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Virtual Museum of Tsunami Project for Increasing Awareness of Disaster Risk Potential in Physics Class

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Abstract

Virtual Reality (VR) development is expected to answer the problem of learning loss in education, especially in disaster mitigation studies. Using VR with artificial environments of scenes and objects appearing to be real, various disaster scenarios were made possible to learn. When this computer-enhanced learning was introduced to high school students, it could reduce both limitations and challenges of real-world learning. Visena (Virtual Museum of Tsunami) is virtual reality-based learning media in the form of a virtual museum which helps students understand the concept of waves and increase awareness of disaster risk potential in earthquakes and tsunamis. This study aims to test the validity, effectiveness, and practicality of Visena when it is implemented in a classroom setting. Visena was developed during the study using a 4D model of define, design, develop, and disseminate. Visena learning media were classified as very valid according to the validation process results. Student's response were categorized very good despite a limited trial of Visena in class. Some students showed good performance with significant results when using Visena. It is recommended to use a smartphone to reduce dizziness when using glasses, and the material should be adjusted to the characteristics of the students. Therefore, an introduction to learning material and teacher assistance is needed.

Keywords: Learning Media; Museum Tsunami; Physics Wave; Virtual Reality

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INTRODUCTION

Indonesia is a country that is very prone to earthquakes and tsunamis. Within four months of 2018, two tsunami disasters claimed many victims on September 28 in Palu Bay, Sulawesi and on December 22, Anak Krakatau in the Sunda Strait. By reflecting on this disaster, people need to learn the importance of disaster mitigation, especially earthquake and tsunami natural disasters. Indonesia has fundamental problems such as low performance in dealing with disasters, less awareness of disaster mitigation, and a lack of school involvement in introducing disaster mitigation education (Hayudityas, 2020; Sunyono et al., 2022). Hidayat states that community preparedness is still low; many casualties illustrate this during a disaster, there are many casualties when a disaster occurs, and the lack of public awareness about disaster vulnerability and mitigation efforts (Hidayat, 2008). According to (Nurwin et al., 2015), most fatalities were children who did not understand. They still felt panic and confusion; some were running and scattering aimlessly. Mitigation involves acts and protective actions that can begin before the disaster occurs, such as assessing disaster hazards and disaster management in rescue, rehabilitation, and relocation (Maryani, 2010). This disaster mitigation education needs to be instilled in the community as early as possible and can also be applied through formal education in schools since elementary school. As stated by (Suharini et al., 2014), reducing the risk of natural disasters in Indonesia must take into account the sustainability and participation of all parties, as well as the World Conference on Disaster Risk Reduction held in Sendai, Japan on March 14-18, 2015, which decided that the "Sendai Framework for Natural Disaster Risk 2015-2030.". One of the structure contents is that each degree of society should comprehend or know about catastrophes to build readiness and starting abilities in expecting cataclysmic events. Disaster mitigation efforts must be known and socialized early on to the community, especially those living in disaster-prone areas. Creating a responsive and alert community to disasters is imperative so that all relevant parties can minimize risks when an earthquake or tsunami occurs.

Based on Government Regulation of the Republic of Indonesia No. 21 of 2008, article 14 clarifies that to reduce the impact of natural disasters, reduce the number of mass casualties and reduce losses caused by disasters, it is necessary to have disaster mitigation in the form of formal education, non-formal education and informal education that local governments can carry out. Disaster mitigation informal education is carried out through disaster education. Disaster education can be applied by integrating it into one of the subjects at school. Physics subjects, especially vibration and wave materials at the high school level, are suitable for integrating earthquake and tsunami materials. An earthquake is a significant vibration that spreads to the earth's surface caused by disturbances in the lithosphere; this process generates waves called earthquake waves (LPBD Team in Sasma & Fauzi, 2020). However, the earthquake and tsunami disaster mitigation material in schools has not been delivered optimally to students; moreover, it is only taught to students majoring in social studies and needs to be better integrated with students from other majors. It is related to the statement by Meiliyana (2019) that in implementing disaster mitigation learning often, the media used are less interactive media, such as books, globes, world maps, atlases, and other media that are less oriented to student participation or student experience. The method used in learning has used the discussion method, but there are often obstacles in the discussion, such as taking a long time and needing to be more conducive to students.

The success of an educational process are determined by its stage of learning. Media plays a fundamental part in learning (Sulistyowati & Rachman, 2017). Learning media is an instrument or delegate that works with the educating and growing experience to smooth out correspondence among educators and students. Learning media is an instrument that can be utilized as an apparatus to convey all learning materials (Wahyuni & Yokhebed, 2019). The utilization of learning media can assist educators with conveying learning materials. Learning media is expected to improve and create new desires and interests in the learning process. The development of Science and Technology these days affects the technology used in learning, resulting in more and more demands to utilize and make better and more useful innovations for education. In the millennial era, teachers have challenges in delivering subject matter that students can accept. One of the innovations that can be provided in education is to determine a good learning strategy. The characteristic of a good learning strategy is that learning can involve n students carrying out an activity that follows the learning objectives (Dalyono, 2016). Learning strategies can be viewed from the consideration of teacher-student interactions proposed by Dalyono, namely: (1) face-to-face strategy, the use of teaching props will give a better impression (2) learning strategies through media, students interact with the media as a "representative" of the teacher, media used can be in the form of modules, computers, and other technologies. Research by Purwono in 2014 showed that student learning outcomes increased after the teacher used audio-visual media or illustrations. Increased scores on test results and student understanding supported this result.

The development of Science and Technology is currently proliferating, affecting the technology used in learning. One of them is Virtual Reality (VR); VR is a technology that involves interaction in a computer-simulated environment. (Prayudha et al., 2017). VR is widely used in education and training because of its potential to provide stimulating interactive activities and motivations (Freina & Ott, 2015). Furthermore, VR is ideal for anyone who prefers a visual, auditory, or kinesthetic learning style to approach, learn, and remember new knowledge. Helped by these events, a virtual world can be made for the public and experts to drench themselves in an environment to encounter a disaster or outrageous climate occasion. Using VR with artificial realistic various natural disaster scenarios makes it possible to learn, train, and reduce real-world learning limitations and challenges (Sermet & Demir, 2019). Virtual reality can introduce practical knowledge into the classroom without actually leaving the classroom, making the educational experience worthwhile. Invaluable experiential disaster and emergency risk reduction lessons can be gained from a VR environment where different disaster scenarios can be simulated, and individuals can be trained to respond confidently to critical situations. Emergency preparedness virtual reality simulations can provide a more varied scenario and help avoid the panic that could lead to accidents and deaths that should not have occurred (Velev & Zlateva, 2017).

Based on the description of the background that has been stated, researchers are interested in researching the development of learning media using Virtual Reality (VR) technology with the title Virtual Museum of Tsunami (Visena) Project for Raising Disaster Risk Awareness at Physics Class. This study intends to test the validity, effectiveness, and practicality of Visena.

METHOD

The Research and Development (R&D) method was used in this study. The steps of the product development model developed by Thiagarajan, Semmel (1974) are define, design, develop, and disseminate (4D) (in Rizki, 2016). R&D is a research method used to create products and test their effectiveness (Sugiyono, 2011). The product that will be produced in this research is a virtual reality-based learning media named Visena (Virtual Museum Tsunami). The purpose of developing this media is to help students understand the concepts of wave physics and raise disaster risk awareness in earthquakes and tsunamis. The steps of the 4D product development model can be described as follows:

Define

At this stage, potential and problem analysis are carried out, determining and defining learning conditions: such as limiting the objectives and limitations of the material developed.

Potential and Problem Analysis

Potential and problem analysis aims to investigate the problems in a learning process. In developing a product, it should be based on a need assessment and also a real problem. Some of the problems found include the importance of disaster mitigation education in Indonesia, which is a country with a high potential for earthquake and tsunami disasters, obstacles in teaching or integrating disaster mitigation education, which in most cases are due to the media being used less interactive, less participation oriented students or student experience. This includes finding solutions to these problems, namely developing a VR-based learning media using Millelab. Media selection is also carried out to obtain media that follow the material.

Concept Analysis of Learning Materials

Analysis of learning materials identifies the material concepts of the mechanism of the occurrence of earthquakes and tsunamis associated with wave material. It collects and organizes them systematically into a VR learning media scenario (design).

Objective Specification

The specification of learning objectives is to formulate learning objectives on wave material and their application in daily life based on Basic Competence, analyzing physical quantities of travelling waves and stationary waves in most real cases, listed in the Physics 11^{th} grade 2013 curriculum. The purpose of developing this media is to help students understand the concepts of wave physics in earthquakes and tsunamis and to train natural disaster mitigation.

Design

The planning stage includes designing research instruments, learning media scenarios, and developing products. Before developing the product, the researcher created a scenario by looking for references that would be included in the VR media. VR product development is carried out using Millelab software.

Develop

The development stage aims to produce learning media that has been validated and revised based on expert recommendations. The steps taken include:

Expert Validation

The expert's assessment of the learning media at this stage includes language, illustrations, and content. Validators are University Physics Education lecturers with related scientific fields and other physics learning media development experts such as high school teachers. The validation results will be used as a reference in improving the learning media, which is then a revision I produced.

Limited Trial

After being revised, the media was tested on a limited basis on 24 students in $11^{th}$and 12^{th} grades at two state senior high schools in Lamongan.

Disseminate

The dissemination process is the final stage of development. This process is divided into three activities: validation testing, packaging, diffusion, and adoption. However, in this study, it was ended until the validation testing stage and limited trials. In the testing validation phase, the product revised during the development phase is implemented on the actual target at the limited trial. A limited trial was carried out by testing the learning media to several students to see the effectiveness of the products that had been developed so that some deficiencies were identified that needed to be corrected. It is also carried out at this stage to promote product development in order for it to be accepted by users, whether individuals, groups, or systems.

Table 1 shows Likert scale categories for validation instruments. The data obtained through the validation instrument in the Likert scale were analyzed in the form of a descriptive percentage (Midroro et al., 2021). The Likert scale uses several questions or statements to measure the behaviour of each individual by responding to the choice of each question or statement item (Budiaji, 2013). The percentage is calculated using equation (1). The maximum ideal score varies depending on the number of statement items in each aspect.

Table 1 Likert scale categories.

Score	Criteria
1	Very Invalid
2	Invalid
3	Enough
4	Valid / Good
5	Very Valid / Very Good

Table 2 shows the category criteria for both expert validation and student responses. The minimum media validity score reaches 61% according to the calculation of the percentage of equation (1). Meanwhile, the student response questionnaire used yes-no questions with several statement items, as shown in table 3-5. Response questionnaires play a role in directing students' thinking in learning (Efendi, 2015).

Table 2 Interpretation categories

Interval	Criteria
0%-20%	Very Invalid
21%-40%	Invalid
41%-60%	Enough
61%-80%	Valid / Good
81%-100%	Very Valid / Very Good

The percentage of data can be calculated by the formula (Asyhari & Silvia, 2016):

$$Percentage = \frac{Total\ score\ (\sum x)}{Ideal\ score\ maximum\ (\sum i)} x100\% \quad (1)$$

RESULT AND DISCUSSION

This section further discusses the steps of the product development model at the development and dissemination stages as follows:

Develop (Development)

The product developed is in the form of virtual reality with a duration of about 17 minutes which explains the material for the earthquake and tsunami, especially the 2004 Aceh Tsunami, in the form of a virtual museum. Visena can be accessed via the Millelab Viewer app on Android. Learning media is also used as a learning video uploaded to YouTube with the link address https://youtu.be/czQjs7qiPSM.

The topics discussed in the media are divided into several sections, including video footage of the 2004 Aceh tsunami (Figure 1), pictures related to the 2004 Aceh Tsunami, graphic illustration of the impact of the tsunami on the development sector, graphic illustration in the form of a table of the number of victims and refugees affected by the tsunami occurred in countries affected by the tsunami. Source: Report of the International Federation of Red Cross and Red Crescent Societies (IFRC), graphic illustration of explanation related to active tectonic areas in Indonesia, especially Aceh, a video explaining mechanism around the earthquake (Figure 2), a video explaining mechanism surrounding tsunami (Figure 3), and finally a quiz (Figure 4).

Figure 1 Standpoint 2 Watching Video Footage of The 2004 Aceh Tsunami Incident

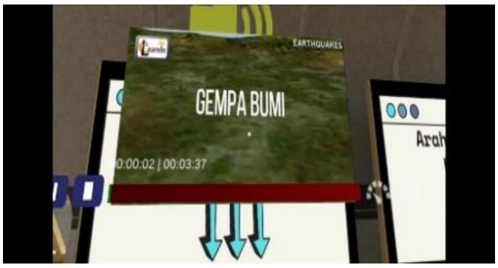

Figure 2 Standpoint 7 Watching A Video Explaining The Mechanism Surrounding The Earthquake

Figure 3 Standpoint 8 Watching A Video Explaining The Mechanism Surrounding The Tsunami

Figure 4 Standpoint 9 Doing The Quiz

Disseminate

Six validators have validated the Visena learning media using a media validation instrument, two from lecturers, high school teachers, and media experts. Aspects assessed include media display, suitability of learning materials, and media engineering and processes.

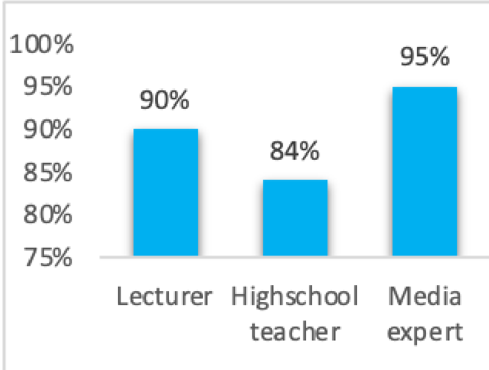

Figure 5 The Results of The Media Display Validation

Figure 5 shows that the learning media validation score on the Visena media display aspect reached more than 80% of all parties, with an average of 90% included in the very valid category, according to Table 2, which shows the criteria for the media validity category. Most of the comments related to the narrative were delivered too quickly for people still unfamiliar with the earthquake and tsunami phenomenon; the audio narration was not heard because the background music needed to be louder, so a narration in the form of subtitles was needed.

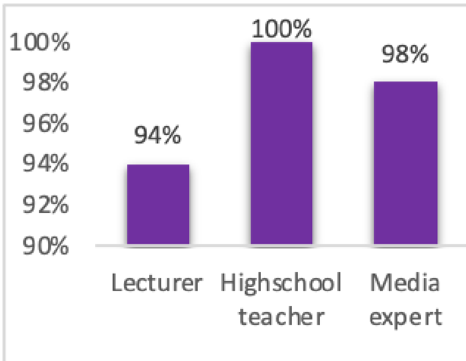

Figure 6 The Results of The Suitability of Learning Materials Validation

Figure 6 shows the validation score of the suitability aspect of learning materials having the highest score among the other two aspects with an average of 97% included in the very valid criteria according to table 2. Even high school teachers gave a perfect score for each statement item. It shows that the material delivered fulfils the 2013 high school physics curriculum grade 11 basic competence 3.4, analyzing physical quantities of travelling waves and stationary waves in most real cases.

Figure 7 shows the validation score of the engineering and process aspects of the media, having the lowest score with an average of 89% included in the very valid criteria according to table 2. Most comments point to a positive mark, such as virtual-based learning media. It is very interesting and follows today's learning innovations because it can introduce new technologies that open boundaries in the real world.

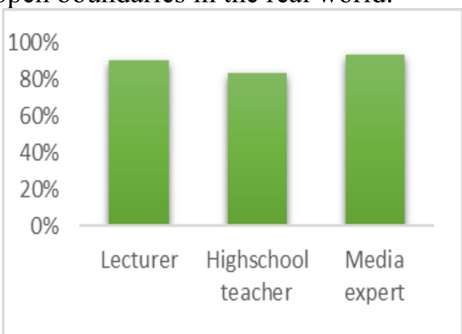

Figure 7 The results of The Media Processing Validation

After being revised according to the suggestions and comments of the media validators, it was tested on a limited basis to 24 students in 11thand 12th grades at two state senior high schools in Lamongan, consisting of 12 students per class. Previously, observations were made in the learning process at two state senior high schools in Lamongan to determine the condition of students in the learning process. Physics learning in grade 11 has yet to reach the Wave Chapter because this chapter is taught at the end of the semester. Six students in one class containing 12 students try to use VR and Non-Gyro modes. The VR mode in question uses VR oculus rift glasses (Figure 8), while the Non-Gyro mode uses a hand-phone without a Gyroscope, or it can be said to use your finger to move like in mobile games in general (Figure 9). The viewer mode also influences the outcome of the limited trial used by students when running the application, which will be explained further.

Figure 8 Student using VR Glassess

Figure 9 Student using Non-Gyro Mode

The media response questionnaire for students used a yes-no question with a rating scale (1-10). In this study, only the yes-no question is discussed. The yes-no question responses were divided into four aspects: application access, media (audio and visual), learning process, and quiz features. To access Visena media, students must first install the Millealab Viewer application on their cell phones.

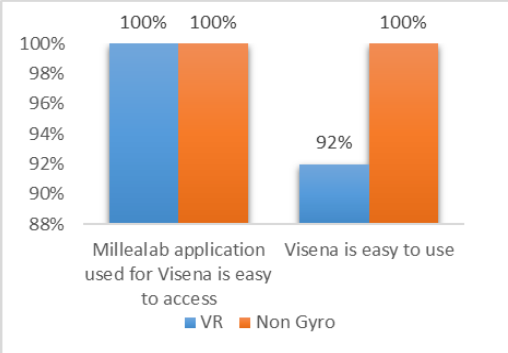

Figure 10 The Result of Application Access Questionnaire

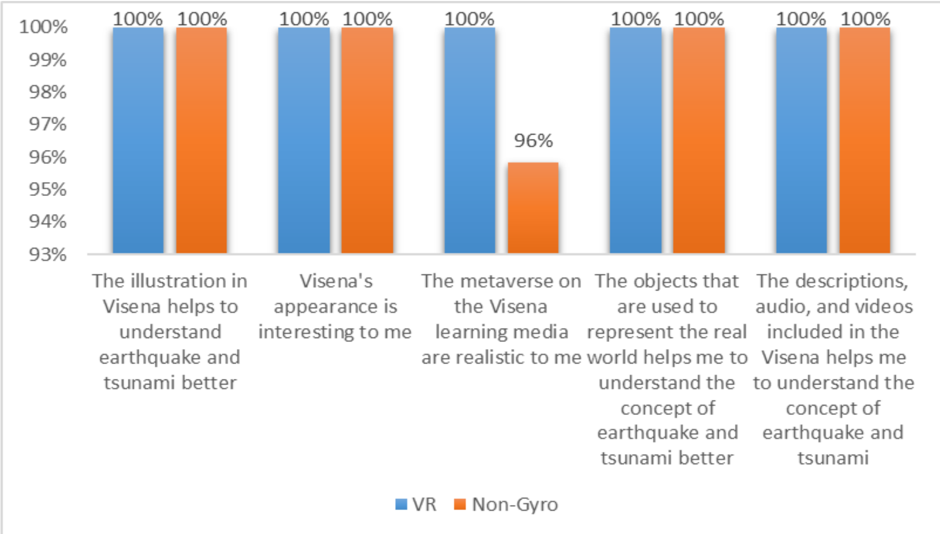

Figure 11 The Result of Audio and Visual Questionnaire

In terms of application access, we want to know how easy the Millealab Viewer application is used to access the media. All students think that Millealab is easy to access. Student can use the application and Visena media well due to the availability of guidebooks and video tutorials on Youtube. However, this application has several flaws, such as it can only be accessible on Android-based smartphones, long loading times, and the use of VR glasses makes you dizzy. It can be seen when conducting a limited trial, as well as in Figure 10, that 92% of students mean that 8% of students left, who used VR mode, disagree that Visena is easy to use. Because students have never used VR before, they cannot adapt to the shocks; then, over time, they become dizzy. According to previous research (Pirker et al., 2017), the VR environment can be unsettling sometimes. Sensory input from real life did not correspond to what students saw in VR. The first few times the student used the teleport to move around, he felt dizzy. Perhaps because of the sudden change in scenery in front of their eyes. Children can only use VR to a limited extent because they are still in their developmental stages, and 3D vision, hand-eye coordination, and balance are still developing (Freina & Ott, 2015).

Figure 11 shows that all students agree that the visual display, including the objects, audio, video, and media narration, is interesting and helpful in understanding the material. This is also reinforced by several students who got good quiz scores. It can be said that how the material being taught in the media helped them understand it better.

Virtual reality plays an important role in the teaching process, providing interesting and engaging ways of acquiring in- formation and making the learning process more interesting and fun (Kamińska et al., 2017; Pantelidis, 2010). How the teacher delivers information determines whether or not the information will be readily accepted. The content, including visualization, language, and writing style, must be customized to the characteristics of the students (Chen & Hsu, 2020; Hamilton et al., 2021).

Wave is one of the abstract concepts in physics (Prabowo & Sucahyo, 2018). Students can only imagine it without being able to see it directly. In wave motion, teachers need to display waves in motion. This will not be easy to display using conventional media (Perdana et al., 2019). Therefore, this material needed illustration or media to display the waveform in certain conditions. The wave material presented in VR media will be simple for students to learn and understand. According to previous research, virtual reality (VR) is very useful in teaching abstract material because it allows students to easily imagine and visualize (Sumardani et al., 2020; Zulherman* et al., 2021).

The meta-verse on the Visena learning media is realistic, but 4% of students who used non-gyro mode disagree. This may be due to the virtual appearance in rough 3D, and developing a VR system for education has been extremely difficult for educators with non-specialized backgrounds. (Hanson & Shelton, 2008)

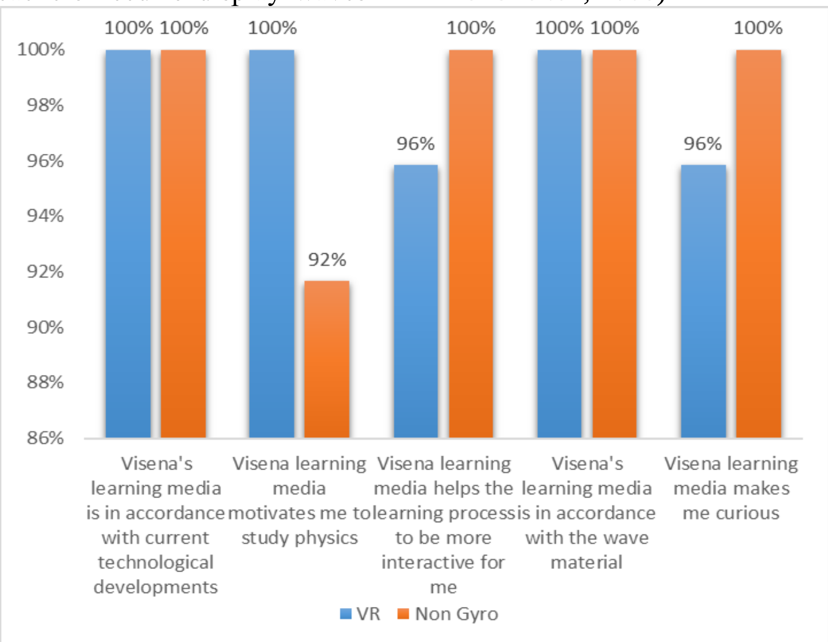

Figure 12 The Result of Learning Process Questionnaire

Figure 12 explain that all students agree that the Visena learning media is following current technological developments. As it is well known, Virtual Reality is an example of the very rapid development of Science and Technology in this era, supported by the emergence of the meta-verse concept. VR is generally widely used in education and training. One of the primary reasons VR has been used for educational and training purposes is the ability to present a virtual environment similar to the real world (Pirker et al., 2017). Learners can use this technology to explore and manipulate a three-dimensional (3-D) interactive environment. Furthermore, VR is ideal for anyone who prefers a visual, auditory, or kinesthetic learning style to approach, learn, and remember new knowledge (Freina & Ott, 2015). It is proven in Figure 12 that some students agree that this learning media helps the learning process to be more interactive. Virtual reality-based 3-dimensional material and media are suitable for education use (Zulherman et al., 2021). According to studies, learning media in 3D is more captivating than learning media in 2D (Chien et al., 2020). However, there were still some 8% of students, who used non gyro mode, disagree that the visuals media aroused their motivation to learn physics, 4% of students, who used VR mode, felt that this learning media has not helped the learning process to be more interactive and growing curiosity. The limited trial was conducted in partially or semi-immersive VR, a system that provides users with the perception of being at least slightly immersed in a virtual environment (Lee & Wong, 2008) while keeping them aware of their surroundings (Bowman et al., 1997; Mania & Chalmers, 2001). The tools used are only VR glasses; hence hand movements are only limited to pressing the button on the glasses. Moreover the body movements are also limited because they feel dizzy, so they use it while sitting.

Figure 12 also explains that all students agree that Visena follows the wave material. As stated before, the subjects suitable for integrating earthquake and tsunami materials are physics subjects, especially vibration and wave materials at the high school level (Sasma & Fauzi, 2020). It shows that the material delivered fulfils the 2013 high school physics curriculum grade 11 basic competence 3.4, analyzing physical quantities of travelling waves and stationary waves in most real cases.

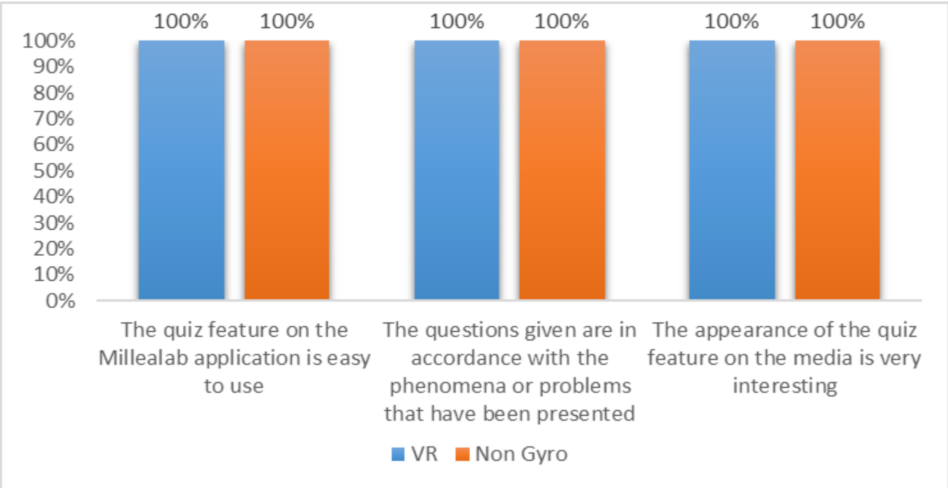

Figure 13 The Result of The Quiz Features A Questionnaire

According to Figure 13, all students agree with all of the statements, which means that the quiz features on the learning media can be used easily, and attractively and follow the material presented. The availability of guidebooks and video tutorials on Youtube makes it easy for students to operate the quiz feature in learning media. This quiz feature is one of the advantages of the Millealab software. Millealab is a cloud computing-based

VR platform designed for education, creating VR-based learning content easily, quickly, and inexpensively (MilleaLab, 2019). This local product platform offers easy content creation for VR.

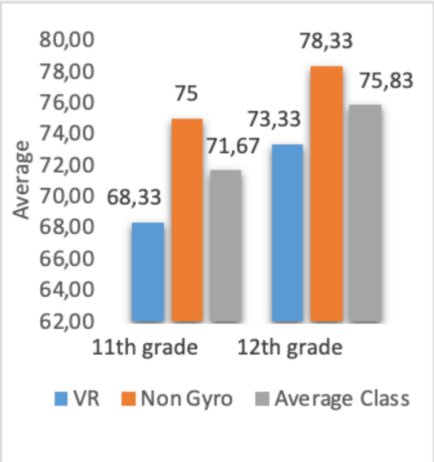

Figure 14 Average Quiz Score According to The Class And Mode

The limited trial also tested students' understanding by using the quiz feature in the learning media at the end of the lesson. The quiz contains 10 multiple-choice questions that match the material presented. According to the 2013 curriculum demands on wave physics, these ten questions vary in their cognitive levels. Each question is worth 10 points, with a minimum score of 70.

According to Figure 11 the average score of the 12^{th} grade is bigger than the 11^{th} grade. This is because the twelfth class grade has already received the previous wave of material learning in the eleventh grade. In contrast, eleventh grade still needs to receive the wave material that should be taught after the middle of the semester.

VR users have less average scores than non-gyro users, as Figure 14 shows. In contrast to previous research (Allcoat & von Mühlenen, 2018), VR demonstrated an improved learning experience compared to traditional and video learning methods. Some students who use VR mode tend to feel dizzy at the end, possibly because the quiz display is not clear when VR makes students understand the questions and answer choices. Previous research (Agusty & Anggaryani, 2021) found that the viewer mode influences the outcome of the limited trial students use when running the application. Three students do not meet the pass criteria in twelfth grade, and two use VR mode. Then in eleventh grade, five students did not meet the pass criteria, and three used VR mode.

With a duration of about 17 minutes with a relatively fast learning topic for people still unfamiliar with the phenomenon of earthquakes, tsunamis, and waves, it might cause students to be less able to understand learning. Therefore, it takes an introduction to learn the wave material and teacher assistance in learning using the Visena media so that at least students already know the description of the wave material at the beginning.

CONCLUSION

The Visena learning media developed is "very valid" according to the validation result. Based on the limited trial, the questionnaire responses have been categorized as "very good" for each aspect. Besides that, some students have a significant result when using Visena. It can be concluded that Visena is very valid and very effective in learning, especially in this topic of physics waves and tsunamis, as well as increasing the awareness of disaster risk potential in earthquakes and tsunamis. The community, especially students and validators, showed enthusiasm and high hopes for using VR in the learning process.

It is recommended to use a smartphone to reduce dizziness when using glasses, and the material should be adjusted to the characteristics of the students. Therefore, introduction to learning material and teacher assistance is needed so that at least students already know the description of the material at the beginning.

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