

STEAM Integrated Role Playing in Project-Based Disaster Mitigation Learning at Vocational High Schools

¹Rina Marlina*, ¹Tri Cahyanto, ¹Neneng Windayani, ²Lilik Sopiyantri

¹Sunan Gunung Djati State Islamic University Bandung, West Java, Indonesia

²State Vocational High School 3 Bandung, West Java, Indonesia

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Article Info	ABSTRACT
Article history Received : 03-07- 2026 Revised: 19-08-2026 Accepted : 20-09-2026 Published : 21-09-2026 Keywords disaster mitigation education; project-based learning; STEAM; role-playing; vocational education; disaster literacy Corresponding Author Rina Marlina Sunan Gunung Djati State Islamic University Bandung, West Java, Indonesia *E-mail: 2259450001@student.uinsgd.ac.id	<i>Disaster mitigation education in vocational high schools requires learning approaches that connect scientific knowledge, vocational competencies, collaborative skills, and decision-making. This study examines the implementation of Project-Based Learning (PjBL) integrated with Science, Technology, Engineering, Arts, and Mathematics (STEAM) and role-playing in disaster mitigation learning within the IPAS Project at SMKN 3 Bandung. A qualitative descriptive design was employed involving one teacher and seven students selected purposively based on their active participation throughout the learning activities. Data were collected through classroom observations, semi-structured interviews, and document analysis of teaching modules, worksheets, drama scripts, props, portfolios, photographs, videos, and peer assessments. Data were analyzed thematically and validated through source and methodological triangulation. The findings show that learning progressed through problem identification, project planning, task organization, rehearsal monitoring, simulation performance, and evaluation and reflection. Science was the most prominent STEAM component, particularly in explaining disaster causes, impacts, and mitigation strategies. Technology supported information retrieval and communication, while arts were manifested through script development and performance. Engineering and mathematics were less explicitly integrated, primarily appearing in property management, spatial planning, and time allocation, without systematic design testing or quantitative measurement. The approach promoted student engagement, communication, collaboration, and disaster literacy. However, implementation was constrained by limited instructional time, differences in student confidence, and uneven participation. Strengthening engineering scaffolding, quantitative data use, explicit STEAM assessment rubrics, and individual accountability is therefore recommended.</i>
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INTRODUCTION

Disaster education in Indonesia plays a crucial and urgent role because Indonesia is a country whose geographical territory is largely located within the Ring of Fire. This makes Indonesia highly vulnerable to various large-scale natural disasters, including earthquakes, volcanic eruptions, tsunamis, landslides, and floods (Dinda et al., 2024). Therefore, building disaster literacy in schools is essential. Students are among the most vulnerable groups during disasters because they spend most of their time in the school environment (Gideon Walter, 2026). Students' awareness and preparedness in facing disasters play a crucial role in mitigating risks and reducing the fatal impacts of disasters on the broader community. (Çelik, 2023).

At the Vocational High School (SMK) level, disaster mitigation education has a specific level of importance and unique characteristics. The IPAS project aims to link scientific knowledge to environmental, social, and workplace issues, while the focus of SMK graduates' career orientation requires applied skills, procedural communication, teamwork, and awareness of occupational health and safety. Disaster mitigation education can support the social participation of SMK students, but it is not always offered as a separate subject; therefore, integration through contexts and strategies relevant to the nature of vocational learning is necessary (Kamaruddin, 2023; Zuhriyah & Rokhman, 2025).

Project-Based Learning provides a structure for initiating problem-based learning, designing products, managing processes, and evaluating outcomes that can be integrated with the STEAM (Science, Technology, Engineering, Art, Mathematics) framework, thereby enhancing the potential for developing disaster education for students. A STEM-based disaster education model is necessary to develop disaster literacy and 21st-century skills (Aroyandini et al., 2024). Through the PjBL framework, students not only learn theory but are also challenged to design real-world projects that utilize observations of numerical data, engineering processes, and natural science knowledge to form a comprehensive understanding of disaster prevention systems (Sato, 2025). The integration of PjBL and STEAM facilitates learning experiences rooted in local contexts, enabling teachers and students to explore the potential for disaster mitigation (Chen & Wu, 2024) an area that remains underrepresented in guidelines or standard textbooks for the IPAS Project course under the Merdeka Curriculum (Roshayanti et al., 2025).

In addition to an analytical and innovative project-based approach, disaster mitigation education requires simulations through experiential learning. In this context, the role-playing learning model is one of the methods used in natural disaster education to analyze students' knowledge and attitudes when facing natural disasters; it is not enough to rely solely on conceptual understanding, but simulation practice is also necessary, making this model relevant in helping students understand their roles, responsibilities, and decision-making processes (Asiah et al., 2023). Through role-playing simulations, students are presented with scenarios that train them to understand their roles and responsibilities in making quick decisions under critical conditions. Student empowerment and meaningful participation in disaster mitigation education in schools are necessary through the expansion of learning methods (Rofiah et al., 2021).

Although various studies have addressed disaster mitigation education, role playing, and STEM/STEAM, there are still research gaps that require further investigation. Most previous studies have focused on developing models and teaching materials or assessing the effectiveness of learning through quantitative data, and have examined PjBL STEAM and role-playing separately. The novelty of this study lies in the integration of PjBL STEAM with the role-playing method, evaluated through a qualitative descriptive approach. Qualitative research is essential for gaining a deep understanding of the dynamics of the learning process based on individual experiences, rather than merely on final numerical outcomes (Van Ijzendoorn & Miedema, 2025). However, research on STEAM-based natural disaster mitigation learning

through role playing in the classroom based on direct observation and the perceptions of teachers and students remains very limited. Therefore, this study aims to holistically describe the learning process, the level of student engagement, and the representation of STEAM component integration based on the perceptions of teachers and students, as well as to identify obstacles that arise during the implementation of disaster mitigation instruction. Based on the research objectives, the discussion in this study is limited to addressing the following research questions:

RQ1: How is the implementation of STEAM-based disaster mitigation learning through role-playing applied in Science Project Learning?

RQ2: How are STEAM components represented in role-playing activities on disaster mitigation issues?

RQ3: How are challenges, participation, and pedagogical responses related to science project-based learning?

RQ4: How are the implications of the implementation of STEAM-based disaster mitigation learning through role-playing on science project learning?

METHOD

This study employs a descriptive qualitative approach aimed at providing an in-depth description of the implementation of STEAM-based disaster mitigation through role-playing in the IPAS project-based learning. This approach was chosen because the study focuses on the implementation, participants' experiences, the representation of STEAM components, and the challenges that arise rather than on testing the impact or changes in students' learning outcomes. (Creswell & Guetterman, 2024) or, in other words, to explore natural learning phenomena based on the experiences, activities, and meanings constructed by participants in the classroom (Fraenkel et al., 2022)

The study was conducted during the month of May at SMKN 3 BANDUNG in Class 10 Phase E of the Office Management and Business Services Specialization Program. This learning context was selected because the IPAS Project allows for an integrated study of safety and environmental issues relevant to students' lives and work readiness. The learning scenarios developed included simulations of floods, earthquakes, landslides, and volcanic eruptions to highlight the relevance to the vulnerability of the West Java region and the issue of multiple disasters in Indonesia.

The research subjects were selected using a purposive sampling technique, consisting of one IPAS Project teacher and seven students. The criteria for selecting the teacher were based on their role as the designer and direct implementer of the STEAM-integrated IPAS Project teaching modules. Meanwhile, students were selected based on diagnostic assessments and initial observations that represented varying levels of engagement, ranging from active to less active students. This variation in participant characteristics aimed to elicit the maximum amount of data regarding students' roles within the group and to interpret responses to role-playing-based learning experiences (Creswell & Guetterman, 2024). The participant sample size was not intended for statistical representation but rather to obtain in-depth information based on direct experience; data adequacy was assessed based on the recurrence of patterns observed in observations, interviews, and documents, rather than on population generalizations.

Data were collected through direct observation, semi-structured interviews, and documentation. Direct observation covered the implementation of PjBL integrated with role-playing, student activities, group interactions, the use of media and props, and the presence of STEAM components. Semi-structured interviews were conducted with Project IPAS teachers twice: before and after the learning activities. Interviews with seven students were conducted once, after the learning activities, to obtain in-depth data regarding their perceptions,

experiences, and challenges during the learning process. This aligns with the theory that interviews in qualitative research can be used to gain deep insights into participants' perspectives and experiences (Creswell & Guetterman, 2024). Documentation included learning materials, worksheets, photos of activities, simulation videos, and student work. These various techniques were employed to gather rich and comprehensive data through data triangulation, thereby enhancing the validity of the findings

The primary instrument in this study is the researcher themselves, as the researcher plays a direct role in the processes of data collection, interpretation, and drawing conclusions (Creswell & Guetterman, 2024). Supporting instruments include observation sheets, teacher interview guidelines, student interview guidelines, and a documentation checklist format, all of which are used to facilitate the systematic data collection process. The flexibility of the instruments is crucial so that they can be adapted to the field context and allow for in-depth interpretation of the data (Fraenkel et al., 2022)

According to Braun and Clarke, the thematic analysis approach to qualitative data involves a six-step procedure: 1) familiarizing oneself with the data through repeated transcription of interviews and reading of field notes, 2) initial coding of data segments relevant to the research focus, 3) identifying and grouping codes into potential themes, 4) reviewing themes to ensure consistency among data extracts, 5) defining and naming themes specifically, and 6) writing a final report in a narrative and descriptive manner. This systematic approach ensures that the analysis does not merely stop at a superficial description but rather maps out patterns of learning experiences in depth (Roseveare, 2023).

The validity of the data in this study was tested through source triangulation—involving teachers and students—and methodological triangulation through direct observation, semi-structured interviews, and documentation, followed by an examination of the alignment between the instructional design and its implementation. In addition, the researcher's direct involvement in the field for a sufficient period of time was necessary to gain an in-depth understanding of the research context. This is consistent with the assertion that the results of qualitative research are achieved through diverse and consistent data collection (Creswell & Guetterman, 2024). This study employed both emic and etic approaches (Lisboa & Julio, 2018). The emic perspective was adopted by exploring the experiences of teachers and students regarding STEAM-based disaster mitigation learning through role-playing. As for the etic perspective, it was applied to maintain the confidentiality of participants' identities by assigning specific codes. All participants provided prior consent to participate in the study, ensuring that data reporting was conducted responsibly and with respect for participants' rights. The research procedure is outlined in Figure 1.

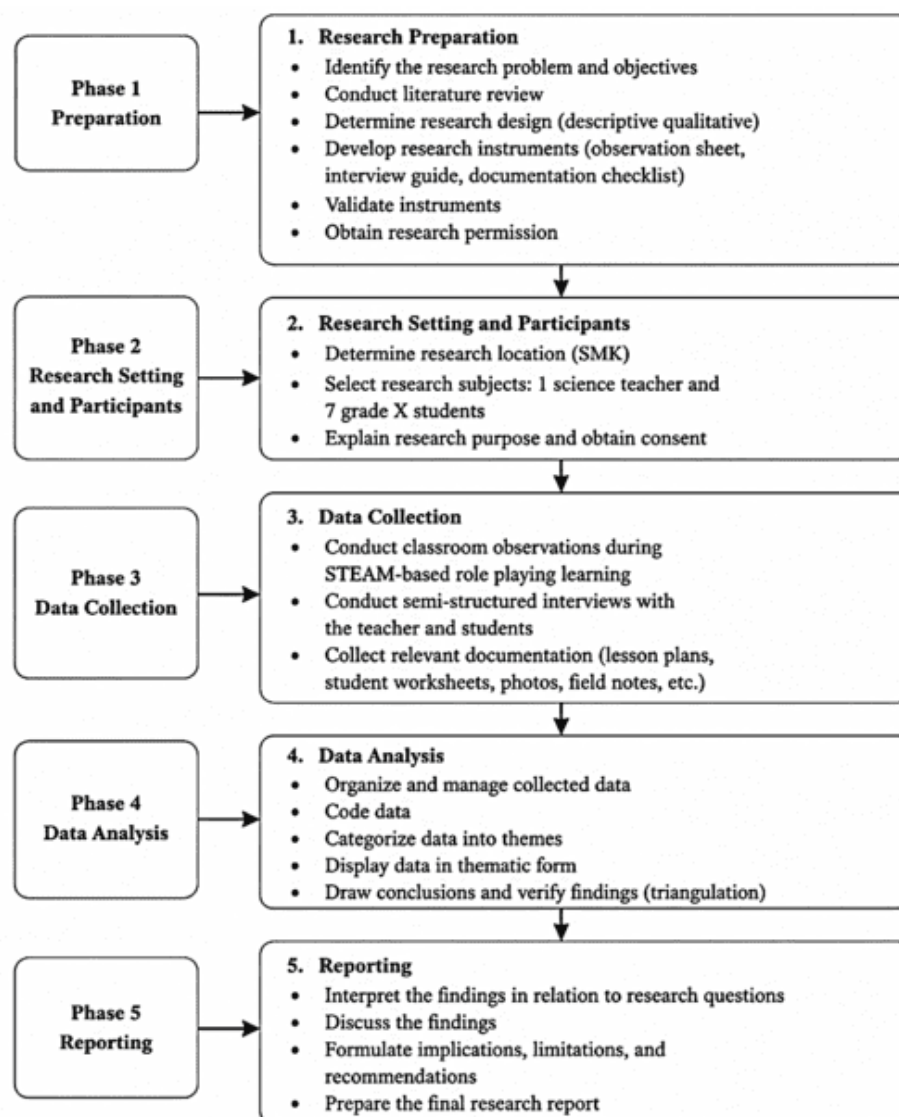


Figure 1. Research Procedure

RESULTS AND DISCUSSION

The results of the observations showed that the learning process spanned from project planning to the implementation of the simulation. Six groups selected different disaster scenarios, wrote scripts, assigned roles, arranged the classroom, created and selected props, rehearsed, and performed the simulation. In the flood scenario simulated by the third group, the sequence included warnings, power outages, the use of emergency kits, evacuation, and post-event response. Meanwhile, other students acted as observers and provided peer assessments as a form of student involvement in the learning evaluation process and the development of responsibility for learning.

The implementation of STEAM-based disaster mitigation through role-playing demonstrates active student engagement in the classroom. Observation results show that students are involved in the learning process from scenario planning and role assignment to the simulation itself—within an interactive and collaborative classroom environment. Students do not merely passively receive information but are able to build understanding through direct experience, reflection, and social interaction (Lestari et al., 2024). Thus, student engagement was evident not only during role-playing but also in product development and group evaluation.



Figure 2. Conducting a disaster mitigation simulation

Figure 2 shows that the classroom layout designed by the students supports role-playing activities, allowing students to interact more freely and extensively in simulation-based learning (Asiah et al., 2023).

Document analysis indicates a fundamental alignment between planning and implementation. The teaching modules include learning outcomes, learning objectives, learning activities, and structured assessments. The student worksheets align with the lesson plans by including a drama script that reflects the integration of STEAM components. However, the documents do not yet demonstrate criteria for design testing, risk assessment, or duration tracking using formal instruments.

The implementation of Project-Based Learning (PBL) integrated into role-playing activities can be classified into three phases: planning, production, and presentation/evaluation. The planning phase covers the stimulus, problem selection, script development, role assignment, and scheduling. The production phase includes information gathering, prop creation, set design, and rehearsals. The presentation and evaluation phase includes the simulation performance, peer observation, discussion, and reflection. These findings address RQ 1, which posits that PjBL functions as a project management framework, while role-playing serves as an outcome of simulation and action, as well as a space for reflection.

The assessments included formative assessments, a portfolio of written work, teachers' anecdotal notes, performance demonstrations, and peer evaluations. These results allow for process tracking; however, the indicators of disaster literacy and each STEAM component have not been operationally separated, so the performance of an engaging drama simulation has the potential to receive greater attention than the accuracy of mitigation actions, as well as the quality of engineering and the use of quantitative data.

Results from interviews with the teacher confirmed the patterns observed. The teacher, a woman with a Master's degree in Science Education and 18 years of teaching experience, explained that instruction was directed toward the cognitive, affective, and psychomotor domains through simulations. After the lesson, the teacher assessed that science, technology, and art were more easily identifiable, while product engineering and the use of mathematical elements were still considered suboptimal. This finding aligns with documents that presented properties and time estimates but did not show any revised design-test cycles or formal measurements.

Furthermore, student interviews were analyzed alongside observational data and documentation. Table 1 presents themes, codes, and representative evidence from the data sources so that the description of the findings can be distinguished based on their interpretation.

Table 1. Presents themes, codes, and representative evidence

Theme	Subtheme/ code	Observational evidence	Interview evidence	Documentary evidence
Project	Planning- Performance- Reflection (RP- P1/RP-P2)	Six groups divided roles, arranged the space, performed, and evaluated their peers	Students mentioned that their peers' support helped them carry out their roles and understand the sequence of a flood	Modules, worksheets, scripts, assessment sheets, photos, and videos.
Science	Mitigation Sequence (SCI- 1/SCI-2)	Scenes included warnings, emergency actions, evacuation, and post-disaster response.	Students mentioned emergency kits and power shutoffs in the flood scenario.	The script outlines actions before, during, and after a disaster
Technology	Information and Communication (TEC-1/TEC-2)	Cell phones, the internet, sirens/PA systems, walkie- talkies, and audio were used	Students explained how they searched for references and audio for the performance	Digital references and media were evident in the script and recordings.
Engineering	Space/Props Design (ENG- 1/ENG-2)	Spaces and props made from recycled materials are arranged collaboratively.	The teacher notes that product engineering remains limited.	No evidence-based design criteria, functional testing, or redesigns were identified
Art	Dramatic Communication (ART-1/ART- 2)	Dialogue, expression, costumes, and sound create a disaster atmosphere.	Students prioritize acting and creative scriptwriting as their main activities.	Scripts, costumes, audio, photos, and videos document artistic choices.
Mathematics	Time Estimation (MATH- 1/MATH-2)	Groups manage the duration within a three-class-period allocation	The teacher assesses that the integration of mathematics is not yet optimal	No stopwatch records, data tables, scales, or risk estimates were found.
Challenges	Self- confidence, time, contribution (REF-1/REF-2)	Participation varied; more expressive students often took the lead	teachers and students noted that time, self- confidence, and contribution were unevenly distributed	Schedules and group communication aided monitoring; artifacts of individual responsibility were limited.

Based on Table 1, it is evident that the STEAM components appear with varying levels of contextual depth. Science is the most prominent, as students must develop disaster mitigation measures covering the pre-disaster, emergency response, and post-disaster phases. Technology is used to support the search for references, audio, warning signals, and communication. The Art component is integrated through dialogue, expression, and costumes during the simulation, as well as through costumes and atmosphere during the simulation performance. Engineering is evident in the spatial arrangement and the creation of props; however, it has not yet extended to the formulation of criteria, the testing of simulation prototypes, or revisions based on results. Mathematics is limited to time allocation and performance duration estimates without the use of a stopwatch. Thus, while the data supports the representation of all components, it does not constitute a claim that these five components have been integrated in a balanced manner.

Implementation of STEAM-Based Role-Playing in Disaster Mitigation Education

The implementation of STEAM-based role-playing in disaster mitigation education is reflected in the results of the analysis of teaching modules, worksheets, drama scripts,

assessment rubrics, portfolios, photos, and videos. This systematic analysis was conducted to evaluate the alignment between the instructional design and its implementation and to reinforce findings obtained through observations and interviews (Morgan, 2022). Student products, such as completed worksheets and drama scripts, served as guidelines for the activities. Both documents demonstrate the integration of STEAM components, although the balance among them was not yet optimal in practice. The science component appears more dominant through the understanding of the types, causes, impacts, and mitigation stages of disasters, while the art component is evident in the development of dialogue, character portrayal, costumes, and props used. In contrast, the engineering and mathematics components were still limited to the creation of props, the arrangement of the simulation space, and the estimation of the simulation performance duration; therefore, they required guidance to incorporate data-driven processes of design, testing, measurement, and improvement (Chen & Wu, 2024).

In practice, students developed and acted out scenarios depicting pre-disaster, emergency response, and post-disaster actions. These findings were reinforced by interviews with students, who stated, “I felt more confident acting out disaster scenarios because I worked with my friends to strengthen the character I was playing and understand the process of flood mitigation.” This statement indicates that peer support helps students perform their roles while also understanding the sequence of mitigation actions. Teachers also noted that role-playing activities facilitate students’ direct engagement in understanding mitigation concepts through simulated situations. These findings align with research showing that role-playing provides students with opportunities to practice preparedness knowledge and actions in a contextual manner (Asiah et al., 2023). Participatory and experience-based learning are also considered important in disaster risk reduction education (Rofiah et al., 2021; Tyas et al., 2025). However, the self-confidence and understanding identified in this study represent participants’ perceptions, not evidence of causal or quantitative improvement.

The implementation of learning is supported by authentic assessments, including written portfolios, practical assessments, teacher observation notes, and peer assessments. These assessments enable teachers to evaluate students’ planning, the accuracy of their mitigation concepts, role distribution, collaboration, creativity, and performance during simulations. The use of performance-based assessment aligns with the principles of competency-based learning because the evaluation encompasses the process and application of knowledge in real-world activities, not just the final product (Fawns et al., 2025). Thus, STEAM-Based Role Playing facilitates contextual, collaborative, and experience-based learning in disaster mitigation. Optimizing its implementation requires strengthening the engineering and mathematics aspects through the formulation of design criteria, testing of properties, measurement of evacuation times, data presentation, and design improvements based on evaluation results.

Representation of STEAM Components in Role-Playing Activities Integrated with Project-Based Learning (PjBL)

The PjBL and role-playing learning framework is implemented through distinct yet complementary activities. During the problem-identification and project-planning stages, students develop a disaster-related theme and a drama script. Subsequently, project organization involves assigning roles, creating a schedule, preparing props, and arranging the performance space. Monitoring takes place during rehearsals, while product presentation and evaluation are carried out through performances, peer assessment, discussions, and reflection. This learning sequence aligns with the characteristics of PjBL-based learning, which emphasizes contextual problems, collaboration, product creation, presentation, and reflection (Markula & Aksela, 2022). Thus, the integration of PjBL and role-playing facilitates learning experiences relevant to vocational education through task management, collaboration, communication, and

performance presentations. Role-playing also supports disaster preparedness education by placing students in simulated situations and responses that resemble real-world conditions (Asiah et al., 2023).

Nevertheless, the engineering and mathematics components do not appear to have been developed optimally. Projects are more oriented toward the creation and staging of plays than toward solving design problems with measurable success criteria. Props have not undergone functional testing and iterative refinement, while neither the duration nor the spatial layout has been analyzed using systematic data, measurements, and calculations. Furthermore, the rubric does not explicitly assess the design process, disaster literacy, timeliness, and risk analysis. These conditions explain the dominance of science and the arts and highlight the need for more targeted scaffolding and assessment to ensure that all STEAM components are integrated in a balanced manner (Pérez Torres et al., 2024). A description of the integration of the Project-Based Learning stages into STEAM-based role-playing is presented in Figure 3 in the form of a learning process flowchart.

Figure 3 shows that this instructional approach which integrates role-playing with STEAM-based project-based learning enhances student engagement in understanding disaster mitigation concepts in a contextual manner. STEAM-based learning focuses not only on conceptual mastery but also on the development of 21st-century skills such as problem-solving, critical thinking, and creativity (Oanh & Dang, 2025). Recent research on the integration of STEAM and the SDGs in the IPAS Project at vocational high schools (SMK) indicates that the IPAS Project-based learning approach has significant potential to address social and environmental issues in the local community and is considered effective in developing 21st-century skills and innovative solutions to environmental problems (Budiati et al., 2025). The context of disaster mitigation learning using the STEAM approach is crucial because disasters are not merely a topic in science but also require early warning technology, the engineering of evacuation routes, social communication, message visualization, as well as risk assessment and response time calculations. This aligns with the Comprehensive School Safety Framework 2022–2030, which emphasizes education on disaster risk reduction and resilience through learning, school participation, and preparedness drills (UNESCO, 2022). Therefore, STEAM-based role-playing can be highly relevant for implementation in the IPAS disaster mitigation project because it transforms learning from merely understanding disasters into a learning experience that trains students to think, design, take on roles, make decisions, and build real-world preparedness.



Figure 3. Integration of Project Based Learning to Role Playing base on STEAM in Disaster Mitigation Learning

Constraints, Participation, and Pedagogical Responses

Triangulation of data obtained through observations, interviews with teachers and students, and learning documents revealed three main constraints: 1) time constraints, as students had to understand disaster concepts, write scripts, assign roles, prepare props, rehearse, perform the play, and reflect on the experience; 2) differences in students' self-confidence and level of contribution, which led to an unbalanced division of labor; 3) the tasks and rubrics did not explicitly guide students through the engineering cycle and the application of mathematics. These findings align with previous research indicating that the implementation of PjBL requires structured support to maintain student engagement throughout the project process (Zhong & Lyu, 2022).

More expressive students tend to dominate rehearsals and performances, while other members prefer to rely on group decisions. This is related to the risk of reduced individual contributions resulting from the lack of visibility of personal responsibility and work outcomes in group tasks (Luo et al., 2021). In activity-based learning, an imbalance in role distribution tends to occur when individual responsibilities are not clearly defined within the group (Tosuntaş, 2020). However, this study does not conclude that differences in students' self-confidence or readiness are the direct causes of disparities in student contributions. The data

merely indicate that variations in student characteristics co-occur with differences in the form and intensity of their involvement throughout the project.

The pedagogical interventions implemented in this study included forming small groups, assigning roles, teacher monitoring, utilizing practice time at school, scheduling, and communication via a WhatsApp group. These strategies were reinforced through individual artifacts—such as process journals and evidence-based reflections so that students' contributions could be traced. To optimize engineering and mathematics in future projects, criteria should be established for design, sketches, duration measurements, test result tables, prototype revisions, and the rationale for design choices. Such practice reinforcement and assessment are necessary to ensure that engineering and mathematics components are not merely supplementary but are genuinely integrated into the project (Pérez Torres et al., 2024)

Differences in students' learning styles affect their understanding and engagement in collaborative projects, as well as their speed in grasping activity-based learning and their ability to comprehend the material (Yang, 2025). Role-playing instruction requires a considerable amount of time because students must understand the material, assign roles, develop a scenario, practice, perform their roles, and reflect; thus, each stage of the activity carries the risk of suboptimal discussion and reflection.

Implications of Implementing STEAM-Based Role-Playing in Science Learning

The findings indicate that implementing STEAM-based Project-Based Learning (PjBL) through role-playing activities can facilitate student engagement, communication, collaboration, and the application of disaster mitigation concepts through simulation exercises. Students' involvement in writing scripts, assigning roles, preparing props, rehearsing, and staging disaster mitigation simulations encourages them to determine actions for communicating ideas and working together, resulting in group performances consistent with the nature of PjBL which emphasizes authentic activities, collaboration, products, presentations, and reflection allowing students and teachers to focus on different aspects (Markula & Aksela, 2022). Communication is related to social-emotional competencies because it involves self-confidence, empathy, emotion regulation, and responding to others (Owens & Hite, 2020) as well as students' personal readiness (Rahayu, et al, 2022).

The implementation of STEAM-based role-playing guides a shift in the teacher's role from the primary source of knowledge to a learning facilitator who helps students explore and understand science concepts as they relate to everyday life. Teachers play a role in designing learning scenarios, managing student group dynamics, and ensuring students' active engagement during the simulation process by providing data on local events, hazard maps, mitigation measures, and learning tools with separate rubrics for each type of mitigation tailored to the characteristics needed to connect academic concepts with real-world and workplace contexts, which are key features of vocational education (Arango-Caro et al., 2025). The use of technology such as videos, smartphones, AI, and other communication media should be directed toward critical digital literacy in verifying the sources and accuracy of the information obtained (Yulia., et al, 2022). Portfolios can document initial drafts, feedback, test results, revisions, and reflections so that the learning process is not reduced to the quality of the final performance simulation (Muhamad, 2024)

Constructivist and experimental learning builds understanding through experience-based activities and supports the development of scientific literacy and contextual thinking skills necessary to achieve 21st-century competencies (Oktaviani., N. et al, 2024). Particularly at the vocational high school level, which demands competency-based work readiness. Effective STEAM curricula and practices are needed to prepare students to face the challenges and demands of 21st-century jobs (Arango-Caro et al., 2025). However, experience must be

accompanied by analytical skills to distinguish appropriate mitigation measures and representative design decisions. A digital-based curriculum that enables easier access to learning resources and more diverse, student-centered interactions (Maq et al., 2023) can support the learning process.

The constructivist theory perspective emphasizes that knowledge is actively constructed through social interaction and collaborative learning experiences. In this constructivism perspective, students dynamically construct knowledge through direct engagement in meaningful activities, thereby receiving information actively rather than passively (Vygotsky, 2019). This learning process aligns with STEAM based role playing, which positions students as active participants in the learning process. Meanwhile, the cooperative learning model reinforces the learning process through group work characterized by positive interdependence and mutual accountability. Interactions are carried out to achieve common goals. Collaborative learning models have been proven to improve students' conceptual understanding and social skills in science education (Slavin, 2025). Thus, the integration of STEAM-based role-playing into science education particularly in vocational high schools can strengthen conceptual understanding and develop students' collaboration and communication skills in line with the demands of 21st century learning. In the context of 21st-century education, a systemic transformation is required that encompasses pedagogy and technology (Harahap et al., 2026) therefore, learning innovations are constantly needed to strengthen vocational education.

CONCLUSION

The results of the study indicate that integrating Project-Based Learning with STEAM-based role-playing in disaster mitigation education can facilitate contextual and collaborative learning experiences for vocational high school students. Students engaged in scriptwriting, role assignment, prop preparation, rehearsals, performances, and reflection to gain opportunities to understand and communicate disaster mitigation concepts through simulations of real-life situations. The components of science, technology, engineering, art, and mathematics were identified in the learning process, although science and art appeared to be more dominant, while engineering and mathematics had not yet been optimally integrated.

Findings from observations, interviews, and documentation indicate that this approach facilitates student engagement, communication, collaboration, problem-solving, creativity, and disaster literacy. However, this study does not quantitatively prove an increase in these competencies. The implementation of the learning process also faced limitations such as time constraints, varying levels of self-confidence, differences in the level of contribution among students, and the lack of explicit engineering and mathematics requirements in both assignments and assessment rubrics. Teachers need to provide a clear division of responsibilities, adequate practice time, gradual guidance, design assessment and testing activities, and rubrics that evaluate individual contributions and all components of STEAM.

This study was limited to one teacher and seven students in a single classroom context; therefore, its findings cannot be widely generalized. Furthermore, the qualitative descriptive approach used did not include pre- and post-instructional assessments. Future research is recommended to involve more classes and schools, use a mixed-methods approach, and incorporate measurable instruments to evaluate disaster literacy and 21st-century skills. Nevertheless, this study provides a contextual overview of the potential for integrating PjBL and STEAM-based role-playing as an alternative approach to disaster mitigation education in vocational education.

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REFERENCES

- Anindya Ika Yulia & Hastuti Diah Ikawati. (2022). Peran pengembangan teknologi pendidikan dalam meningkatkan kualitas pembelajaran.. *Jurnal Cahaya Mandalika ISSN 2721-4796 (Online)*, 2(3). <https://doi.org/10.36312/jcm.v2i3.544>
- Arango-Caro, S., Langewisch, T., Ying, K., Haberberger, M. A., Ly, N., Branton, C., & Callis-Duehl, K. (2025). 3D plants: the impact of integrating science, design, and technology on high school student learning and interests in STEAM subjects and careers. *Disciplinary and Interdisciplinary Science Education Research*, 7(1). <https://doi.org/10.1186/s43031-025-00120-4>
- Aroyandini, E. N., Supriyadi, Rusilowati, A., Hartono, & Juhadi. (2024). Disaster Education Model for Prospective Science Teachers: Needs Analysis and Initial Development. *Journal of Disaster Research*, 19(3), 560–569. <https://doi.org/10.20965/jdr.2024.p0560>
- Asiah, S., Asofi, T. S., Setyowati, D. L., Suharini, E., Hashim, M., & Nayan, N. (2023). Earthquake Disaster Education to Students of Senior High School Using Role Playing Learning Model. *International Journal of Social Learning (IJSL)*, 3(2), 173–187. <https://doi.org/10.47134/ijsl.v3i2.108>
- Çelik, İ. H. (2023). A Research on Vocational School Students within the Framework of Disaster Awareness and Disaster Preparedness Levels. *Journal of Disaster and Risk*, 6(3), 852–869. <https://doi.org/10.35341/afet.1236274>
- Chen, M. K., & Wu, C. C. (2024). Integrating Science, Technology, Engineering, and Mathematics (STEM) into Indigenous Education for Sustainability: The Development and Implementation of a Curriculum Based on Disaster Prevention for Young Children. *Sustainability (Switzerland)*, 16(21). <https://doi.org/10.3390/su16219186>
- Creswell, J. W., & Guetterman, T. C. (2024). Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research, Ebook, Global Edition. In *Pearson Education, Limited*.
- Delta Septya Rahayu & Nurul Iman. (2022). Hubungan antara kecerdasan emosional dengan keterampilan berkomunikasi pada siswa kelas XI SMA Negeri 6 Mataram tahun pelajaran 2021/2022. *Jurnal Cahaya Mandalika, ISSN: 2721-4796 (Online)*, 3(1). <https://doi.org/10.36312/jcm.v3i1.553>
- Fawns, T., Bearman, M., Dawson, P., Nieminen, J. H., Ashford-Rowe, K., Willey, K., Jensen, L. X., Damşa, C., & Press, N. (2025). Authentic assessment: from panacea to criticality. *Assessment and Evaluation in Higher Education*, 50(3), 396–408. <https://doi.org/10.1080/02602938.2024.2404634>
- Fraenkel, J., Wallen, N., & Hyun, H. (2022). How to Design and Evaluate Research in Education. In *Journal of American Optometric Association* (Vol. 60).
- Idha budiati, M. Syaiful Hayat, & Siti Fatonah. (2025). Potensi Integrasi STEAM-SDGs dalam Pembelajaran Proyek IPAS di SMK Bina Utama Kendal. *Jurnal Pendidikan Mipa*, 15(1), 148–155. <https://doi.org/10.37630/jpm.v15i1.2451>
- Kamaruddin, S. (2023). Education on Disaster Mitigation and Social Participation among Vocational School Students in Pangkep Regency. *Tamaddun*, 22(2), 97–110. <https://doi.org/10.33096/tamaddun.v22i2.557>
- Lestari, S., Manurung, A. A., & Sumarni, S. (2024). Teori Belajar Konstruktivisme dan

- Implikasi dalam Pembelajaran IPA SD. *JIIP - Jurnal Ilmiah Ilmu Pendidikan*, 7(9), 10622–10628. <https://doi.org/10.54371/jiip.v7i9.5476>
- Lisboa, J. L. C., & Julio, J. F. M. (2018). Qualitative research: Emic-etic approach. *Revista Cubana de Investigaciones Biomedicas*, 37(4).
- Luo, Z., Marnburg, E., Øgaard, T., & Okumus, F. (2021). Exploring antecedents of social loafing in students' group work: A mixed-methods approach. *Journal of Hospitality, Leisure, Sport and Tourism Education*, 28. <https://doi.org/10.1016/j.jhlste.2021.100314>
- Mahlaini Azizah Harahap, Chardinal. DV, Eggi Martiansyah, Syarifuddin, & Ferialia Eka Putri. (2026). Integrating Teacher Professional Ethics, Guidance Counseling, and School Management for 21st Century Education: A Systematic Review. *CAHAYA: Journal of Research on Science Education*, 4(1). <https://doi.org/10.70115/cahaya.v4i1.447>
- Maq, M. M., Damanik, F. H. S., Camelia, R. D., Widyanti, E., & Febianti, K. (2023). Pengembangan kurikulum pendidikan digital : Analisis kontribusi kurikulum terhadap prestasi belajar dan pengalaman siswa.. *Jurnal Cahaya Mandalika ISSN 2721-4796 (Online)*, 3(2). <https://doi.org/10.36312/jcm.v3i2.2476>
- Markula, A., & Aksela, M. (2022). The key characteristics of project-based learning: how teachers implement projects in K-12 science education. *Disciplinary and Interdisciplinary Science Education Research*, 4(1). <https://doi.org/10.1186/s43031-021-00042-x>
- Morgan, H. (2022). Conducting a Qualitative Document Analysis. The Qualitative Report, 27(1). *Qualitative Report*, 27(1).
- Novita Oktaviani, & Ulinuha Nur Faizah. (2024). the Effect of Science Literacy Skills To Contextual Thinking Skills on Science Literacy-Based Learning. *INSECTA: Integrative Science Education and Teaching Activity Journal*, 5(1), 1–10. <https://doi.org/10.21154/insecta.v5i1.8852>
- Oanh, D. T. K., & Dang, T. D. H. (2025). Effect of STEAM Project-Based Learning on Engineering Students' 21st Century Skills. *European Journal of Educational Research*, 14(3), 705–721. <https://doi.org/10.12973/eu-jer.14.3.705>
- Owens, A. D., & Hite, R. L. (2020). Enhancing student communication competencies in STEM using virtual global collaboration project based learning. *Research in Science and Technological Education*. <https://doi.org/10.1080/02635143.2020.1778663>
- Pérez Torres, M., Couso Lagarón, D., & Marquez Bargalló, C. (2024). Evaluation of STEAM Project-Based Learning (STEAM PBL) Instructional Designs from the STEM Practices Perspective. *Education Sciences*, 14(1). <https://doi.org/10.3390/educsci14010053>
- Rahmadani Dinda Ayu, Wati Desi Tri Ambar, Hanifah Norma Widya, & Fauziyah An Nuril Maulida. (2024). Analisis Mitigasi Bencana Banjir Di Indonesia Berbasis Pendekatan Kuantitatif Dalam Studi Literatur . *Jurnal Matematika Dan Ilmu Pengetahuan Alam*, 2(3).
- Rofiah, N. H., Kawai, N., & Hayati, E. N. (2021). Key elements of disaster mitigation education in inclusive school setting in the Indonesian context. *Jamba: Journal of Disaster Risk Studies*, 13(1), 1–8. <https://doi.org/10.4102/JAMBA.V13I1.1159>
- Roseveare, C. (2023). Thematic Analysis: A Practical Guide , by Virginia Braun and Victoria Clarke . *Canadian Journal of Program Evaluation*, 38(1). <https://doi.org/10.3138/cjpe.76737>
- Roshayanti, F., Pramasdyahsari, A. S., Burhanudin, A., Khasanah, N., & Ha, M. (2025). STEAM and Disaster Mitigation in Curriculum Merdeka for Junior High School Phase D. *KnE Social Sciences*, 10(9), 560–571. <https://doi.org/10.18502/kss.v10i9.18527>
- Sarifuddin Muhamad. (2024). A Study on Student's Learning Achievement with Traditional Assessment and Portfolio Assessment. *Jurnal Cahaya Mandalika ISSN 2721-4796 (Online)*, 5(1). <https://doi.org/10.36312/jcm.v5i1.2587>
- SLAVIN, R. (2025). Educational Psychology : theory and practice / Robert E. Slavin, Johns

- Hopkins University. In *The ECPH Encyclopedia of Psychology*.
- Tosuntaş, Ş. B. (2020). Diffusion of responsibility in group work: Social loafing. *Journal of Pedagogical Research*, 4(3), 344–358. <https://doi.org/10.33902/JPR.2020465073>
- Tyas, R. A., Wilujeng, I., Rosana, D., Kuswanto, H., & Purwasih, D. (2025). A review of disaster risk reduction education implementation: Integration, trends, and trajectories. In *Social Sciences and Humanities Open* (Vol. 12). <https://doi.org/10.1016/j.ssaho.2025.102015>
- UNESCO. (2022). Comprehensive school safety framework 2022–2030 - Global Alliance for Disaster Risk Reduction and Resilience in the Education. In *Unicef*. <https://www.unesco.org/>
- Van Ijzendoorn, M. H., & Miedema, S. (2025). The quality of qualitative research. *Medical Humanities*, 51(2), 202–206. <https://doi.org/10.1136/medhum-2024-012990>
- VYGOTSKY, L. S. (2019). Mind in Society. In *Mind in Society*. <https://doi.org/10.2307/j.ctvjf9vz4>
- Yang, C. (2025). Adapting Teaching Methods to Accommodate Diverse Learning Styles in Education. *Journal of Higher Education Research*, 5(6), 535. <https://doi.org/10.32629/jher.v5i6.3382>
- Zhong, C., & Lyu, K. (2022). Scaffolding Junior Middle School Students' Engagement in Online Project-based Learning During the COVID-19 Pandemic: A Case Study from East China. *SAGE Open*, 12(4). <https://doi.org/10.1177/21582440221131815>
- Zuhriyah, A., & Rokhman, N. (2025). Utilising Disaster Mitigation Educational Videos To Improve the Understanding of Students in Reducing Environmental Problem Solving. *Journal of Sustainability Science and Management*, 20(1), 122–138. <https://doi.org/10.46754/jssm.2025.01.007>