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Development of Jono Oge Walking House Liquefaction Media for Science Learning and Mitigation

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Abstract: In natural disasters, the scientific phenomenon of liquefaction occurs, causing houses to sink into the ground, the houses shifting from their original position so that they are like 'walking houses'. However, students do not understand this phenomenon scientifically and mitigate it. Seeing these problems, a research was conducted on the development of props for the phenomenon of 'walking houses' during liquefaction for science learning. The formulation of the problem is how to develop props of the 'walking house' phenomenon during liquefaction for science learning. The goal is to develop props of the 'walking house' phenomenon during liquefaction for science learning. As well as providing an understanding that the phenomenon of walking houses and trees is a scientific phenomenon that occurs during liquefaction. This research uses the 4D model with the stages of defining, designing, developing, and disseminating. From the results of the research conducted, a normal gain of 0.31 was obtained at SMPN 1 Sigi, SMPN 13 of 0.33 Sigi SMPN 27 Petobo of 0.19 and SMPN 21 Petobo of 0.32. Overall, the results of this study state that the 'walking house' props are effective for science learning and disaster mitigation.

Keywords: Earthquake; Jono oge; Liquefaction; Learning Media.

Introduction

Liquefaction is a geological phenomenon that can cause large-scale damage to infrastructure and loss of life (Montoya & Mesri, 2021). Liquefaction occurs when fine-grained, water-saturated soil loses strength due to earthquake tremors, turning into a liquid-like state (Dashti et al., 2019). The impact is devastating, as happened in Jono Oge, Central Sulawesi, during the Palu earthquake in 2018. In this incident, residential settlements were displaced by hundreds of metres due to soil liquefaction (Prasetyo et al., 2020).

The lack of public understanding of liquefaction is a challenge in disaster mitigation (Youd & Idriss, 2018). Disaster education needs to be developed with an experiment-based and interactive approach to improve students' understanding of this geological phenomenon (Cahyono et al., 2022). Experiment-based learning has been shown to improve concept understanding in science (Kolb & Kolb, 2017). Therefore, innovative educational media is needed to explain liquefaction mechanisms effectively (Aydan, 2019).

This research proposes the development of a liquefaction media 'Walking House', inspired by the real events in Jono Oge. This media was developed as an experiment-based science learning tool, which aims to: Explain the liquefaction mechanism concretely (Ishihara, 2020); Improve students' understanding of the concept of earthquakes and their impacts (Towhata, 2019); Educate the public on liquefaction mitigation strategies (Sitharam & Jakka, 2021).

Experiment-based learning approaches have been widely applied in geoscience studies to improve student understanding (Hicks et al., 2020). Studies show that visual aids and hands-on experiments can improve retention of scientific concepts up to 70% more

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effectively than lecture methods (Mills & Treagust, 2018). In addition, learning media based on local reality is more easily understood by students than a purely theoretical approach (Widodo et al., 2021).

Globally, liquefaction mitigation has become a concern in geotechnical and disaster studies (Tatsuoka et al., 2019). Various methods have been developed to reduce liquefaction risk, such as soil improvement (Robertson & Wride, 2020) and liquefaction-resistant infrastructure-based approaches (Kramer, 2019). However, public understanding of this hazard is still low, especially in developing countries (Rahardjo et al., 2021). Therefore, experimentation and visualisation-based education is needed to increase awareness of liquefaction risk (Kayen et al., 2020).

The development of the 'Walking House' media is expected to be an innovative solution in improving disaster literacy from an early age. With a better understanding of liquefaction, it is hoped that the community can be better prepared to deal with potential disasters in the future (Cetin et al., 2018).

The role of Science Learning Media in Disaster Mitigation regarding liquefaction is very important to improve community preparedness, especially for students. According to Ariyanti et al. (2021) the use of experiment-based learning media can improve students' understanding of science concepts more significantly than conventional methods.

Some studies that examine the same thing include Hidayat et al. (2020) stated that experiment-based interactive media can improve students' understanding of liquefaction mechanisms up to 85% better than the lecture method. Ramdani et al. (2021) developed a simple physical model of liquefaction using sand and water to show how houses can 'walk' due to earthquakes. The model proved effective in raising students' awareness of the liquefaction hazard. Nurhayati et al. (2019) showed that the STEAM (Science, Technology, Engineering, Art, Mathematics) approach in disaster mitigation can increase students' conceptual understanding up to 40% higher than traditional methods. Sari & Mulyadi (2022) found that the use of digital simulation can help students better understand the trigger factors and mitigation strategies for liquefaction. Rahmat et al. (2020) stated that experiment-based disaster mitigation education helps students understand the relationship between pore water pressure, soil structure, and liquefaction risk. Fauzan et al. (2022) found that an experiment-based miniature liquefaction model increased students' curiosity about geological phenomena and strengthened their understanding. Lestari & Nugroho (2021) developed a demonstration method using water-saturated sand that helped students understand how liquefaction occurs in real life. Suprapto et al. (2020) showed that augmented reality (AR)-based animation is effective in improving students' recall of liquefaction concepts. Yuliani et al. (2021) conducted research on the effectiveness of project-based learning in teaching liquefaction mitigation to high school students. Hidayah et al. (2022) examined how a combination of physical and digital media can help students understand the impact of liquefaction more thoroughly.

According to Juang et al. (2018), some liquefaction mitigation strategies that can be taught through this learning media include: Soil improvement through cement injection or drainage methods to reduce pore water pressure. Use of deep foundations such as piles to improve building stability. Spatial engineering, i.e. avoiding development in areas with high liquefaction potential.

Thus, the development of the Jono Oge 'Walking House' media is expected to make a real contribution to improving disaster literacy and community preparedness for future liquefaction risks (Mavrouli et al., 2022).

Figure 1. Fenomena Rumah Berjalan

Method

This research was conducted in the Physics Education Study Programme environment, Faculty of Teacher Training and Education, Tadulako University. The time of this development research is approximately 8 months from March to November 2023. The subject of this research is the application of the test in students of SMP 1 Sigi class XI A with a total of 26 students, SMP 13 Sigi class XI A with a total of 27 students, SMP 27 Sigi with a total of 24 students and SMP 21 Petobo 11 students. The sample of the population was obtained by purposive sampling based on the school is located around the liquefaction affected areas of Petobo and Sigi. student class samples were selected based on the availability of students and students in the class experienced liquefaction phenomena.

The changes measured are the values of the development of learning tools from students in understanding the process of liquefaction disasters and being able to take quick action in disaster mitigation knowledge.

In this experiment-based learning device development research using the steps of the 4D research and development model. Research and Development (R&D) is the process of creating products that have never existed before or improving existing products into newer products (Okpatrioka, 2023). The 4D model has several stages, defining, designing, developing, and disseminating (Thiagarajan et al., 1974). According to Arywiantari et al. (2015), one of the advantages of 4D is that it is more appropriate to use as a basis for developing learning aids rather than for developing learning systems. The advantages of the 4D model according to (Agustina & Vahlia, 2016). The selection of the 4D development model has advantages, namely in the 4D model involves material analysis in determining the learning objectives to be achieved.

The details of the development stages in accordance with the research are as follows: The initial stage in the 4D model is defining related to development requirements. Define is a stage to identify development objectives, target audience, learning context, and analyse media development needs (Jasmine et al., 2023). Simply put, at this stage is the needs analysis stage. In developing teaching aids for the running house phenomenon, developers need to refer to the development requirements, analyse and collect information on the extent to which development needs to be carried out. The defining stage or needs analysis can be done through analysis of previous research and literature studies. This stage includes analysing needs, problems and gathering information and formulating goals.

At the design stage or design is a stage that aims to prepare the initial design of a product (Nurroby et al., 2020). Design includes the design process such as preparation of instruments, selection of tools and initial design of props. The develop stage contains development activities and testing the validity of the design, as well as design revisions. Validation is carried out to analyse the feasibility of product design, and product trials are carried out to analyse the effectiveness of the product in answering needs (Marinu Waruwu, 2024). The dessimination stage is the stage of disseminating the products that have been produced (Suprapto et al., 2019).

Data collection methods or techniques are ways of working to do or capture the results of the work of the mind that is operationalised strictly empirical realities. Questionnaires and Observations To see the effectiveness of understanding teaching aids in schools, the formula developed by Hake, R.R. (1998) is used, namely normalised gain analysis with the following equation (1):

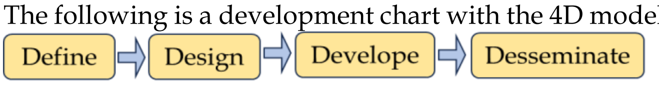
$$g = \frac{S_{post} - S_{pre}}{S_{maks} - S_{pre}} \, x \, 100\% \quad (1)$$

The gain criteria are:

Table 1 .N-Gain Criteria (Hake, 1998)

N-gain	Value Level of understanding
>0,7	high
0,7< g < 0,3	medium
<0,3	low

The following is a development chart with the 4D model



Result and Discussion

The things that have been done in this research are conducting a need assessment. need assessment to schools around Jono Oge. SMPN 1 Sigi, SMPN 13 Sigi, SMPN 13 Sigi and SMPN 21 Petobo.

Figure 2. Need assessment of teaching aids at SMPN 1 Sigi.

Figure 3. Need assessment of teaching aids at SMPN 27 Sigi and assessment of teaching aids at SMPN 1 Sigi

Figure 4. Need for assessment of liquefaction teaching aids 'walking house' at SMPN 13 Sigi

Figure 5. Needa assessment of liquefaction prevention equipment's mobile home at SMPN 21 Petobo

From the results of interviews and discussions with several schools, the idea of developing a liquefaction media 'walking house' is considered necessary and urgent. With various reasons such as the location close to the scene. Even some students were directly affected during the disaster. On the other hand, there is a myth that there are snakes below from the Napu mountain range. The strongest reason is that students live in the surrounding area so they need to know the condition of their area. All schools themselves do not yet have concrete actions for disaster mitigation.

Figure 6. The initial design of the silent red roof house and the moving zinc roof house.

Making BTS (base transmission station) props stationary BTS is made of wire and made not to move during earthquake shocks.

Figure 7. BTS (Base Transmison Sytation) Tower made stationary during an earthquake.

Furthermore, the maker of an earthquake table tool made of per which will be moved by a motor.

Figure 8. Earthquake Table for Simulation of Vertical and Horizontal Motion Earthquakes

Figure 9. Earthquake table and Simulation box

Because the spring was too strong, the motor was unable to move the box. Then it is revised in the following form:

Figure 10. Earthquake Table Revision With Drill Vibrator

Figure 11. Revision of 'walking house' and 'moving garden'

After completing the creation of the simulation props of 'walking house' and 'moving garden', validation was carried out for the props in relation to the concepts and media. Repeated revisions were made so that the props were in accordance with the science concept. For the media effectiveness instrument, the development of an instrument for the test using the components of the instrument components can be presented below The components of the instrument for measuring the effectiveness of asseara are briefly as follows:

1) Understand earthquake liquefaction, its causes, impacts and mitigation methods (Questions 1-5).
2) Introduce the 'walking house' teaching aid as an interactive learning tool for liquefaction (Questions 6-10).
3) Raise awareness on the importance of evacuation and prevention of house liquefaction (Questions 11-14).
4) Raising public awareness about liquefaction risk and disaster education (Questions 15-18).
5) Understand concrete actions to deal with liquefaction and earthquakes (Questions 19-23).
6) Recognise the role of students in liquefaction risk awareness in the environment (Questions 24-25).

The description of each question's main objective is:

1) Understand the phenomenon of 'walking houses' due to liquefaction and how it occurs.
2) Know the causes of liquefaction in earthquakes, related to water-saturated soil conditions.
3) Knowing the impact of liquefaction on building structures, especially 'walking houses'.
4) Understand how important it is to use proper construction and foundation techniques to mitigate liquefaction risk in buildings.
5) Know how to identify signs of liquefaction around the house and how to behave during an earthquake and possible liquefaction.
6) Understand the government's role in reducing liquefaction risk in earthquake-prone areas.
7) Know how the 'walking house phenomenon' teaching tool works in teaching about liquefaction in an interactive way.
8) Recognising that liquefaction not only affects buildings and houses but also infrastructure such as roads and bridges.
9) Understand the importance of public awareness of liquefaction risks and preventive measures that can be taken.
10) Recognising the importance of staying calm and avoiding panic during an earthquake and the possibility of liquefaction.
11) Knowing the actions to take if a house is affected by liquefaction and damaged.
12) Understand that liquefaction can occur in areas with water-saturated soils, regardless of location.
13) Know that geological research and expert consultation are important before building a house in a liquefaction-prone area.
14) Realising that a lack of public understanding of liquefaction risk can lead to unpreparedness for disasters.
15) Knowing that the 'walking house phenomenon' teaching aid can help in learning about liquefaction by visualising it.

16) Knowing that the "walking house phenomenon" teaching tool can help in learning about liquefaction by means of interactive visualization.
17) Understand that evacuation is necessary when an earthquake occurs and signs of liquefaction are detected around the house.
18) Knowing that people need to take precautionary and evacuation measures in the event of an earthquake and potential liquefaction.
19) Recognizing that it is important for people to understand the phenomenon of liquefaction in order to anticipate risks and be prepared for disasters.
20) Recognizing that the "walking house phenomenon" teaching aid is important in the learning process about liquefaction because it can show the impact in real time.
21) Understand that staying calm and not panicking during an earthquake and potential liquefaction is an important step to reduce risk.
22) Knowing that an understanding of liquefaction must be accompanied by concrete actions to mitigate the risk and reduce its impact.
23) Knowing that liquefaction not only affects buildings and houses but also infrastructure such as roads and bridges.
24) Understand the importance of evacuating and taking precautions when signs of liquefaction are detected around a house or building.
25) Knowing that public understanding and awareness of liquefaction risk can be intensified through education and regular evacuation drills.
26) Recognize that students' understanding of liquefaction risk can be realized through active participation in education and information dissemination about liquefaction in the school and surrounding environment.

After the components of the instrument are outlined, questions are made in the question items which are presented in full in appendix 1. The next stage is the implementation of the pilot test at SMPN 21 Petobo.

Figure 12. Implementation of the pilot test at SMPN 21 Petobo

Figure 13. Implementation of liquefaction demonstration at SMPN 27 Sigi

Figure 14. Implementation of the pilot test at SMPN 13 Sigi

Figure 15. Testing at SMPN 1 Sigi

Figure 16. Implementation of demonstration test at SMPN 1 Sigi

After processing data from the answers to questions from students of SMPN 1 Sigi, SMPN 13 Sigi, SMPN 27 Sigi and SMPN 21 Petobo, the gain results are shown in Table 1.

Table 1. Pretest and post test results

School	Student Sampel	Average Pre Test	Average Post Tes	Average normalized gain
SMPN 1 Sigi	26	50.90	66.77	0.31
SMPN 13 Sigi	27	36.20	56.46	0.33
SMPN 27 Sigi	24	30.70	44.50	0.19
SMPN 21 Petobo	12	49.50	44.50	0.32
			Average	0.23

As for the results of the level of difficulty of students in the indicators of understanding the concept of liquefaction, introduction of props, evacuation and prevention measures, concrete actions and the role of students, the results of the research can be seen in Table 2.

Table 2. Summary of students' level of difficulty per category on the concept of a mobile home in Jono Oge

	Earthquake-induced liquefaction concept	Introduction of teaching aids	Importance of evacuation and prevention measures	Public awareness raising	concrete action	Student role
SMPN 1 Sigi	0.73	0.55	0.72	0.67	0.68	0.65
SMPN 13 Sigi	0.58	0.47	0.56	0.51	0.56	0.69
SMPN 27 Sigi	0.57	0.36	0.54	0.27	0.46	0.48
SMPN 21 Petobo	0.51	0.60	0.70	0.55	0.62	0.55
Average	0.59	0.50	0.63	0.50	0.58	0.59

Discussion of Research Results

Based on the results of data processing from table 1, the normalised gain for each school is 0.31, 0.33, 0.32, which means that the props are quite effective for science and mitigation learning. This is in accordance that g> 0.30. Meanwhile, the gain in SMP 27 Sigi obtained a gain of 0.19, or <0.30, indicating that the teaching aids are less effective for science learning and mitigation in that school. This different condition is because of the whole school, only SMP 27 Sigi is the farthest position from the liquefaction affected location so that students' understanding has a low increase.

For the three schools that have a fairly effective increase, namely 0.31, 0.33, 0.32. This is due to the position of the residence of students who are respondents and the position of the school is very close to the liquefaction affected area. In addition to this, this condition is further strengthened by the existence of a viral liquefaction process video, which this liquefaction area is the area where the student lives. this viral moving house and moving garden video has been watched by 184 thousand viewers on youtube (Wahyono, 2020). The video was titled Banguna Terbawa Tanah Bergerak video aired on the CNN Indonesia Channel. When students from the three classes who were samples from the three schools were interviewed, they all stated that they had watched the video and stated that they were suitable for the teaching aids developed.

For the category of mitigation capability related to liquefaction, students gave precise answers on the question sheet. Most students answered in different ways. The difference in mitigation methods was apparently adjusted to the experience of survivors who survived when the liquefaction event occurred. The ability to answer in different ways is due to the independence of students looking for mitigation information in the affected area. This statement is in accordance with the results of the research. This is in accordance with the interviews of survivors of different ways of saving themselves according to what they encountered during the incident (Wahyono, 2020).

For the category of students' level of difficulty on liquefaction material with props, in general, the answers to the questions were obtained in the range of 0.55 to 0.63. This is included in the moderate category (Arikunto & Suharsimi, 1999). This is probably because during learning, using props that are appropriate to the context of the home helps the students' thinking process. There is specific data from table 2 for SMPN 27 Sigi students on the introduction of teaching aids scored 0.36. This score indicates that 36 per cent of students answered correctly. This may be due to the props being too small compared to the actual conditions seen daily. So that less focus of attention from props. So if in the future the media is made bigger. In addition, their distance from SMPN 27 is the farthest from other schools.

In the category of raising community awareness, SMPN 27 Sigi students obtained a fairly low score of 0.27. This score is low compared to other schools. This is probably because the school is further away from the disaster site than other schools. This is reinforced from table 2 above on the role of students which also only reached 0.48. This score is low compared to other schools. The main cause of this is the lack of information they obtain in terms of liquefaction disaster mitigation. Similar research on students' low awareness of disasters was also obtained by Syahrial et al. (2020). This is due to the lack of proper disaster information. Similar research conducted by Shania Maharani also found the fact that students' understanding of disaster mitigation is low. Students' low knowledge of disaster mitigation is often caused by the lack of integration of this material in the school curriculum and the lack of routine implementation of disaster simulations (Shania Maharani et al., 2024). Similarly, research conducted by Maharani. The results show that the level of earthquake knowledge of children is still low due to the absence of counselling to these children either through agencies, community leaders, campuses and local community leaders (Nia Maharani, 2024).

In table 2 of the questions related to the concept of liquefaction, it turns out that understanding props facilitates understanding liquefaction. This is in line with the results of uwahyono's research that props facilitate understanding of the liquefaction concept (Wahyono et al., 2022). This is also in line with research conducted by Prihatiningsih, where the development of 3D mockups as liquefaction learning media can improve student understanding better and improve learning outcomes (Nur Laili Prihatiningsih, 2020). In addition, this condition can be proven through the findings of Prasetya et al. (2017), which state that the use of 3D mockup media can increase student activity, student response and positive interest to improve learning outcomes because the liquefaction material can be conveyed with geography more concretely, in this case students can see, touch and feel directly. The condition of increased understanding and enthusiasm of students observing earthquake props was also experienced by Saifuddin et al. Students are more active and feel happy to follow the learning that is carried out and the science linteration of the liquefaction phenomenon is getting better (Hazairin et al.,.2024).

In addition to the above, the ease of understanding liquefaction is also supported by the condition of students who learn through discussions with the community, and the massive information about liquefaction according to social media statements greatly affects mitigation knowledge (Wahyono et al., 2022). From the students' answers regarding the causes of "walking houses" such as due to sandy soil conditions and containing high water content (moisture), sloping soil conditions and the trigger is an earthquake. After being confronted to students whether it is possible for this incident to happen again, many students were doubtful. It is possible that students have not connected the material on the layers of the earth and faults in the earth layer symmetry at the junior high school level, especially the geographical location conditions. For this reason, integration and a comprehensive understanding of earth needs to be done. This is supported by research on student knowledge at SNPN 21 Palu on earth science (Saehana & Wahyono., 2018)

In general, although the average gain value between the pretest and post-test is still low, the development of the Jono Oge 'Walking House' liquefaction media for science learning and mitigation is enough to help students and teachers at school understand the existing liquefaction events.

Conclusion

Based on the analysis of normal gains in the application of 'walking house' props for science learning and mitigation at SMPN1 Sigi 0.31 SMPN 13 by 0.33 Sigi SMPN 27 by 0.19 and SMPN 21 Petobo by 0.32 Petobo can be concluded that the 'walking house' props are quite effective for science learning and mitigation. With this developed learning media can provide students with understanding and mitigation of the liquefaction phenomenon. Suggestions for further research are that the size of the props can be enlarged and multiplied so that each student can do and use the props properly.

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K: Collect data, analyze data, and preparearticles for publication

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