has identified varying levels of tidal flood vulnerability across Semarang's coastal districts, with several areas, including Tugu, West Semarang, North Semarang, Gayamsari, and Genuk, showing predominantly high vulnerability (Setyaningsih et al., 2024). These conditions provide an authentic learning context in which students can connect disaster mitigation concepts with spatial phenomena encountered in their everyday lives (Findayani et al., 2024). In this context, Grade 11 students are expected not only to learn about different types of disasters but also to analyze relationships among elevation, land use, settlement patterns, drainage networks, and levels of risk through the interpretation of maps and spatial data. Location-based learning using Inarisk personal is therefore relevant because it enables students to identify risks in their surrounding environment, evaluate spatial evidence, and formulate mitigation decisions based on local conditions. Accordingly, State Senior High School 11 Semarang was selected not merely as a site for data collection, but as an educational context that, both geographically and socially, supports the development of risk-aware critical thinking (Mulianingsih Ferani et al., 2023). Critical thinking requires a more demanding sequence: students must analyze a complex situation, evaluate claims and possible actions, and construct a defensible response. In the revised cognitive taxonomy, these processes are represented by analyzing, evaluating, and creating (Builes-Jaramillo et al., 2025; Haque et al., 2022; Zunariyah et al., 2018). The distinction is educationally important. A student may identify a high-risk area on an application without being able to assess the credibility of a proposed solution, recognize uncertainty, or consider how the solution may affect groups with different levels of vulnerability.

Numerous previous studies demonstrate that the use of geospatial-based digital media and applications has the potential to support disaster education. (Suharini et al., 2023) found that the ease of use and usefulness of InaRisk influence user attitudes and usage intentions based on the Technology Acceptance Model (TAM). Similarly, (Adelina et al., 2024) showed that using Google Earth significantly improves students' spatial thinking skills compared to instruction without such media. (Febrianto et al., 2021) also found that WebGIS InaRisk is more effective in enhancing spatial thinking skills than traditional map media, yielding an N-Gain of 43.7% in the experimental class compared to 32.09% in the control class. Furthermore, (Sephia et al., 2024) reported that InaRisk Personal is moderately effective in improving student learning outcomes on disaster mitigation topics, achieving an N-Gain of 57.94%. Meanwhile, (Nia Kurniawan et al., 2020) revealed that InaRisk Personal is significantly more effective than textbooks in improving disaster information literacy, particularly in searching for, identifying, evaluating, and utilizing information. Overall, these findings highlight that digital geospatial media, especially InaRisk Personal, hold strong potential for enhancing students' spatial abilities, learning outcomes, information literacy, and disaster preparedness.

The contribution of the present study is therefore not simply the introduction of a mobile application. InaRisk Personal is examined as a contextual cognitive scaffold within a social studies-oriented disaster unit. The application provides authentic, location-sensitive representations of risk, while the learning tasks are intended to turn those representations into questions, arguments, and mitigation decisions. Recent evidence indicates that scaffolding-based digital instructional media can support higher-order thinking by guiding learners through problem-solving processes, providing feedback, and facilitating deeper engagement with learning tasks (Setyaningrum et al., 2024). This approach also brings digital literacy into dialogue with place-based education because students work with information related to the school and surrounding neighborhoods rather than relying only on national examples. Place-based education emphasizes the integration of local environmental, cultural, and community contexts into learning, thereby strengthening students' connections with the places in which they live and learn (Brunold-Conesa, 2024). Lamper Tengah, Semarang, offers an urban setting in which waterways, roads, settlements, and public facilities can be considered as interconnected elements of disaster risk. Three questions guided the investigation: how did students' critical-thinking scores change after learning with InaRisk Personal; was that change different from the change produced by conventional instruction; and which critical-thinking dimensions displayed the clearest improvement patterns? The study consequently assessed both overall and dimension-specific outcomes and interpreted them in relation to disaster-resilience education and the SDGs. Theoretically, the study evaluates the assumption that contextual digital data can function as cognitive scaffolding. Practically, it offers evidence for teachers deciding whether the application is adequate on its own or must be combined with explicit inquiry, source evaluation, argumentation, and collaborative decision-making.

METHOD

The research adopted a quantitative quasi-experimental design using a nonequivalent control group. Two intact Grade XI geography classes were selected purposively from students enrolled in the elective geography subject at State Senior High School 11 Semarang. Class XI-11 was assigned as the control group, and Class XI-12 as the experimental group. Each class consisted of 36 students, yielding a total sample of 72. Both groups completed the same pretest and posttest. During the disaster-mitigation unit, the experimental class used InaRisk Personal, whereas the control class followed the school's conventional lesson plan without the application. Because students were not randomly allocated and the classes differed at baseline, pretest equivalence was examined, and the initial score was entered as a covariate in the principal between-group analysis.

Primary data were directly gathered from teachers and the learning process through observation, testing, and interviews. Additionally, secondary data were collected from relevant documents, archives, and supporting literature. The sampling technique used in this study was purposive sampling. Purposive sampling is also known as judgmental sampling. This study tested the hypothesis that Inarisk Personal has a positive effect on improving students' critical thinking skills, specifically focusing on Higher Order Thinking Skill (HOTS) across the dimensions of analyzing (C4), evaluating (C5), and creating (C6).

To evaluate this effect, the following statistical hypotheses were established: H0: There is no significant difference in students' critical thinking skills between the class utilizing the Inarisk Personal application-based learning and the class utilizing conventional instruction. H_1: There is a significant difference in students' critical thinking skills between the class utilizing the Inarisk Personal application-based learning and the class utilizing conventional instruction.

In the experimental class, InaRisk Personal was used as evidence to be investigated rather than as a digital presentation tool. Students located potential hazards, interpreted the risk information displayed for a selected place, connected that information with exposure and capacity, reviewed recommended actions for the periods before, during, and after a disaster, and proposed mitigation decisions suited to the local context. Teacher prompts focused on causal links, the adequacy of evidence, alternative courses of action, and the consequences of each decision. The control class addressed the same learning objectives through explanation, discussion, and conventional resources. Two experts validated both lesson plans.

Critical thinking was measured using ten constructed-response tasks. Each task was scored from 0 to 4, producing a maximum raw score of 40, which was then converted to a 0-100 scale. The assessment blueprint covered three higher-order dimensions: analyzing (items 1-4), evaluating (items 5-7), and creating (items 8-10). Analyzing items required students to identify patterns, causal relationships, and relevant risk evidence. Evaluating items asked students to judge claims, recommendations, or proposed actions using stated criteria. Creating items required them to organize or formulate a mitigation solution. Documentation, preliminary interviews, and classroom observation were also used to describe the instructional context, although the present article reports primarily the test outcomes available in the uploaded datasets.

Data analysis combined descriptive and inferential procedures. Means, standard deviations, ranges, mastery rates, and averages for each critical-thinking dimension were calculated first. A score of 75 was used as the school's mastery threshold. Group-level normalized gain was computed using g = (posttest - pretest)/(100 - pretest); values below .30 were interpreted as low, values from .30 to .69 as moderate, and values of .70 or above as high. Shapiro-Wilk tests were used to examine score and gain distributions, while Levene's test assessed variance homogeneity. Paired-samples t-tests tested the change within each class. Because the change scores were normally distributed and homogeneous. The experimental group entered the study with a significantly higher pretest mean, so ANCOVA served as the primary comparison: posttest score was the dependent variable, group was the fixed factor, and pretest score was the covariate. Cohen's d was reported as the effect-size measure, and alpha was set at .05.

The conceptual sequence presented in Figure 2 separates access to risk information from the instructional work needed to convert that information into learning. InaRisk Personal supplies location-based hazard data, mitigation recommendations, and self-assessment features. Contextual tasks then require students to interpret, question, and apply the information. Through analyzing, evaluating, and creating, students move from viewing risk data to making risk-informed decisions. The SDGs provide the wider orientation for sustainability and disaster resilience, but the critical-thinking processes and classroom scaffolding constitute the mechanism examined in this study.

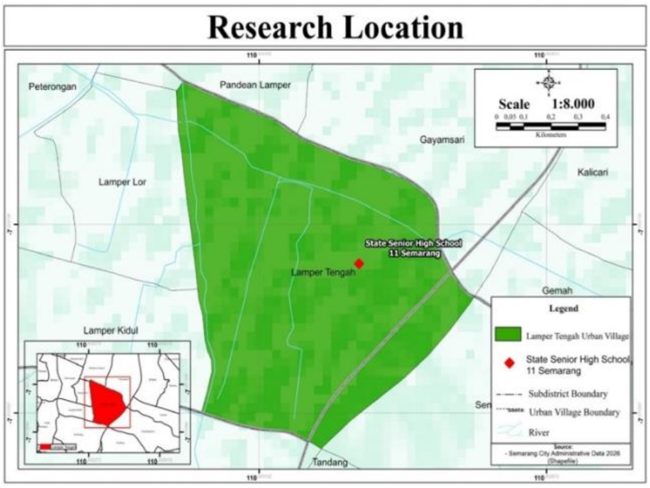

Figure 1. Research location at State Senior High School 11, Semarang

Source: Semarang City administrative data, research map supplied by the author, 2026

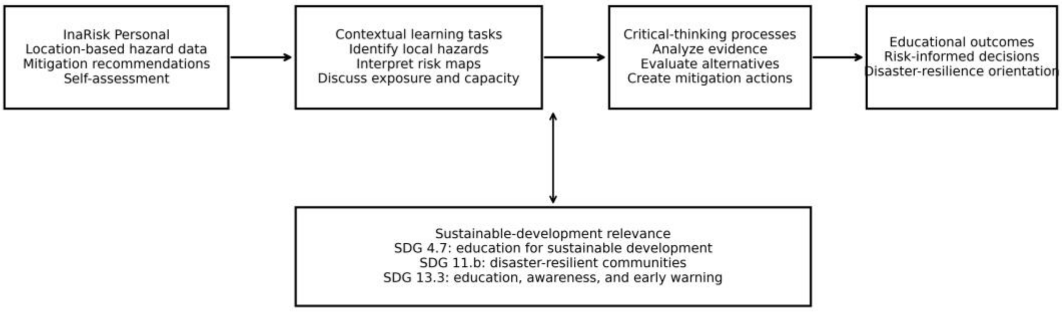

Figure 2. Research and pedagogical framework

Source: Developed by the authors from the study design and SDG-DRR framework, 2026

FINDINGS AND DISCUSSION

Findings

The two classes did not enter the study at the same average level of critical-thinking performance. The control group obtained a pretest mean of 57.92 (SD = 15.53), whereas the InaRisk Personal group obtained a higher pretest mean of 66.53 (SD = 15.04). Thus, the experimental group began the study 8.61 points above the control group. The baseline difference was statistically significant, $t(70) = 2.39$, $p = .020$, 95% CI [1.42, 15.80], with a moderate standardized mean difference (Cohen's $d = 0.56$). This finding indicates that the two groups did not begin the study at an equivalent level of critical-thinking performance, and therefore, the initial difference should be considered when interpreting the posttest results.

On the posttest, the control group obtained a mean of 66.67 (SD = 19.05), whereas the InaRisk Personal group achieved a substantially higher mean of 84.58 (SD = 8.05). The posttest difference of 17.91 points favored the InaRisk Personal group. Because the posttest variances were unequal (Levene's $p < .001$), Welch's independent-samples t-test was appropriate for comparing the two groups. The posttest difference was statistically significant, $t(47.12) = 5.20$, $p < .001$, 95% CI [10.98, 24.85], with a large standardized mean difference (Cohen's $d = 1.23$). However, because the experimental group also started with a higher pretest score, the posttest difference should not be interpreted independently of the baseline difference.

Learning gains were observed in both classes. The control group increased by an average of 8.75 points, from 57.92 to 66.67. This within-group improvement was statistically significant, $t(35) = 3.59$, $p = .001$, 95% CI [3.80, 13.70], with a moderate paired effect size (paired $d = 0.60$). The InaRisk

Personal group increased by an average of 18.05 points, from 66.53 to 84.58. This improvement was also statistically significant, $t(35) = 7.27$, $p < .001$, 95% CI [13.01, 23.10], with a large paired effect size (paired $d = 1.21$). Therefore, the experimental group showed a 9.30-point greater descriptive gain than the control group.

The difference in change between the two groups was statistically significant. The InaRisk Personal group improved by approximately 9.31 points more than the control group, with a 95% CI of [2.36, 16.25], $t(70) = 2.67$, $p = .009$, and a moderate-to-large standardized effect (Cohen's $d = 0.63$). This pattern indicates that both instructional approaches were associated with improvement in critical-thinking performance, while the increase was significantly larger in the InaRisk Personal group.

The normalized gain results showed a similar pattern. The control group obtained an N-gain of .208, categorized as low, whereas the InaRisk Personal group obtained an N-gain of .539, categorized as medium. Thus, students in the InaRisk Personal group achieved a greater proportion of the possible improvement than students in the control group. The N-gain results, therefore, provide descriptive evidence that the InaRisk Personal group experienced greater learning improvement relative to its available room for improvement. However, because the two groups differed significantly at pretest, the N-gain comparison should be interpreted together with the baseline-adjusted analysis rather than as independent evidence of treatment effectiveness.

An additional ANCOVA was therefore used to examine whether the higher posttest performance of the InaRisk Personal group remained after controlling for the initial difference in critical-thinking performance. In this analysis, posttest scores were treated as the dependent variable, group as the independent variable, and pretest scores as the covariate. After adjusting for the baseline difference, the estimated InaRisk Personal effect was 13.69 points, with a 95% CI of [7.51, 19.87]. The adjusted group effect was statistically significant, $t(69) = 4.42$, $p < .001$, with a large effect (partial $\eta^2 = .22$). This baseline-adjusted result indicates that the higher critical-thinking performance of the InaRisk Personal group at posttest remained statistically significant even after accounting for differences in initial performance. Therefore, the findings provide stronger evidence that the InaRisk Personal intervention contributed to the greater improvement in critical-thinking performance observed in the experimental group.

Table 1. Descriptive statistics and normalized gain

Group	n	Pretest M (SD)	Posttest M (SD)	Mean change (SD)	N-gain
Control	36	57.92 (15.53)	66.67 (19.05)	8.75	.208 (low)
InaRisk Personal	36	66.53 (15.04)	84.58 (8.05)	18.05	.539 (medium)

Source: Research data processed by the authors, 2026

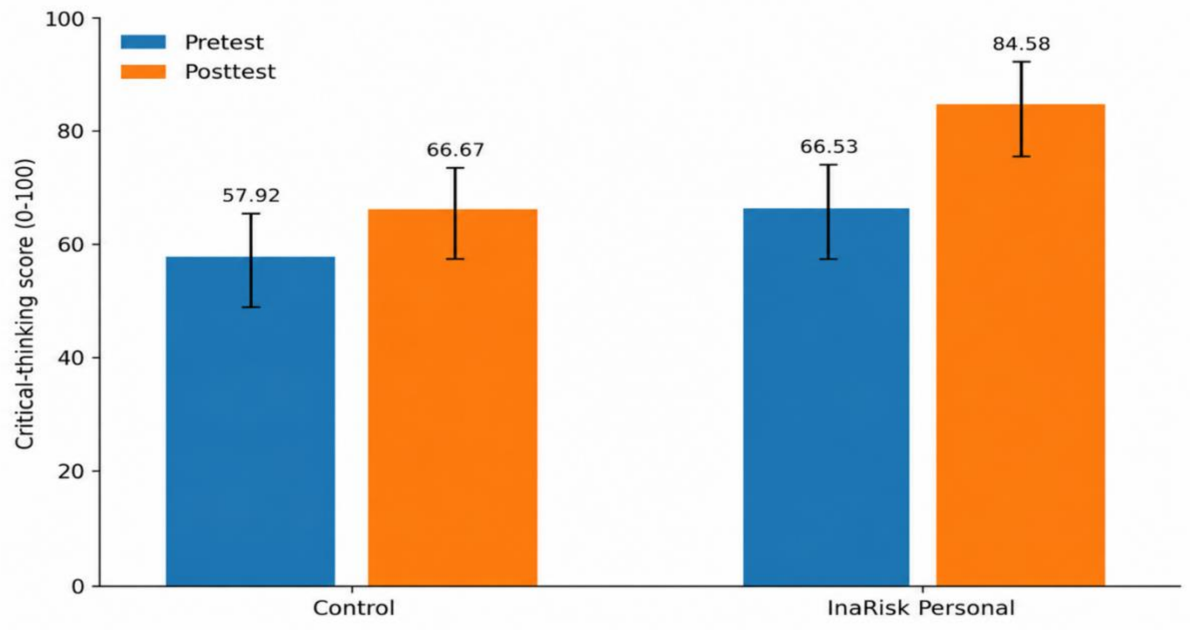

Figure 3. Pretest and posttest critical-thinking scores by group (mean and standard deviation)

Source: Pretest and posttest workbook supplied by the author, processed in 2026

Table 2. Inferential Results for Overall Critical-Thinking Scores

Analysis	Estimate	95% CI	Test statistic	p	Effect size
Baseline group difference	8.61	1.42 to 15.80	t(70) = 2.39	.020	d = 0.56
Control pre-post change	8.75	3.80 to 13.70	t(35) = 3.59	.001	paired d = 0.60
InaRisk pre-post change	18.06	13.01 to 23.10	t(35) = 7.27	< .001	paired d = 1.21
Difference in change (InaRisk-control)	9.31	2.36 to 16.25	t(70) = -2.67	.009	d = 0.63
Adjusted InaRisk effect (ANCOVA)	13.69	7.51 to 19.87	t(69) = 4.42	< .001	partial effect large

Source: Research data processed by the authors, 2026

Analysis based on dimensions shows a more varied picture compared to the total score. In the experimental class, the ability to analyze increased from 66.67 to 84.03, or an increase of 17.36 points, while the ability to create increased from 66.90 to 83.33, or an increase of 16.43 points. Evaluating ability showed the largest increase, from 65.97 to 86.57, with an increase of 20.60 points.

In the control class, analytical skills increased by 4.51 points, evaluation by 15.74 points, and creation by 7.41 points. Thus, the experimental class showed greater improvements in all three dimensions, with the greatest advantage in the ability to evaluate, followed by the ability to analyze and create. This pattern was consistent with the overall results, where the InaRisk Personal group showed a significantly greater improvement than the control group (change difference = 9.31, $p = .009$, $d = 0.63$), and the effect remained large after adjusting for initial ability ($p < .001$, partial $\eta^2 = 0.22$). The N-gain results also showed the same pattern, with the control group obtaining N-gain = 0.208 (low category), while the InaRisk Personal group obtained N-gain = 0.539 (medium category). This pattern shows that the use of the InaRisk Personal application is very suitable to assist students in interpreting disaster risk information, evaluating risk conditions, and generating mitigation responses. The greatest improvement can be seen in the ability to provide an evaluative assessment of risk conditions as well as the ability to analyze information and produce solutions oriented to disaster mitigation.

Table 3. Critical-Thinking Dimensions by Group

Dimension	Control Pre	Control Post	Control Gain	Inarisk Pre	Inarisk Post	Inarisk Gain
Analyzing	64.93	69.44	4.51	66.67	84.03	17.36
Evaluating	51.62	67.36	15.74	65.97	86.57	20.6
Creating	54.86	62.27	7.41	66.90	83.33	16,43

Source: Research data processed by the authors, 2026

Discussion

The findings show that both groups experienced improvements in critical-thinking skills, but the improvement was substantially greater in the InaRisk Personal group. The experimental group showed an increase of 18.05 points, compared with 8.75 points in the control group, with *N-gain* values of 0.539 (moderate category) and 0.208 (low category), respectively. The comparison of learning gains indicated a significant advantage for the InaRisk Personal group ($p = 0.009$; $d = 0.63$). Although the experimental group had a higher mean pretest score (66.53) than the control group (57.92), the ANCOVA results still showed a significant difference after controlling for initial ability, with an adjusted mean difference of 13.69 points, $p < 0.001$, and a large partial effect size ($\eta^2 p = 0.22$). These findings indicate that InaRisk Personal contributed to the development of critical-thinking skills beyond the improvement achieved through conventional learning.

Theoretically, these findings can be interpreted through the role of geospatial technology as a cognitive scaffold in deep, project-based, and contextual learning. InaRisk Personal provides location-based information that enables students to examine the relationships among hazards, exposure, vulnerability, and mitigation within familiar environments. This condition transforms disaster learning from merely receiving abstract information into a process of analyzing evidence, evaluating alternatives, and developing solutions. Such a process corresponds to the dimensions of critical-thinking skills, namely analyzing, evaluating, and creating. The integration of geospatial technology into inquiry- and project-based learning can encourage students to use spatial information in the processes of investigation, analysis, problem-solving, and solution development for geographical issues (Hursen & Beyoğlu, 2025). Thus, the educational value of InaRisk Personal lies not only in its function as a source of digital information but also in its ability to provide an authentic spatial context that enables students to use evidence to develop accountable mitigation decisions. This interpretation is consistent with the view that critical thinking requires students.

This result is consistent with the positive effects reported in studies of Google Earth, WebGIS Inarisk, Inarisk Personal, learning video, and multimedia GIS e-modules (Diehr et al., 2025; Fadly et al., 2022; Prechtel et al., 2013). The findings are connected to several previous studies (Suharini et al., 2023), which demonstrated that perceptions of ease of use and usefulness influence attitudes and intentions to use InaRisk, indicating that technology accessibility is an important condition for its use in learning. (Febrianto et al., 2021) found that WebGIS InaRisk was more effective than conventional map media in improving spatial-thinking skills, while (Adelina et al., 2024) demonstrated similar benefits through the use of Google Earth. (Sephia et al., 2024) also showed that InaRisk Personal could improve students' learning outcomes in disaster-mitigation topics, with an N-gain of 57.94%. Meanwhile, (Nia Kurniawan et al., 2020) found that InaRisk Personal was more effective than textbooks in developing disaster information literacy, particularly in searching for, identifying, evaluating, and utilizing information. The present study extends these findings by demonstrating that the benefits of InaRisk Personal can reach higher cognitive levels, particularly when the application is integrated into learning activities that explicitly require critical judgment and reasoning.

The findings for each dimension further strengthen this interpretation. The InaRisk Personal group demonstrated greater improvements than the control group in the analyzing dimension (17.36 points versus 4.51 points), evaluating dimension (20.60 points versus 15.74 points), and creating dimension (16.43 points versus 7.41 points). The largest improvement occurred in the evaluating dimension, indicating that students not only identified information about disaster risks but also considered their relevance, evidence, consequences, and possible mitigation responses. The improvement in analyzing suggests that spatial information helped students understand the relationship between location and disaster risk, while the improvement in creating indicates that students were able to use this information as a basis for formulating mitigation solutions. These findings are consistent with previous studies emphasizing the potential of geospatial media to improve spatial-thinking skills, disaster literacy, and learning outcomes (Febrianto, 2021; Adelina et al., 2024; Kurniawan et al., 2020). However, the present study provides a broader cognitive interpretation by demonstrating improvements across all three dimensions of critical-thinking skills.

Nevertheless, these findings provide an important qualification to previous research. The effectiveness of InaRisk Personal should not be understood as an automatic consequence of providing digital disaster risk information. (Suharini et al., 2023) emphasized the importance of perceived usefulness and ease of use, whereas the present findings indicate that pedagogical integration also plays an important role. Students may be able to identify locations with high levels of risk through the application, but this does not necessarily mean that they can evaluate the credibility of the information, compare different mitigation alternatives, or provide strong justifications for particular decisions. Therefore, InaRisk Personal becomes more meaningful when embedded within inquiry and project-based learning that includes the interpretation of evidence, disaster-risk mapping, discussion, argumentation, and the creation of mitigation solutions. In this respect, the present study reinforces previous research on the benefits of geospatial technology while extending it by emphasizing the role of instructional scaffolding in transforming digital disaster information into higher-order thinking skills (Yang et al., 2024).

Overall, the findings confirm that InaRisk Personal can function as an effective digital scaffold for developing critical thinking skills in disaster-mitigation learning. The ANCOVA results, which remained significant after controlling for initial ability, indicate that the higher posttest performance of the experimental group was not solely attributable to its higher initial ability. These findings support previous research on the benefits of InaRisk, Google Earth, WebGIS, and digital geospatial media, while providing additional evidence that such technologies can support analyzing, evaluating, and creating when integrated into a structured learning process. However, because the study involved two intact classes from a single school and did not employ individual randomization, causal interpretations should be made with caution. Thus, the main contribution of this study is not merely demonstrating that students can access disaster risk information digitally, but rather that InaRisk Personal can serve as a meaningful cognitive scaffold when spatial information is intentionally connected to critical thinking activities and disaster-mitigation decision-making.

CONCLUSION

The findings demonstrate that InaRisk Personal can function as an effective digital cognitive scaffold for developing students' critical-thinking skills in disaster-mitigation learning. Although the InaRisk Personal group entered the study with a higher mean pretest score than the control group (66.53 vs. 57.92), it achieved a substantially greater learning gain (18.05 vs. 8.75 points), a higher N-gain (0.539 vs. 0.208), and a significant advantage in learning gain ($p = 0.009$; $d = 0.63$). The ANCOVA results also demonstrated a significant effect after controlling for baseline ability, with an adjusted mean difference of 13.69 points ($p < 0.001$; $\eta^2 p = 0.22$). Improvements were also observed across the analyzing, evaluating, and creating dimensions, indicating that InaRisk Personal not only helped students identify disaster risks spatially but also supported them in evaluating evidence and formulating mitigation solutions relevant to local contexts. These findings extend previous research on InaRisk, WebGIS, Google Earth, and other geospatial technologies by demonstrating that the benefits of such technologies can reach higher-order cognitive processes when supported by structured pedagogical scaffolding. Thus, the effectiveness of InaRisk Personal derives not only from access to digital disaster-risk information but also from its integration into inquiry- and project-based learning involving evidence interpretation, argumentation, evaluation of alternatives, and mitigation decision-making. This finding highlights that the educational contribution of InaRisk Personal lies in transforming spatial disaster risk information into opportunities for students to reason critically about real-world problems and make evidence-based mitigation decisions. Therefore, InaRisk Personal should be positioned not merely as a technological learning medium but as part of an instructional strategy that connects geospatial information, critical thinking, and authentic local problem-solving. In the broader context of sustainable development, this approach contributes to SDG 4.7 by strengthening education for sustainable development and disaster-risk awareness, supports SDG 11.b by developing students' capacity to understand and respond to disaster risks, and is relevant to SDG 13.3 through the enhancement of education, awareness, and human capacity for climate-related risk reduction and adaptation. However, the use of intact classes from a single school and the absence of individual randomization require causal interpretations to be made with caution. Future research should involve larger and more diverse samples, stronger experimental controls, and measures of long-term preparedness and behavior. Overall, InaRisk Personal demonstrates meaningful potential for place-based disaster education by connecting geospatial information with critical reasoning, sustainable development education, and locally relevant mitigation actions, while providing a practical pathway for integrating digital geospatial technology into learning that aims to develop students' higher-order thinking and disaster preparedness.

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