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Integrated Physics E-Booklet Model of Tsunami Disaster Mitigation in Outer Islands of The West Coast Sumatra for High School Level

Elsi Adelia Fitri[1], Henny Johan[1,a)], Bhakti Karyadi[1], Sudirman[2], Eli Putriani[3]

[1]*Program Studi Magister Pendidikan IPA, Universitas Bengkulu. Jl. Kandang Limun, Kota Bengkulu, Bengkulu 38371, Indonesia*
[2]*Faculty of Education, Southwest University, Beibei, Chongqing 400715, China*
[3]*Department of Geoscience, National Taiwan University, Roosevelt Road, Taipei 106, Taiwan*
✉: [a)]hennyjohan@unib.ac.id

Abstract

Indonesia is a country located at the confluence of the Indo-Australian and Eurasian plates, which collide with each other, one of which is off the west coast of the island of Sumatra. This situation carries a significant risk of triggering a tsunami disaster. To minimize these risks, it is necessary to provide disaster awareness to all groups, especially students. This study aims to produce an e-booklet on integrated wave material for tsunami disaster mitigation on the outermost islands of Sumatra's west coast. The study employs a research and development methodology. The research instruments were questionnaires, interview guides, validation sheets, and questions. We conducted descriptive, quantitative, and qualitative data analysis. The research results led to the production of an integrated e-booklet for tsunami disaster mitigation, tailored to the region's potential in mitigation efforts. The level of disaster preparedness after using the e-booklet is included in the high preparedness category. The relationship between knowledge and level of disaster preparedness is linear. So that this e-booklet can be used as teaching material to provide disaster preparedness on the outermost islands of the west coast of Sumatra.

Keywords: disaster preparedness, disaster mitigation, e-booklet, outer islands, tsunami

INTRODUCTION

Indonesia is a region that is susceptible to natural disasters, as evidenced by its physical, demographic, historical, and social circumstances. The Indonesian Archipelago is located at the convergence point of three major tectonic plates: Indo, Australia, and Eurasia (Muttaqy et al., 2022). These plates collide along the west coast of Sumatra Island, the west coast of Java Island, the south coast of Java Island, offshore south of the Nusatenggara islands, and then turn northward towards the southern Maluku waters. As a result, Indonesia is very susceptible to many natural calamities, including earthquakes, volcanic eruptions, floods, landslides, and tsunamis. The west coast of the island of Sumatra in Indonesia is prone to frequent natural disasters due to a plate shift of 4-6 cm/year. Enggano island is one of the areas on the west coast that is affected by these disasters (Adityawan et al., 2023).

Enggano Island is the outermost island of western Indonesia which is located in North Bengkulu Regency, Bengkulu province. Based on the strike value, if a natural disaster occurs on the west coast of the island of Sumatra, such as an earthquake with a large force in the sea, it will have the potential to cause a tsunami disaster and Enggano Island will become an area that is more quickly hit by tsunami waves (Haridhi et al., 2023). According to (Richard et al., 2023) earthquakes that occur on the seabed

have the potential to cause tsunamis with up-and-down fault mechanisms causing tsunami waves where changes in the mass of water on the seabed will produce waves with wavelengths of hundreds of kilometers and speeds of up to 800 km/h hours at sea level. As in the case of the 2000 earthquake with a magnitude of 8 on the Richter scale and the 2007 earthquake with a magnitude of 7.9 on the Richter scale that hit Bengkulu, Enggano Island became the worst level of damage based on the survey team report from the Meteorology and Geophysics Agency using the Modified scale Mercally Intensity (MMI). The impact of the tsunami was enormous, such as the loss of thousands of lives, material losses, infrastructure damage, loss of social structure, and others.

In order to mitigate the risk of disasters, it is imperative to implement and promote disaster awareness among individuals of all age groups, including school-age children, such as those in junior and senior high school. One method of implementing schools as catalysts for fostering a culture of disaster preparedness and mitigation is by engaging in collaborative efforts to promote awareness and education on disaster mitigation within the context of physics education. According to initial research conducted using a needs analysis questionnaire and interviews with three teachers, it has been determined that the current learning process primarily revolves around teacher-centered instruction and does not incorporate the surrounding environment as a learning resource. Physics education in schools continues to face several challenges, particularly in comprehending complex concepts that want further, more tangible elucidation. The wave topic is often perceived as challenging by pupils due of its abstract nature. The instructor need a method to facilitate pupils' comprehension of the wave phenomenon. Furthermore, according to the viewpoint of 57% of students, they said that they had never been exposed to any curriculum content pertaining to disasters occurring on Enggano Island within their physics coursework. Students concur that educational resources, such as information on waves, should be used to address catastrophes in a captivating, interactive, and contextually relevant manner.

Therefore, it is necessary to have alternate educational resources to address the constraints of learning mentioned before. An effective approach is to offer instructional resources in the form of booklets, which can foster greater student engagement in the learning process. The booklet should establish a connection between the subject matter and natural disaster preparedness by considering the specific features of the local region, in order to actively engage pupils. Booklets with the ability to captivate students' interest (Allitt et al., 2023) and stimulate curiosity may be created in a straightforward manner. These booklets should be rich in visual content, vibrant in color, and designed to be practical. Additionally, they should be easily portable, allowing students to read them anywhere. By including these characteristics, booklets can effectively enhance student comprehension (Fitriasih et al., 2019). The purpose of this e-booklet is to equip students with the necessary skills for disaster preparation. (Agusti & Rahmah, 2019) conducted a study to create a booklet on earthquake and tsunami catastrophe mitigation. The purpose of the booklet was to provide information to the residents of Padang City. This project involved the development of a booklet that followed a certain structure, including a cover, introduction, and discussion sections. The discussion provides fundamental facts about earthquakes and tsunamis, measures to reduce their impact, details of disaster preparedness packages, and contact information for relevant agencies or institutions. The e-booklet material was adapted and enhanced to create a series of integrated e-booklets on disaster mitigation in the outermost islands of Indonesia, specifically the western part of Sumatra. The booklet structure includes an introduction, core, and closing sections, following the design structure of the study. The beginning section has a cover, directions for utilizing the E-booklet, fundamental proficiencies, and learning indications. The core portion provides an analysis of the tsunami phenomena and the fundamental principles of waves. The last part encompasses endeavors to mitigate the impact of tsunami disasters. This research includes educational movies on the topic of tsunami disasters, as well as the notion of waves and simulations of tsunami disasters.

The problem addressed in this study is how to create an E-Booklet model of integrated wave material for tsunami disaster mitigation on the outer islands of the west coast of Sumatra, with the aim of equipping students with the necessary skills to prepare for tsunami disasters. The research and development method aims to create an e-booklet on integrated wave material for tsunami disaster mitigation on the outer islands of the west coast of Sumatra. This e-booklet will provide information about tsunami disasters and educate students on how to minimize and reduce their impact.

METHODS

The type of research used is research and development using the development model by Thiagarajan (1974), namely Define, Design, Development, and Dissemination. This research was conducted in the even semester of the 2022/2023 academic year. The research was conducted on Enggano Island, North Bengkulu Regency, and the implementation of the e-booklet was carried out in class XI IPA at one of the high schools in Enggano Island. The Enggano island region was chosen because it is one of the outermost islands on the west coast of Sumatra which has not been much touched by humans and has the potential to experience a tsunami disaster. After all, it is directly facing the Indian Ocean. Enggano Island is located in Bengkulu Province which has 6 villages with 600 households and an area of 400.6 square kilometers located at coordinates 05°.23'21" south latitude, 102° 24'40" east longitude.

Sampling in this study uses a purposive sampling technique. Data collection is primary data in the form of direct observation to get an overview of structural and non-structural efforts as potential areas in efforts to mitigate the tsunami disaster on Enggano Island in each village, namely: Kahyapu, Kaana, Meok, Malakoni, Apoho, and Banjar Sari. Secondary data was obtained from the relevant agency, namely the Bayur Bay BMKG in the form of data: wave height, sea current speed, and wind speed. Data collection to measure the level of disaster preparedness using knowledge questions and questionnaires. The research instruments included a needs analysis questionnaire, document review check sheets, interview guidelines, teaching material validation sheets, test instrument validation sheets, post-test question sheets, and preparedness questionnaires.

Analysis of regional potential data in disaster mitigation efforts was analyzed descriptively. For secondary data in the form of wave height, ocean current speed, and wind speed are analyzed using simple statistics to see the average value of each parameter as a picture of sea waves around Enggano Island. As for the analysis of the instrument, namely (1) Test the validity of using the Product Moment Correlation formula by comparing the values of r-count and r-table. If r-count > r-table, then we can conclude that the item is valid. (2) test the reliability of the questions using the Alpha Cronbach formula. (3) discriminating power and (4) item difficulty level. The e-booklet feasibility analysis was analyzed using the feasibility equation of teaching materials from the validator's assessment. Data analysis for disaster preparedness was carried out using post-test results on two parameters of disaster preparedness using descriptive statistics. Where this preparedness analysis uses the disaster preparedness index from LIPI-UNSECO, 2009 to measure the level of student preparedness for the tsunami disaster. Analysis of the relationship between knowledge of the wave concept and the level of tsunami disaster preparedness was analyzed using the correlation formula. The research procedure for developing an integrated e-booklet for tsunami disaster mitigation is as shown in FIGURE 1.

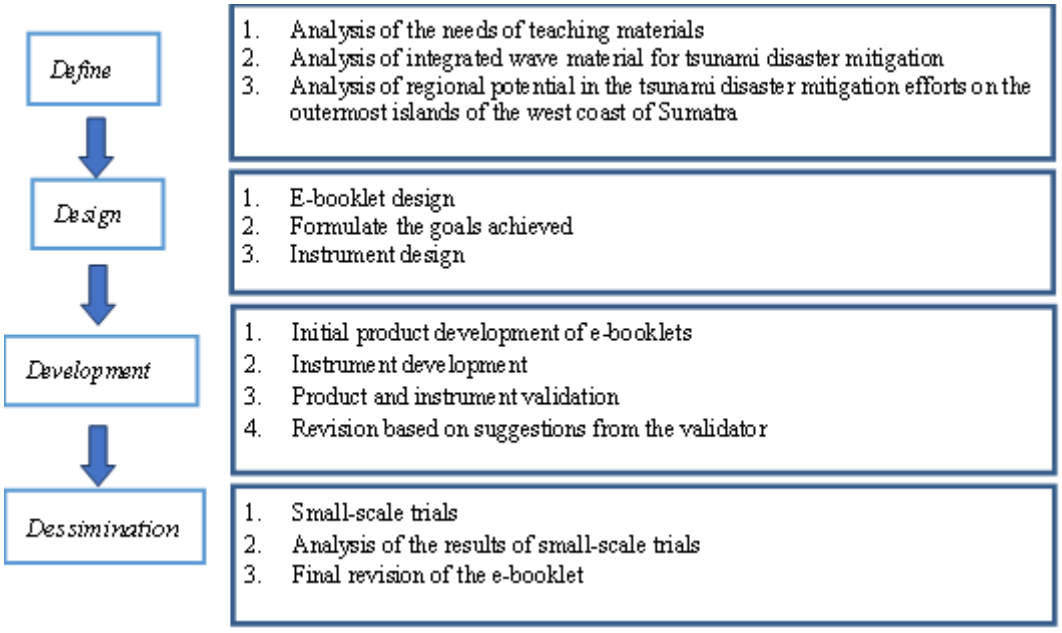

FIGURE 1. Research Procedure

RESULTS AND DISCUSSION

Regional Potential in Tsunami Disaster Mitigation Efforts

Based on the potential results of the area in the tsunami disaster mitigation efforts used to determine the form of tsunami disaster mitigation that has been carried out on Enggano Island consists of primary data in the form of structural and non-structural efforts and secondary data in the form of wave height, ocean current speed and wind speed on the islands. the outermost west coast of Sumatra.

Structural Effort

Structural mitigation efforts are divided into 2 parts, namely naturally in the form of mangrove forests, and artificial structural mitigation efforts, namely breakwaters, and evacuation signs. One of the natural structural mitigation efforts on Enggano Island is in the form of planting mangroves. The vegetation that is most commonly found on Enggano Island is mangrove forest vegetation which is owned by almost every village. The mangrove forest on Enggano Island, covering an area of approximately 1,700 hectares, is one of the widest mangrove ecosystems in Bengkulu Province. The average is generally located at an altitude of 20 meters with a gentle slope of <15° to moderate 15°-25°.

The diversity of mangrove species on Enggano Island consists of 6 families, namely Rubiaceae, Rhizophoraceae, Guttiferae, Rhizophoraceae, Combretaceae, and Lythraceae. There are 5 types of roots in mangroves on Enggano Island, namely stilt roots, respiratory roots, knee roots, and hanging roots. hanging roots: 1-2 m, and knee roots = 10-20 cm. The mangrove root system functions to bind sediment and can act as a wave damper because it can reduce wave energy from the high seas to the coast (Shu et al., 2023). So that mangroves can be one of the natural structural mitigation efforts to reduce tsunami wave heights, this is because when tsunami waves are blocked by mangroves, the energy wave height and tsunami flow will decrease because they are restrained by mangrove forests. The condition of mangroves on Enggano Island, such as in the village of Khayapu, is in good condition, but several trees have died due to being struck by lightning, while those in the villages of Banjar Sari, Meok, Malakoni, Apoho have good conditions. Overall the condition of the mangrove forest is still sustainable and well maintained because the people there still hold their customary traditions to protect the mangrove forest.

FIGURE 2. Mangrove Plants

One of the artificial structural mitigation efforts found on Enggano Island is a breakwater building. those entering or leaving Enggano Island with wave heights that are quite high compared to other villages so breakwaters are made in the form of groynes and tofu stones. The breakwater building on Enggano Island can be seen in the FIGURE 3.

FIGURE 3. Wave breakers on Enggano Island

The condition of the building structures on Enggano Island in the form of groins and tofu stones have started to rust and have been eroded by the waves so the building structures have begun to decrease. So it is feared that it will reduce the function and benefits of the building structure. The distance of the breakwaters such as the tofu stone is very close to residential areas, which is approximately 20 m so that if big waves hit the breakwaters, it will be felt and heard from the houses of the surrounding residents.

Non-Structural Efforts

Based on the results of observations made on Enggano Island, there were structural efforts from the local government to provide evacuation routes in each village and have one assembly point located in Kaana village. However, the reality on the ground found that several evacuation routes were in a state of disrepair. This indicates that there is still a lack of public awareness of tsunami earthquake disaster mitigation. FIGURE 4 and 5 show pictures of the evacuation routes on Enggano Island.

FIGURE 4. Evacuation Route

FIGURE 5. Rally Point

Beach slope

The shape of the land surface on Enggano Island in general can be said to be quite flat to sloping (63.39%) of this island has a gentle slope, with a few areas that are rather steep. The slope of the coast is one of the factors that affect the height of a wave when it reaches land with the distance the tsunami reaches land which is largely determined by the type of beach and the height of the beach. The following is a graph of the average elevation of the area on the island of Enggano.

TABLE 1. Altitude of the Outer Islands on the West Coast of Sumatra

No	Region	Highest altitude (above sea level)	Lowest altitude (above sea level)
1	Kahyapu	32 m	29 m
2	Banjarsari	66 m	13 m
3	Kaana	52 m	14 m
4	Malakoni	74 m	55 m
5	Apoho	63 m	17 m
	Average	57.4 m	25 m

Based on TABLE 1 it can be seen that the Renggano area has the highest average altitude of 57.4 m above sea level and the lowest average altitude is around 25 m above sea level. Where almost every village on the island of Enggano has a gentle slope.

Sea Wave Height

This wave height data is used to determine the condition of sea waves in certain waters and to analyze wave height as one of the parameters for a tsunami disaster. It is difficult to measure the energy of ocean waves because their magnitude and direction are random. One of the areas in Indonesia that has a significant wave height is the coastal area which is directly adjacent to the ocean or the high seas such as the west coast of Sumatra, especially Bengkulu province. FIGURE 6 is a graph of the average wave height on Enggano Island.

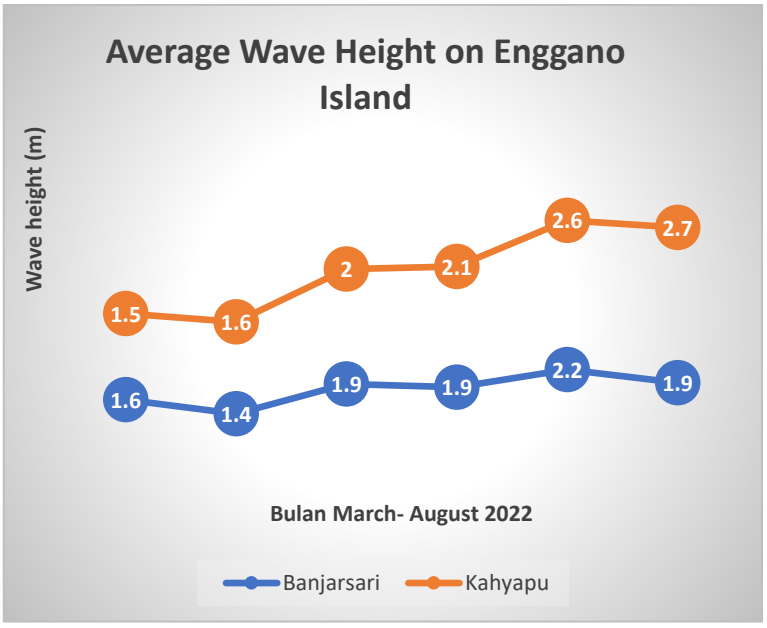

FIGURE 6. Average current speed on the outer islands of the west coast of Sumatra.

Based on FIGURE 6 it can be seen that the average wave height on Enggano Island based on the average graph in Khayapu village and in Banjarsari village from March to August 2022 can be seen that the average wave height is at moderate height, namely between (1, 25m - 2.5 m) based on wave height guidelines. Where in the village of Khayapu it is higher than in the village of Banjarsari which is in the range of 1.5 m-2.7 m while in the village of Banjarsari, it is in the range of 1.4 m-2.2 m. This is because Enggano Island, especially in the village of Khayapu, is the village at the far end that is directly facing the Indian Ocean, causing the wind energy that blows above sea level to tend to be large so that when the energy transferred by the wind to the sea surface is large, the waves and currents generated also tend to big. From May to August, the wave height in the Indian Ocean is higher than the wave height in the Pacific Ocean. The wave height in the southern part of the Java Sea tends to be lower than the wave height in the northern part of the Java Sea. This is due to the pressure of seasonal winds that blow from south to north. On the other hand, the wave height on the west coast of Bengkulu, especially Enggano Island, has increased to 2.2 m - 2.7 m. Therefore, the wind becomes less strong in the Indonesian region. The wind that moves in Bengkulu waters and surface flows also experiences a shift and it be a factor for the the wave height (Lestari et al., 2015). Based on the type of wave, tsunami waves originating from and originating from the sea are examples of transverse waves (Watada, 2023).

Besides that, another factor that causes wave heights to tend to be large is that there are no large islands around Enggano Island that can dampen wave energy before it reaches the beach. If there are other islands around Enggano Island, when a wave hits another island, the wave energy will break so that when it reaches the beach, the energy is smaller. The energy of a wave is getting smaller and smaller if there is attenuation. Attenuation that can reduce wave energy when approaching the coast can be in the form of surrounding islands or can be in the form of breakwaters and mangrove forests or mangroves(Bramaw2Zanto et al., 2015; Subagya, 2007). In addition to the wave height that affects the tsunami disaster, ocean currents are also one of the factors that affect the emergence of large losses in the tsunami disaster. The vertical and horizontal movements of water masses towards equilibrium (Voosen, 2020), or the enormous water movements that occur throughout the world's oceans, are known as ocean currents (Villa Martín et al., 2020).

Development of an Integrated E-Booklet on Tsunami Disaster Mitigation

The e-booklet framework which consists of an initial part in the form of a cover and instructions for using the e-booklet. The booklet developed consists of a cover, contents and cover. The content section consists of physics concepts, insight into tsunami disasters, and disaster mitigation. The contents section is equipped with images and animated videos. The core section contains a discussion of the

tsunami phenomenon and the concept of waves adapted to the environmental characteristics around Renggano Island. The closing part consists of pre-disaster, during-disaster, and post-disaster mitigation efforts where the tsunami disaster mitigation efforts are supplemented with a tsunami disaster simulation video so that students know what to do when a tsunami disaster occurs, when it occurs, and after a tsunami disaster occurs.

Based on the framework, an e-booklet was developed with the core part of the e-booklet starting from the phenomenon of the tsunami disaster and then explaining the concept of waves in a tsunami disaster such as the concept of wave magnitude and wave characteristics then based on the physics concept of the tsunami disaster it can be applied to efforts tsunami disaster mitigation both artificially structural mitigation efforts such as wave breakwaters and natural structural mitigation efforts such as mangroves so that it is expected to increase students' knowledge and disaster preparedness for the tsunami disaster. Each of the contents of this e-booklet contains data on potential areas for tsunami disaster mitigation efforts. The structure of the contents of the e-booklet refers to the inductive content structure where this section explains from specific to general concepts in the form of special concepts of the tsunami phenomenon which are then explained using physics concepts in the form of wave material. Furthermore, the contents of the e-booklet also contain tsunami hazard alerts, tsunami damage, tsunami disaster mitigation, and tsunami disaster simulation to support tsunami disaster preparedness capabilities. The structure of the core parts of the e-booklet can be seen in FIGURE 7.

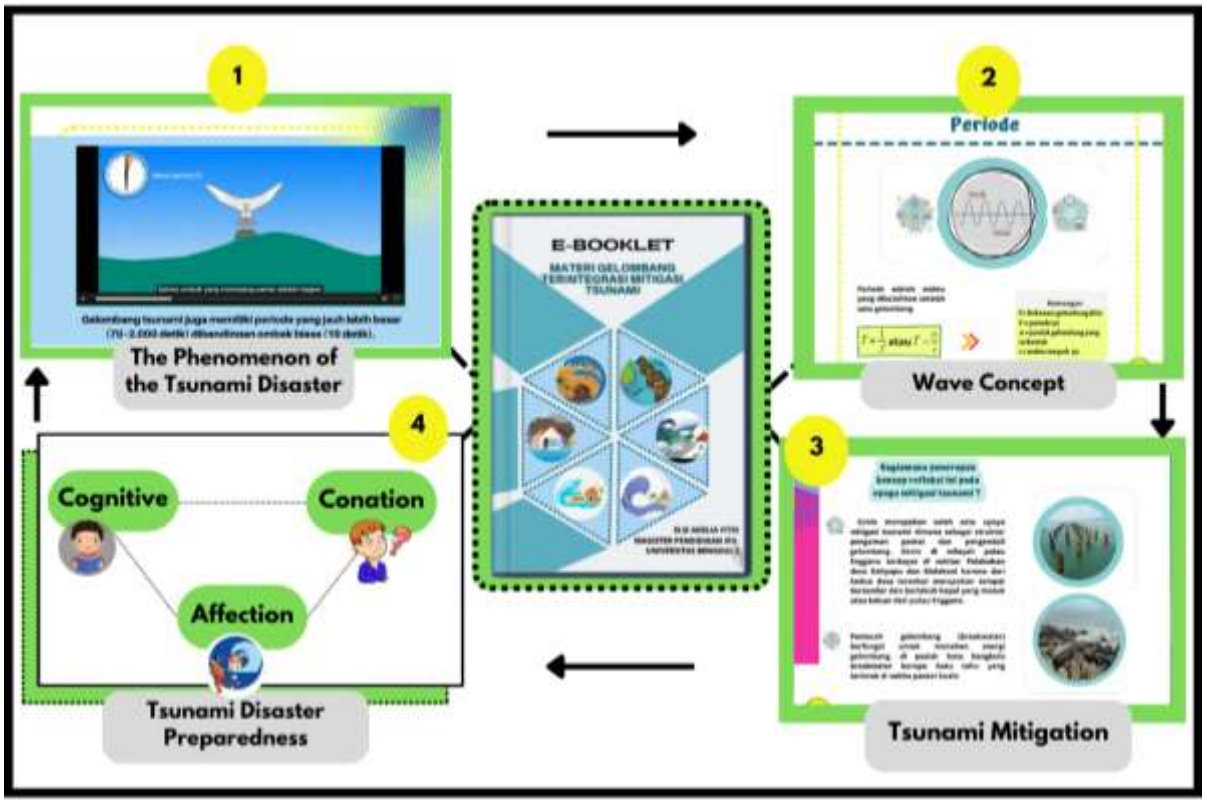

FIGURE 7. Structure of the Core Parts of the Integrated E-Booklet on Tsunami Disaster Mitigation in the Outer Islands of the West Coast of Sumatra

The results of the development of the e-booklet are then validated by the validators and revised according to the suggestions and input from the validator so that the product being developed is even better. The feasibility results of the validator get a percentage of 92% with a very decent category. This means that the e-booklet on integrated wave material for tsunami disaster mitigation on Enggano Island that was developed can be used as teaching material on wave material to provide high school students with tsunami disaster preparedness. After revision, the e-booklet can be implemented with small-scale trials on students.

Implementation of The Integrated Tsunami Disaster Mitigation E-Booklet

Implementation of an integrated e-booklet on tsunami disaster mitigation on wave material is carried out by applying a contextual approach. Towards the end of learning students are given a posttest to determine the level of understanding and attitudes of students towards the material that has been taught. After obtaining information on students' posttest answers, it is then analyzed to determine the level of disaster preparedness possessed by students after being equipped with disaster preparedness skills through mastery of using the integrated e-booklet on tsunami disaster mitigation. The results of the implementation of the e-booklet consist of 3 parts, namely the parameter of preparedness knowledge on the wave concept, the level of tsunami preparedness, and the correlation between the two.

Knowledge Preparedness Of Waves Concept

The results of the analysis of disaster preparedness knowledge on the wave concept can be seen in the TABLE 3.

TABLE 3. Knowledge of preparedness on the wave concept.

Indicator	Average	Max Score	Min Score	SD	Category
Causes of the Tsunami Disaster	58	100	20	16	Low
Mitigation Efforts	91	100	59	22	Very high
Wave Size	66	100	20	8	Tall
Characteristics of Refraction Waves	89	100	33	18	Very high

Based on TABLE 3 above, there is preparedness knowledge of the wave concept. Where in the first indicator, namely explaining the causes of the tsunami disaster, an average score of 58 was obtained in the low category. This shows that most students still do not understand this problem even though the causes of the tsunami disaster students already understand and can answer these questions because the e-booklet contains the causes of the tsunami. In the analysis section of the relationship between wave velocity and wavelength, it is still difficult to answer, this is because the e-booklet only contains theory and a brief explanation of this matter and there are no practice questions to make it easier for students to answer questions. The evaluation components contained in textbooks, for example in the form of questions (both sample questions and practice questions), are one of the important aspects of textbooks. Augmented reality also can be implemented in textbook (AlNajdi, 2022; Johan et al., 2023a; Johan et al., 2023b). So practice questions are important for learning activities using teaching materials that are appropriate to student characteristics.

The mitigation effort indicator, namely explaining tsunami mitigation efforts on the concept of wave reflection, obtained an average score of 91 with a very high category. This is because the e-booklet already contains a section explaining mitigation efforts for the tsunami disaster which is inserted in the context of reflection. Tsunami waves can reflect their energy if they hit a hard surface so that they can hit the area in front of them (Inoue et al., 2021). Therefore the concept of reflection on waves is important to be inserted into the tsunami disaster where it can explain the concept of wave characteristics, namely refraction (reflection) so that it makes it easier for students to understand the concept.

The wave size indicator, which explains the magnitude of the tsunami waves in terms of wave height and wave speed, obtained an average score of 66 in the high category. This shows that students can predict the relationship between the height of the tsunami wave and the wavelength and speed of the wave so that they can solve the problem correctly. So that students not only understand wave material but also know contextually about the tsunami disaster which is one application of the wave concept. Contextual learning encourages students to think more deeply so that students are proficient in understanding and determining what is known and asked about questions (Lengyel et al., 2022). So it will be better if the learning or teaching materials used contextually are by the surrounding environment.

The wave characteristics indicator, which relates the characteristics of the tsunami waves to the concept of wave refraction, obtained an average score of 89 with a very high category. This is because the e-booklet contains sections that explain the characteristics of tsunami waves with the concepts of reflection, refraction, and interference integrated into the concept of waves making it easier for students to analyze and answer questions. Embedding learning in the classroom that is integrated into the phenomenon of disasters is very important to reduce the impact caused by the disaster and make it easier for students to understand efforts in disaster mitigation (Rahma et al., 2023). These results as a whole show that the concept of wave material integrated into tsunami disaster mitigation can provide preparedness skills in disaster preparedness knowledge.

Level Of Preparedness For Tsunami Disaster

The level of tsunami preparedness for students can be seen in the TABLE 4.

TABLE 4. Level of Preparedness for Tsunami Disaster

Parameter	Preparedness Index	Weight	Index
Knowledge and Attitude	88	0.21	18
Emergency Response Plan	90	0.21	19
Disaster Warning System	85	0.20	17
Resource Mobilization	80	0.19	15
Policies and Guidelines	81	0.19	15
Preparedness Level			84

Based on TABLE 4 of the disaster preparedness index above, it was found that the knowledge and attitude index values of the students were 88 in the very prepared category, meaning that the students already had sufficient knowledge about the tsunami disaster. Because students have been provided with knowledge and attitudes through an e-booklet that is integrated with the tsunami disaster. This can be seen in the e-booklet which includes the definition of a tsunami disaster, the process of tsunami occurrence, the impact of a tsunami, potential losses caused by a tsunami disaster, characteristics that affect the height of a tsunami wave, tsunami disaster alarms, and tsunami disaster mitigation. In addition, students understand and know that the area where they live is a disaster-prone area, so it influences their attitude in dealing with the tsunami disaster. After having sufficient knowledge of the tsunami disaster, it will influence their attitude towards the disaster. According to (Bian et al., 2022) it shows that people's attitudes and concerns about disasters affect their willingness to be prepared to anticipate disasters and reduce the consequences of disasters. So, it is important to provide disaster preparedness knowledge so that it influences preparedness attitudes.

The disaster preparedness index value for the emergency response plan parameter is 90 in the very prepared category, meaning that students already know a lot about and have prepared emergency plans in the event of a tsunami disaster. This is by the e-booklet which contains evacuation routes, gathering places in the event of a tsunami disaster, conducting tsunami disaster simulations, and preparing first aid kits and disaster-prepared bags. In addition, most students are also familiar with the evacuation routes and gathering places that they often encounter in their surroundings, making it easier for them to plan emergency measures in the event of a tsunami disaster. In line with the opinion (Jiang et al., 2023) that emergency response plans, especially those related to evacuation and rescue, are important components in the preparedness process to minimize the number of disaster victims. So this parameter is one of the important parameters to support tsunami disaster preparedness efforts so that students get used to the instructions around them to introduce them to the emergency response plan in the event of a tsunami.

Based on TABLE 4, the preparedness index value for the parameter of the disaster warning system was obtained at 85 in the very prepared category. This is because students already know that there is a warning system if a tsunami will occur. The warning system is in the form of familiar tsunami warning sirens that are around the daily environment of students. Apart from that, tsunami sirens can also come from notifications from mosques if a tsunami disaster occurs. In addition, a disaster warning system in

the form of a tsunami siren has been provided through an e-booklet that they have studied, making it easier for students to find out about tsunami warning systems around them. Even though it is only a small-scale non-traditional disaster warning system in the surrounding environment, various preventive measures need to be taken so that conditions remain safe (Yatnikasari et al., 2020).

The student resource mobilization index value of 80 is in the very ready category. The index value on this parameter is smaller than the other parameters because students do not know that disaster learning can not only be provided from disaster material but can be integrated through learning materials such as physics learning on wave material. Embedding learning in the classroom that is integrated into the phenomenon of disasters is very important to reduce the impact caused by the disaster and make it easier for students to understand efforts in disaster mitigation (Indriyanti, 2020). This is supported in the e-booklet which contains actions that can be taken before the tsunami occurs, such as participating in disaster evacuation training and disaster simulation drills. So that after being provided with disaster material which is inserted with wave material, students know that resource mobilization can be obtained through classroom learning.

The value of the disaster preparedness index on policy parameters and student guides was obtained at 81 in the very prepared category. Policies and guidelines on a school scale, especially for students in question, can be in the form of following directions from the authorities, following disaster warning system notifications from the government such as the Early Warning System (EWS), and other guidelines. The government's role in supporting disaster mitigation efforts, especially the tsunami disaster, is by providing disaster literacy, advancing technology and information, and providing disaster warning tools such as EWS and others (Anderson et al., 2022). This has been provided to students through e-booklets contained in the efforts made during the pre-disaster, during the disaster, and after the tsunami disaster so that students know the policies that have been implemented by the government to reduce the impact of the tsunami disaster.

The total value of the student tsunami preparedness index is 84 with a high preparedness category based on the five parameters of disaster preparedness. This means that students are sufficiently prepared in the face of a tsunami disaster. Although there is still much that needs to be improved in dealing with the tsunami disaster such as disaster knowledge that needs to be embedded in other learning materials and also the need to do disaster evacuation and disaster simulation exercises for students to reduce the risk of the tsunami disaster that is generated.

Correlation Between Preparedness Knowledge on The Wave Concept and The Level of Tsunami Disaster Preparedness

The results of the correlation between preparedness knowledge on the wave concept and the level of tsunami preparedness for the tsunami disaster resulted in a correlation of sig count of 0.003 which is much smaller than the reference sig of 0.05. Thus it can be concluded that there is a significant linear relationship between knowledge of preparedness on the wave concept and the level of preparedness for tsunami disasters. Based on strong data, the value relationship is in the moderate correlation category. Correlation results can be seen in TABLE 5.

TABLE 5. Correlation between preparedness knowledge on the wave concept and the level of tsunami preparedness.

Amount Sample	Significant Value	Pearson Correlation	Decision	Criteria
5	0.03	0.52	There is a relationship	Currently

Based on this correlation, it means that students already have enough knowledge about the tsunami disaster which is obtained from the learning process on integrated wave material on tsunami disaster mitigation through e-booklets. Having sufficient knowledge of the tsunami disaster will indirectly affect the level of tsunami preparedness for students. This is in line with the opinion (Indawati, 2015; Ho et al., 2022). The attitude and concern of the community to be alert and alert to disasters is influenced by the knowledge they have, especially people who live in areas prone to natural disasters.

CONCLUSION

The booklet also presents the relationship between wave concepts and tsunami disasters and disaster mitigation. disaster and mitigation equipped with animations and images. This compilation can facilitate students to understand concepts contextually as well as instill insight into disasters and disaster mitigation. Enggano Island is very prone to earthquake and tsunami disasters so this is very necessary. Incorporating tsunami disaster mitigation material into the school curriculum is emerging as an important way to increase students' knowledge and preparedness. The electronic book created serves as a proactive teaching tool in strengthening readiness and reaction skills among the island's young generation. Based on the research that has been done, it can be concluded that tsunami disaster mitigation efforts on the outermost islands of the west coast of Sumatra (Enggano Island) are in the form of mangroves, breakwaters, evacuation routes, gathering places and instilling tsunami disaster mitigation materials through teaching to students at school. Wave height data on Enggano Island ranges from 1.25 m – 2.5 m with moderate heights. While the average speed of ocean currents on Enggano Island ranges from 14 cm/s – 22 cm/s and the wind speed on Enggano Island ranges from 14 cm/s – 27 cm/s.

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