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(Research Article)

Developing physics learning devices focusing on natural disaster mitigation in the coastal area of the gulf of Tomini to foster the attainment of SDGS goals 4 and 13

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Abstract

The research is aimed at developing natural disaster mitigation-based learning devices and analyzing the quality of the devices through their validity, practicality, and effectiveness. It was development research referring to the 4-D model design made up of the define, design, develop, and disseminate phases. The results suggested that the developed devices were valid, practical, and effective. The assessment of two expert validators and the data affirmed the validity of the devices. We decided that the devices were practical based on our analysis of the learning process implementedness and observations of student activities. The learning process implementedness was very good at 90.79%. Student activities came with a very good result at 62.5% and a good one at 37.5%. The devices were considered effective predicated on the assessment of the project of the observation report of natural disasters in a coastal area with a very good assessment criterion. Additionally, the consideration was predicated on student learning completeness of 100% at an N-gain of 0.69, considered medium. In conclusion, our physics learning devices focusing on natural disaster mitigation in the coastal area of the Gulf of Tomini to impel the realization of SDGs Goals 4 and 13 were valid, practical, and effective.

Keywords: Natural disaster mitigation learning; Coastal area of the Gulf of Tomini; Project-based learning.

1. Introduction

Environmental pollution likely leads to crises in a social environment. Crises in the living environment are such a huge challenge. The challenge is noticeable, especially in developing countries, as a result of a range of developing activities to increase prosperity but bring about adverse environmental changes. As a country with natural wealth, Indonesia should be more concerned about the environment. In tandem with development in Indonesia, environmental damage occurs because of various factors.

Living environmental issues may become disasters which can impact the quality of life. Several signs of living environmental problems, e.g., pollution, global warming, photochemistry, fogs, erosion, floods, intrusions, and so forth, are increasingly noticeable. Two dominating environmental issues are climate change and natural resource loss. Environmental damage problems should acquire more attention to administer a new point of view foregrounding environmental protection.

Based on Government of the Republic of Indonesia Regulation Number 21/2008 Article 14 concerning Disaster Management stating that to mitigate the impacts of natural disasters, the number of casualties, and financial loss due to disasters, the local government needs to afford disaster mitigation integrated into formal and non-formal education.

Through learning, teachers can embed moral values and characters in students' social and religious attitudes. Besides, they can also teach some attitudes favoring vulnerable local potencies in Indonesia, such as environmental-caring

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attitudes, disaster-responsive attitudes, and preparedness attitudes. Students, particularly those confronting environments susceptible to flood, drought, and landslides, should nurture environmental-caring attitudes. Learning materials integrated with knowledge about floods can promote the environmental-caring attitudes of students. Learning materials integrated with earthquakes can scale up the disaster-responsive attitudes of students. Indonesia is highly prone to earthquakes, entailing those living there to maintain earthquake-responsive attitudes. Students also need to maintain preparedness attitudes as they live in an environment liable to natural disasters. Nurturing the attitudes is one of the attempts to mitigate natural disaster risks.

Disaster mitigation through formal education is performed through disaster-related education. Disaster-related education is delivered by integrating natural disaster materials into subject materials. Physics is one of the subjects suitably integrated with disaster issues as it studies natural phenomena and the causes bearing on daily life.

We research developing learning devices focusing on natural disaster mitigation in the coastal area of the Gulf of Tomini and targeting SDGs 4 and 13 because Indonesia is notoriously known as the supermarket of disasters. Indonesia is a high-risk country prone to disasters because of its geological, geographic, and demographic conditions. Indonesia, geographically speaking, has potential natural disasters of earthquakes, tsunamis, hurricanes, volcanic eruptions, floods, and landslides. Data from the Regional Disaster Management Agency Pohuwato point out that tornados and landslides are the two most prevalent disasters (BPBD Kab. Pohuwato).

Our observation showed that disaster learning materials integrated into physics at SMK Negeri 1 Popayto were still low in quality. The materials delivered only focused on general themes and less addressed the implementation of the materials in daily life, particularly when facing disasters.

Several parents agreed with our results and conveyed students lacked awareness of environmental pollution. During an interview discussing disasters, no students comprehended mitigation and preparedness to face off disasters.

Such phenomenon is regrettable, considering that students serve as the continuant agent contributing to minimizing natural disasters by showcasing positive character changes. Such changes are possible if students fathom and change behaviors by retaining, preventing, and finding solutions once they are confronting disasters. Through education, students are expected to nurture empathy and willingness to help others (Desfandi, 2014).

The Sustainable Development Goals (SDGs) require the endeavors to combat climate change (Goal 13) frequently giving off natural disasters. Accordingly, students must elevate their learning competencies to manifest quality education (Goal 4) and have the knowledge and skills to realize Goal 13.

SDGs comprise 17 goals, 169 targets, and some indicators embracing a range of sustainable development issues. We focus on Goals 4 and 13 only. SDG 4 is concerning Education – Ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all. Meanwhile, SDG 13 is germane to climate – Taking urgent action to combat climate change and its impacts (Francis, 2001).

In SDG 4, we focus on Target 4.7, i.e., ensuring that all learners acquire the knowledge and skills needed to promote sustainable development. Moreover, in SDG 13, we focus on Target 13.3, namely improving education, awareness-raising, human and institutional capacity on climate change mitigation, adaptation, impact reduction, and early warning.

SDGs 4 and 13 are in connection with the research on devices integrated with disaster mitigation and adaptation. As stated in SDGs, education is a basic human right. SDG 4 encompasses various educational aspects, including learning quality and outcomes. In achieving SDG 4 in education, the greatest challenge lies in ensuring quality, inclusive, and equal education, specifically in formal schools.

2. Method

The research method employed was Research and Development (R&D), with the 4D model developed by Thiagarajan consisting of four stages: Define, Design, Develop, and Disseminate. The research developed physics learning devices focusing on natural disaster mitigation in the coastal area of the Gulf of Tomini to motivate the attainment of SDGs 4 and 13.

The products developed were physics learning devices focusing on natural disaster mitigation in the coastal area of the Gulf of Tomini to prompt the realization of SDGs 4 and 13 validated by three lecturers. The research subjects were tenth graders of SMK Negeri 1 Popayato in the academic year 2021/2022.

Practicality was measured by teachers' and experts' consideration of the usability of the materials for teachers and students. Learning activities were related to material practicality. Conforming to the results of previous research, practicality was measured based on the aspects of efficiency in use and material presentation. The efficiency in use covered efficiency when comprehending materials and the language exerted. The presentation aspect focused on appearance (Agustyaningrum & Gusmania, 2017). It conformed with Sehe, Tolla, Kamaruddin, & Hamsa (2016) that learning material practicality was measured based on learning feasibility and learning activity management. The practicality test was carried out after 57 instruments and products were considered valid. Practicality criteria referred to the questions about the clarity of the learning devices developed, punctuality, and use for teachers and students. The learning device practicality was decided by expert or practitioner assessment and evidence that the learning devices developed were applicable. To implement the devices, the practicality aspect was pertinent to: (1) whether experts and practitioners stated that the devices developed were implementable and (2) whether the devices developed were significantly implementable and practical (Kurniati, 2013). Techniques deployed for collecting data on the practicality of the natural disaster mitigation-based learning devices were employing learning implementedness observation sheets and distributing student response questionnaires.

3. Results

It was development research. The research focused on making learning devices developed into practical natural disaster mitigation-based ones. The products of the learning device development were a syllabus, lesson plans, learning materials, and student worksheets. Instruments to access practicality criteria were learning implementedness observation sheets, and instruments exerted to assess effectiveness criteria were learning outcome tests and skill assessment sheets for assessing reporting projects.

3.1. Define

The define phase was made up of several analyses, which were the front-end analysis, student analysis, concept analysis, task analysis, and learning objective analysis.

3.1.1. Front-End Analysis

The front-end analysis was identifying the issue being faced during a learning process. Here, it aimed to determine problems in physic learning at schools. The front-end analysis data were collected through an interview with physic teachers of SMK Negeri 1 Popayato.

The direct interview results pointed out issues in teaching-learning activities. Physic learning still highlighted cognitive aspects of students and, consequently, did not allow active engagement of students in the learning process. Furthermore, physic learning only leveraged a lecturing method, and teachers did not spur students to apply physic concepts in their daily life, making students only concentrate on formulas and calculations. Physic teachers did not face off significant problems attributed to learning devices, especially in making them, including looking for learning sources.

3.1.2. Student Analysis

A student analysis analyzed student characteristics, embracing the abilities, knowledge background, and cognitive development levels. The interview results with tenth graders of SMKN 1 Popayato presented the information that students did not understand physic materials, particularly fluid integrated with disaster mitigation materials. Students' lack of apprehension of physic materials was one of the challenges in physic learning. Concerning learning, students preferred a learning style enabling them to experience directly instead of imagining what was being elucidated by teachers. In other words, students wanted to learn using videos and student worksheets. The two learning media allowed students to identify potential disasters in coastal areas and how to cope with them.

3.1.3. Task Analysis

A task analysis was conducted to outline tasks students had to make and classify the task by learning implementation. Our interview with Limna Iron Bioto, a physic teacher at SMKN 1 Popayato, disclosed that student tasks were only in the form of tasks containing question items students should answer. Students were given home works of calculation-related questions left undiscussed at the school on the grounds of time constraints instead of being given home works related to physic implementation in the environment. It led to the low motivation of students to look up information bearing on physic problems concerning the environment, specifically natural disasters, and how to deal with them.

3.1.4. Concept Analysis

We formulated concepts by identifying materials presented in the learning devices developed. Our discussion with physic teachers at SMKN 1 Popayato resulted in identifying physic materials germane to disaster mitigation, e.g., fluid, vibration, and waves. Floods were discussed in fluid-related materials, whereas earthquakes could be addressed in vibration-related ones. A concept analysis corresponded with the materials analyzed.

3.1.5. Learning Objective Analysis

Formulating learning objectives or indicators of learning outcome completeness was based on basic competencies in the syllabus. In formulating learning objectives, we could identify materials which would be delivered and decide the extent of the achievement which should be made in connection with fluid materials.

We used the analysis result to identify student characteristics and examine learning processes at the school. The results enabled us to proceed to the following phase, i.e., designing the learning devices employed to carry out the research.

3.2. Design

In the design stage, we designed the products developed, namely natural disaster mitigation-based learning devices. The learning devices covered a syllabus, lesson plans, learning materials, and student worksheets. We also designed the research instruments employed in the research.

3.2.1. Designing the Learning Devices

The learning devices we designed were a syllabus, lesson plans, learning materials, and student worksheets using the Project-Based Learning model integrated with natural disaster mitigation materials. The syllabus had been made. It included learning indicators and activities in relation to natural disaster mitigation. The lesson plans contained three meetings with different learning objectives to be achieved in each of them. The learning materials contained teaching materials pertaining to fluid and consisted of hydrostatic pressure, Pascal's law, Archimedes' principle, and other topics pertinent to natural disasters and mitigating measures.

3.2.2. Designing Device-Assessing Instruments

Instruments designed were validation sheets of learning devices and observation sheets of learning implementedness to examine the validity and practicality of the learning devices developed, e.g., lesson plans, learning materials, student worksheets, THB, and instruments of skill assessment validation sheets in the form of reports of observation results of coastal areas regarding natural disasters and mitigating quests. Related to research instruments, learning outcomes were made up of several indicators we stylized to the learning objectives to achieve.

3.3. Develop

In the stage, we gathered data on the validity, practicality, and effectiveness of the natural disaster mitigation-based physic learning devices developed. Validity referred to experts' assessments of the learning devices developed, e.g., a syllabus, lesson plans, learning materials, student worksheets, and assessment instrument sheets deployed in the assessments. Practicality referred to learning process implementedness, and effectiveness referred to learning outcome tests and competency assessments in the form of observation reporting projects.

3.3.1. Practicality of Natural Disaster Mitigation-based Learning Devices

Practicality of the natural disaster mitigation-learning devices was demonstrated by data on learning implementedness using the learning devices and the PjBL model and data on student activities when learning physics, especially fluid materials.

3.3.2. Learning Implementedness Analysis

Practicality of the natural disaster mitigation-learning devices was exhibited by data on learning implementedness using the learning devices and the PjBL model and data on student activities when learning physics, especially fluid materials.

Two observers were designated to observe the implementedness in three meetings using the Project-Based Learning (PjBL) model. The results were analyzed based on three learning activities delivered in each meeting.

Figures 1, 2, and 3 feature the results of the observation of implementedness in meeting 1. Figures 4, 5, and 6 indicate the results of the observation of implementedness in meeting 2, and Figures 7, 8, and 9 manifest the results of the observation of implementedness in meeting 3.

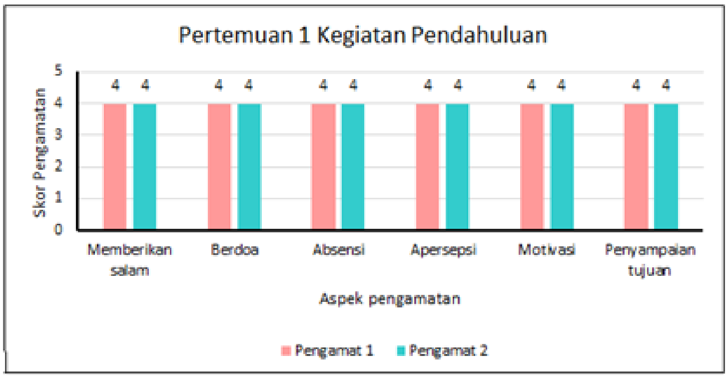

Figure 1 The Result of the Observation of Introductory Activities in Meeting 1

Figure 1 points out that both observers gave perfect scores in introductory activities in meeting 1.

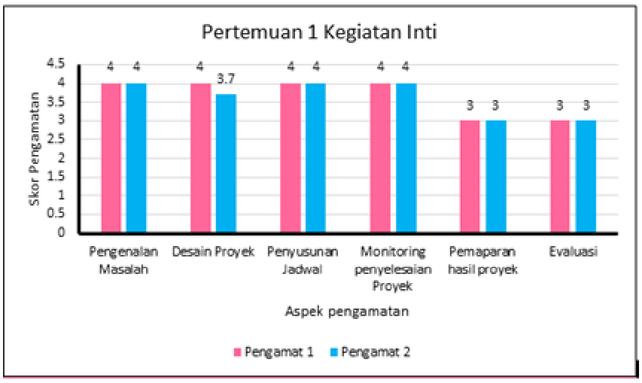

Figure 2 The Result of the Observation of Main Activities in Meeting 1

As presented in Figure 2, the main activities were composed of six assessed aspects. Four aspects came with perfect scores, and two others, i.e., project result presentation and evaluation, had the lowest scores.

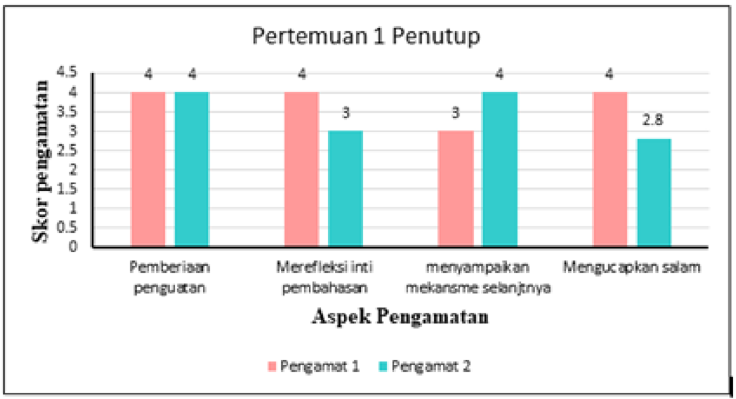

Figure 3 The Result of the Observation of Closing Activities in Meeting 1

Figure 3 shows that for the closing activities in meeting 1, the student reinforcement aspect acquired the highest point.

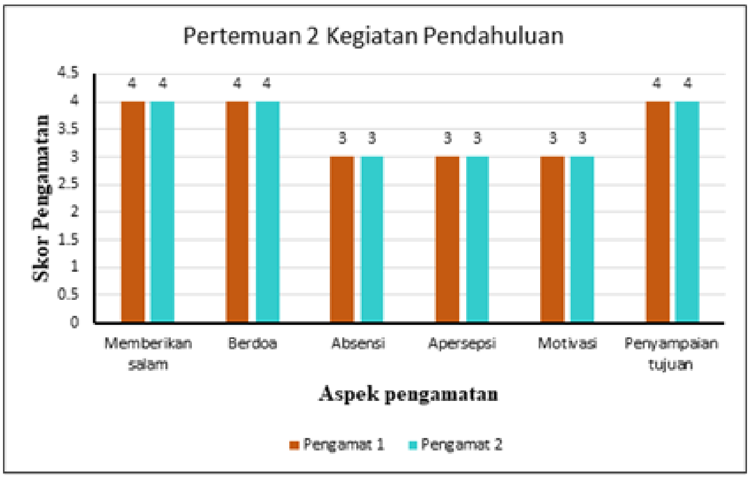

Figure 4 The Result of the Observation of Introductory Activities in Meeting **2**

Figure 4 showcases the observation results in meeting 2. Of the six aspects observed, four achieved the highest scores, whereas two aspects, namely apperception and motivation delivery had the lowest ones.

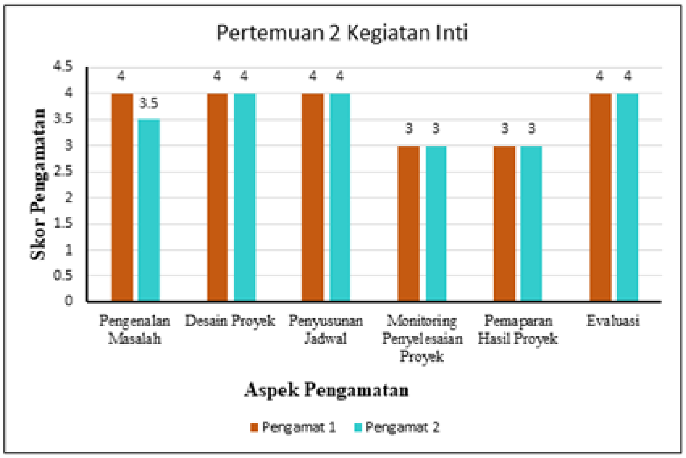

Figure 5 The Result of the Observation of Main Activities in Meeting 2

The observation results in meeting 2 are shown off in Figure 5. Four aspects had the highest scores, and two others, which were project monitoring and project result presentation, had the lowest ones.

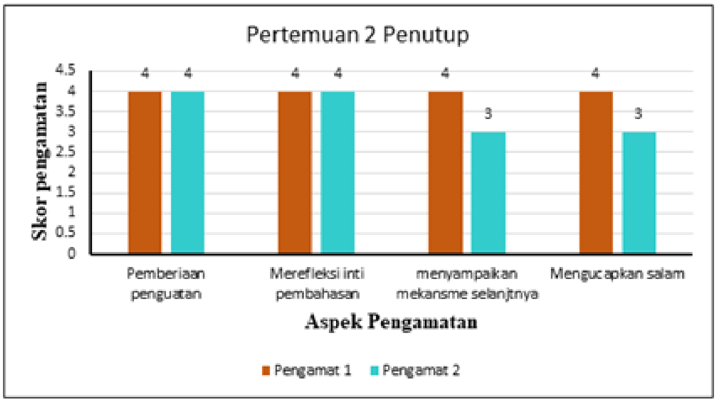

Figure 6 The Result of the Observation of Closing Activities in Meeting 2

Closing activities in meeting 2 acquired similar results. Two aspects had the highest scores, and two others had the lowest ones, as suggested in Figure 6.

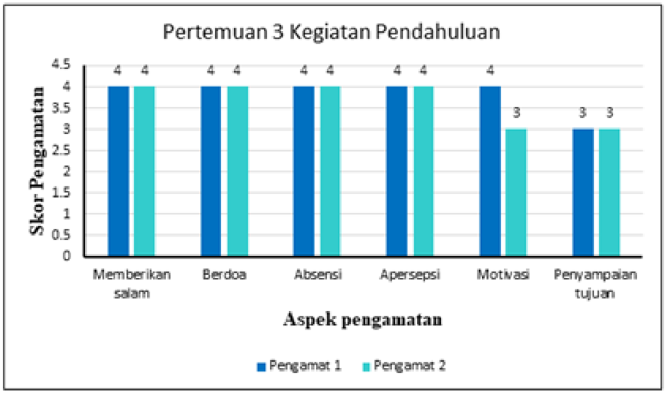

Figure 7 The Result of the Observation of Introductory Activities in Meeting 3

Figure 7 demonstrates the result of the observation of introductory activities in meeting 3. Of the six aspects analyzed, three came with perfect scores yet an aspect, namely learning objective delivery, went with the lowest score, namely 3.

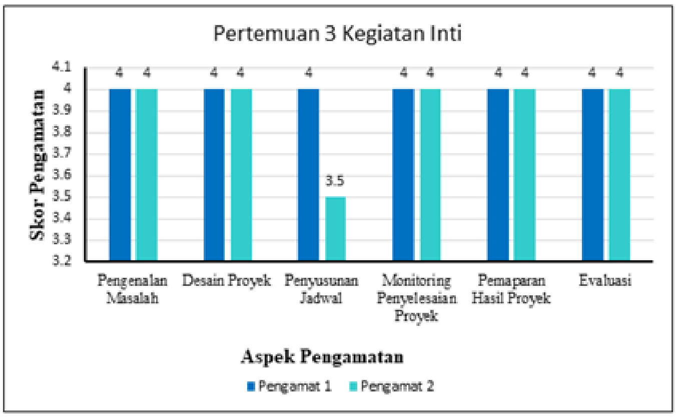

Figure 8 The Result of the Observation of Main Activities in Meeting 3

As exhibited in Figure 8, in the results of the observation of main activities in meeting 2, six aspects had the highest scores according to observer 1. Meanwhile, observer 2 afforded the highest score to the scheduling aspect.

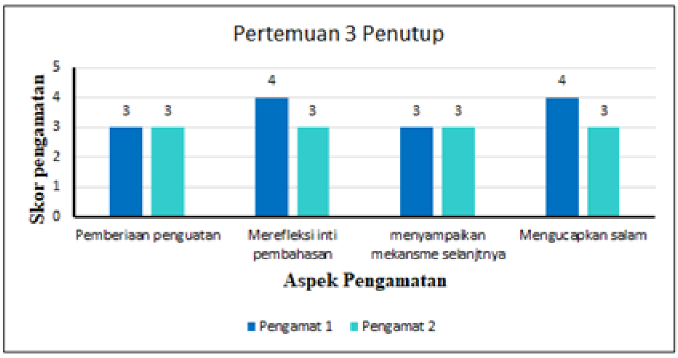

Figure 9 The Result of the Observation of Closing Activities in Meeting 3

Figure 9 features the result of the observation of closing activities in meeting 3. Two aspects achieved high scores, and two other aspects had the lowest ones.

The learning was divided into three stages: introduction, main activities, and closing activities, all of which were implemented using the PjBL model. The introductory activities were commenced by praying and checking student attendance. Teachers conferred initial stimuli by giving apperceptions vis-à-vis the materials being delivered henceforth. Teachers would also render motivations with regard to the paramount importance of keeping the environment clean to minimize natural disaster impacts.

Table 1 The Results of the Observation of Learning Implementedness in Tenth Grade APPL

	Penilaian keterlaksanaan Pembelajaran (%)				
Pertemuan	Tahaap Kegiatan	Pengamat 1	Pengamat 2	Rata - rata	Kategori
1	Pendahuluan Inti Penutup	94.74	94.74	94.74	Sangat Baik
2	Pendahuluan Inti Penutup	90.79	81.58	86.185	Sangat Baik
3	Pendahuluan Inti Penutup	92.11	90.79	91.45	Sangat Baik
	Rata- rata			90.79	**Sangat Baik**

Based on Table 2, the mean score of the implementedness was 90.79%. Accordingly, the implementedness was considered "Very Good".

3.4. Student Activity Observation Analysis

Data on student learning activities were collected by observing student activities during the learning process using the PjBL model. Student activities observed were listening, writing, observing, answering questions, making a presentation, and concluding. Table 2 indicates the scores of each assessment indicator for all respondents.

Table 2 The Scores of Each Indicator from Student Activity Observation for Three Meetings

Pertemuan	**Indikator**									**Keterangan**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
1	27	25	27	26	28	26	27	26	28	1. Mengajukan prediksi 2. Mengamati 3. Mengajukan pertanyaan 4. Melakukan pengamatan
2	27	28	29	28	29	28	30	26	28	5. Menganalisis hasil pengamatan 6. Mempresentasikan 7. Menanggapi presentasi
3	27	26	27	27	29	29	30	31	30	8. Menyimak penjelasan guru 9. Menyimpulkan materi

Figures 10, 11, and 12 point out the observation scores from meetings 1, 2, and 3, respectively.

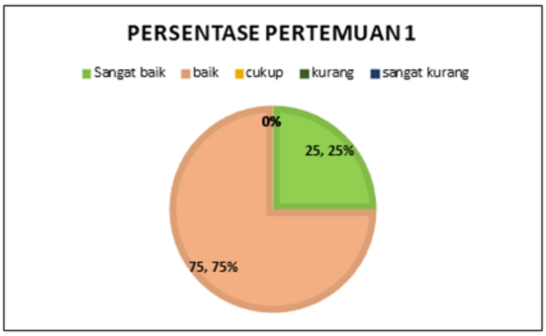

Figure 10 The Observation Scores on Student Activities in Meeting 1

Figure 10 points out that 25.25% of students carried out activities very well. Meanwhile, 75.75% of students conducted the activities well.

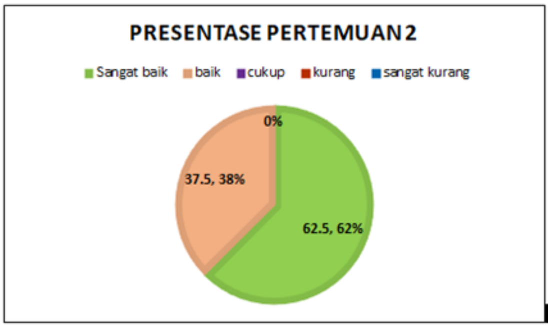

Figure 11 The Observation Scores of Student Activities in Meeting 2

As presented in Figure 11, 62.5% of students did student activities with a very good criterion, and 37.5% executed the activities with a good criterion.

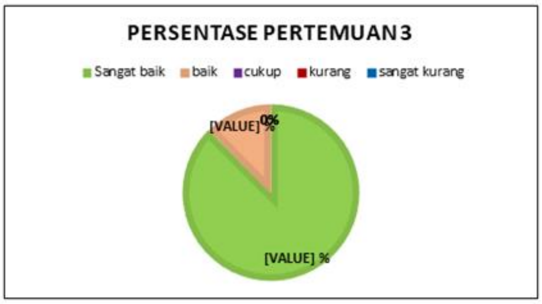

Figure 12 The Observation Scores of Student Activities in Meeting 3

Figure 12 shows the chart of the analysis results of student activity data from meeting 3. 87.5% of students performed student activities with a very good criterion, and 12.5% others carried out the activities with a good criterion.

After processing data gathered from three meetings earned the mean score of student activity observation from three meetings. 62.5% or five of the students conducted activities very well, while 37.5% or three others did the student activities well. No students vested "acceptable" or "poor" responses.

4. Discussion

Learning devices reliable for a learning process were those efficient to use by teachers and students. As such, the practicality of learning devices was measured or investigated from the results of the observation of learning implementedness and student learning activities.

4.1. Learning Implementedness

Learning implementedness in class showcased that learning had been executed aligned with the learning implementation plan. A learning process comprised introductory, main, and closing activities focusing on learning integrated with physic materials of fluid, consisting on some topics, i.e., pressure, hydrostatic, Pascal's law, Archimedes' principle, and disaster mitigation for disasters frequently taking place in the coastal area of the Gulf of Tomini, namely Torsiaje. The research applied the Project-Based Learning model made up of three meetings.

The learning was composed of three activities with the PjBL model implemented: introduction, main activities, and closing activities. In the introductory phase, teachers asked students to pray and checked the attendance list. Teachers then gave apperceptions with respect to the materials to be delivered to afford initial stimuli. Teachers also motivated students as regards the criticality of keeping the environment clean to decrease natural disaster effects.

The main activities are where the syntax of the PjBL model started to be implemented. The implementation embarked upon phase 1: introduction to a problem. One of the ways to introduce the issue being learned was by presenting a video of tsunamis and floods in coastal areas. Introducing problems through videos would likely allow teachers to explain how the materials learned connected to natural disasters and mitigating measures efficiently.

Phase 2 was product designing. In phase 2, teachers divided students into several heterogeneous groups. Each group was given a learning topic they should link to natural disaster mitigation they were about to observe. To make an efficient observation, teachers gave project work guidelines in the form of student worksheets. Student worksheets contained the explanation of group project accomplishment, deadline, and types of assessment given.

Phase 3 was scheduling. Teachers facilitated students to make activity schedules covering planning, preparation, implementation, and presentation. Schedules were made based on the defined deadline. After the deadline was determined, students could arrange the steps needed.

Phase 4 was monitoring students in project accomplishments. Phase 4 was performed in meeting 2. In phase 4, students carried out observation and should meet the deadline. Teachers, who were us, oriented students in conducting the observation. The observation was done indoors, i.e., inside the classroom, and outdoors, i.e., in the coastal area and Torsiaje.

Phase 5 was presenting the project outcome. Each group presented the observation results in front of the class. Phase 6 was evaluating. In phase 6, teachers evaluated the project outcomes. In phase 6, teachers also gave a formative test to assess the learning indicators achieved.

The final activities of the learning process were closing activities. In performing closing activities, students were given opportunities to draw conclusions about the learning process they just participate in. Teachers then strengthened the conclusions the students drew. Teachers stressed how it was crucial to maintain the environment, identify potential natural disasters in coastal areas, and natural disaster mitigation.

Practicality was attested to by the opinions of users, especially teachers and students who perceived it (Nuryadi, 2017). It accorded with Riyadi (2015) that in learning implementation, the indicators of good learning device implementation were practical learning components to be used by teachers in classroom learning.

Learning implementedness demonstrated learning activity implementation using learning devices made. Learning activities were stated in lesson plans and consisted of introductory activities, main activities, and closing activities referring to the syntax of the Project-Based Learning model.

Learning implementedness assessments here were done by two observers in three meetings. The two observers gave results with a mean percentage of 90.79%, which was then considered very good. It exhibited that learning using the devices developed had been implemented commensurate with the lesson plans designed using the Project-Based Learning model.

Considering a multitude of natural disasters, either geological or hydro-climatological in Indonesia, it was imperative for students to augment their knowledge levels associated with disasters and mitigation. They should apprehend how to mitigate natural disasters by nourishing caring behaviors toward the environment.

It comported with Shela (2021) employing the PjBL model to develop online learning devices to elevate practical environmental literacy. The analysis results of the observation of the learning process implementedness featured that the learning devices came with "Very Good" practicality at a mean score of 3.9.

Building on the discussion and supported by the previous research, the quality of our natural disaster mitigation-based learning devices in terms of practicality using the PjBL model was practical for indoor or outdoor learning.

4.2. Student Learning Activity

As indicated in Table 2, the scores of the first aspect, namely proposing a prediction, were the same in meetings 1, 2, and 3. The second aspect, which was an observation, had a low score in meeting 1 as several students did not pay attention to the videos played. The second aspect, i.e., proposing questions, came with a higher score in meeting 2 compared to meetings 1 and 3. Students were active and proposed more questions in meeting 2. The fourth aspect, namely observation, had a high score in meeting 2 because students carried out an outdoor observation project in meeting 2. The sixth aspect, which was presenting the results, acquired a high score. The seventh aspect, i.e., giving responses to the presentation, had a low score in meeting 1. In meeting 1, students were guided to make a project schedule. Some students only concentrated on making their schedules and, hence, did not adequately respond to other groups' presentations. Listening to teachers' explanations in meeting 3 acquired the highest score in all meetings. It was because students manifested a higher enthusiasm when presenting the results, making them more serious in listening to teachers' explanations. The last aspect, i.e., drawing a conclusion, had the highest score in meeting 3 than in meetings 1 and 2.

Learning practicality could be studied in learning implementedness and student activities. Figure 10 showcases that 25.25% or two of the students carried out student activities very well, and 75.75% or six of the students conducted the activities well. Figure 11 shows off that 62.5% or five of the students did student activities very well, and the rest, i.e., 37.5% or three students, executed the activities well. Figure 12 suggests that 87.5% or seven of the students performed student activities very well, and 12.5% or one student carried out the activities well.

Predicated on the discussion and supported by the previous research, the quality of our natural disaster mitigation-based learning devices in terms of practicality using the PjBL model was practical for both indoor and outdoor learning.

5. Conclusion

Based on the results and discussion in the research titled "Developing Physics Learning Devices Focusing on Natural Disaster Mitigation in the Coastal Area of the Gulf of Tomini to Foster the Attainment of SDGs Goals 4 and 13" using the Project-Based Learning model and the 4D research design, we could conclude that the learning devices fulfilled the qualities of validity, practicality, and effectiveness. It was pointed out by an increase in student learning outcomes at an N-Gain of 0.69 with a medium criterion. The increase showed student abilities or knowledge attributed to natural disaster mitigation.

Suggestion

Building on the results, we could propose several suggestions as follows.

- An increasingly polluted environment leads to environmental crises, e.g., natural disasters. Integrating education with knowledge will minimize natural disaster implications.
- The natural disaster mitigation-based learning devices developed can be used in other subjects bearing on the surrounding environment.
- Future researchers may carry out further studies or similar studies using different environmental conditions or natural disasters.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest.

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