



The Effectiveness of Tornado Physics Enrichment Book to Increase Science Literacy of High School Students

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Abstract: Scientific literacy is a need and learning goal in the industrial era 4.0. Indonesia's low scientific literacy is an urgent problem. There are many ways that can be used in learning to hone scientific literacy, including choosing sources and teaching materials that are integrated with natural disaster environmental. In this research, scientific literacy was sharpened in physics learning through the use of a knowledge enrichment book entitled Tornado. In this enrichment book, the discussion of tornadoes is presented from a physics perspective including the concepts of energy, heat, fluid dynamics and global warming. The aim of this research is to increase students' scientific literacy by using physics enrichment books on the theme of the tornado disaster. This research uses an experimental research method in the form of a quasi-experimental design with a one-group pretest-posttest design. The results of the trial of 60 students from SMAN 13 Padang and SMAN 2 Padang Panjang showed that the use of enrichment books was able to increase students' scientific literacy, with an average pretest scientific literacy of 46 and an average posttest of 87, and an N-gain of 0.76. These results indicate that the use of tornado physics enrichment books is effective in increasing students' scientific literacy.

Keywords: Immediately enrichment books physics; Science literacy; Tornado

Introduction

Physical science has a significant contribution in many modern discoveries, as well as helping to explain many of the events that are taking place in everyday life (Erinosho, 2013). However, physics is still considered a difficult subject to understand (Camarao & Nava, 2017). The level of difficulty in studying physics is more emphasized by the factor of the content of the subject matter, then the student or class environment factor, and finally the teacher factor (Ekici, 2016). Poor mathematical ability and lack of understanding of problems are major constraints (Ismiati et al., 2020).

Physics is part of the natural sciences, so the learning of physics must also be based on scientifically proven findings and occur around (Utami et al., 2017). Understanding of concepts in Physics subjects can be improved by learning based on natural phenomena (Rohadi et al., 2017). Learning that involves the environment as a learning resource will be able to support the application of current physics learning

(Afrizon et al., 2017). Studying physics will make students become familiar with a number of natural phenomena as well as their scientific explanation. On the contrary, applying advanced technology in accordance with the development of physics will make it easier for students to understand the phenomena of the surrounding nature (Tuksanova & Nosirova, 2021). Thus, learning physics as an effort to understand and learning physics as a way of obtaining the interpretation of natural phenomena will be fulfilled (Chiou et al., 2013), as well as overcome the difficulties of students in studying physics.

Indonesia is known as a disaster-prone country. Natural disasters such as tornadoes, floods, landslides, abrasion, forest and land fires, earthquakes, tsunamis, volcanic eruptions are the most frequent natural disasters in Indonesia (BNPB, 2012). Environmental content including various natural disasters can be used as learning materials (Azmanita, & Festiyed, 2019). Physics learning, which is carried out through the assessment of environmental themes, such as one of

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these natural disasters, will produce interesting learning while increasing interest in studying physics (Irwandi & Fajeriadi, 2020). Physics learning based on environmental themes is also felt by students lighter than they memorize the formula and then apply it to environmental problems.

The increasing frequency of disasters illustrates the occurrence of environmental crises (Ebadi et al., 2020). The environmental crisis is also related to global environmental change. The global environmental crisis is caused by two factors, natural disasters and human-made consequences that are not environmentally aware (Raksanagara et al., 2022). This damage is generally caused by human activities that are not environmentally friendly such as forest destruction and land conversion, mining, industrial waste disposal, waste disposal that is not easily decomposed carelessly and other activities (Kelana, 2017). Changes in global environmental conditions have an impact on changes in ecosystems and living things (Liverman, 2013).

Environmental problem solving is concerned with reimagining the overall relationship between humans and natural systems (Pattberg & Widerberg, 2015). Environmental problems will not be solved if only a certain part of the components of life, let alone humans who play a role in solving environmental problems. Therefore, it is important to implement environmental education both through formal education and environmental care agencies or institutions. A number of countries have successfully addressed environmental problems through appropriate environmental governance processes (Young et al., 2015). Despite good governance, the number of disaster victims is still quite large (Padmaja et al., 2022).

Environmental education in Indonesia refers to the joint decision of the Ministry of education and the Ministry of Environment and forestry. Joint decree No. 07/MenLH/06/2005 issued by the Minister of Environment and the Minister of National Education, emphasizes that environmental education is carried out in an integrated manner with existing subjects. Through the integration of environmental education in physics learning is expected to be honed various abilities of students, including scientific literacy. Thus the attitude of caring for the environment is formed through the learning process (Fua et al., 2018). The physical sciences that students learn are expected to have a positive impact on improving the environment and reducing disaster victims.

Planning and designing a comprehensive education program is very necessary for the community to deal with disasters (Torani et al., 2019). Disaster-themed learning is designed by combining elements of science, technology, and social. The element of science

serves to equip students with sufficient knowledge about natural disasters and signs of natural change seen from the perspective of science. Elements of science are then followed by some environmental conditions that were avoided before the disaster (Atmojo et al., 2018). Students who are able to associate and apply the concepts learned with real situations in their environment, can understand the concept of learning and can train to reason scientifically through scientific literacy (Widiana et al., 2020). In other words, through disaster learning integrated into physics subjects can affect the level of science literacy of students.

The results obtained from the PISA survey from 2000 to 2018 placed Indonesia as one of the countries with a low scientific literacy rating. In fact, one of the main goals of Science Education is to create a young generation that has adequate science literacy skills (Narut & Supardi, 2019). Factors that cause low scientific literacy of students is the selection of textbooks, misconceptions, learning that is not contextual, and the ability to read learners (Fuadi et al., 2020).

The high school physics subject is one of the subjects relevant to disaster-themed environmental education (Sudrajad & Napitupulu, 2022). This is because the causes, processes, impacts of natural disasters, and Disaster Mitigation can be explained by knowledge of physics in accordance with core competencies and basic competencies in the applicable curriculum (Sudrajad, 2015). The integration of environmental education in the form of natural disaster studies and mitigation into physics learning, is likened to a symbiosis of mutualism that mutually reinforces one another. Compared to conventional approaches, environment-based learning approaches are more effective in sharpening scientific literacy (Muhlis & Ali, 2020). A number of studies related to disaster integration in physics learning have been carried out. However, the use of these research results in schools is still limited (Rahmawati & Wiyatmo, 2018). Therefore, it is necessary to make efforts to apply the results of the study directly, in order to see the impact on improving scientific literacy.

Referring to the explanation that has been submitted, it can be said that various environmental problems that cause natural disasters can be integrated into school subjects, including physics. In addition to increasing students' understanding of knowledge, ways of mitigating and managing natural disasters, students can also see a natural disaster process from the point of view of physics so as to improve students' scientific literacy. Students' science literacy can be improved through teaching materials that present natural phenomena and problems that occur around students (Pursitasari et al., 2019). The use of teaching materials

has a very large role in learning activities. One of the teaching materials is used to help teachers deliver learning material and create student-centered learning (Desnita et al., 2021).

Teaching materials are one of the factors that influence the level of students' scientific literacy abilities. The existing teaching materials in Indonesia do not yet contain balanced aspects of scientific literacy. So it is necessary to develop teaching materials based on scientific literacy with a balanced content of scientific literacy aspects (Ummah et al., 2018). Seeing the low scientific literacy of Indonesian students which is influenced by one of the teaching materials, and various environmental problems that cause natural disasters, as well as the need to integrate the environment through the theme of disasters to increase students' scientific literacy, teaching materials are needed that integrate natural disasters in the surrounding environment which can influence students' scientific literacy, for example the natural disaster of a tornado.

Has developed a physics enrichment book entitled tornado and declared valid and practical but not yet known the level of effectiveness (Desnita et al., 2016). This book is classified as non-text teaching materials type of knowledge enrichment with the theme of disaster. This book was developed based on the essential concepts of tornado disasters including energy, heat, fluid dynamics, and global warming. In this paper convey the results of the test of the effectiveness of the use of books that have been developed against the scientific literacy of high school students. The purpose of the study is to determine the effectiveness of tornado physics enrichment book. Through the use of integrated physics enrichment books tornado natural disasters that have been developed, will be seen the effect on student science literacy.

Method

The form of research used is quasi-experimental design with one-group pretest-posttest design. The design of one group pretest and posttest design is done by giving a pretest and then giving treatment deliberately and systematically to a group and at the end of the learning is given a posttest. Sugiyono (2013), said that conducted on one group without any control group or comparator. In this study the treatment given is the provision of reading material enrichment book tornado.

The independent variable in this research is the use of tornado physics enrichment books, while the dependent variable is students' scientific literacy. This research was conducted at senior high school 13 Padang and senior high school 2 Padang Panjang. The research population was all students of class XI science at senior

high school 13 Padang and senior high school 2 Padang Panjang. The research sample was one class each in each school with a total of 60 students taken using purposive sampling technique. The research instrument used in this research is a student scientific literacy instrument based on the tornado physics enrichment book which has been developed and declared valid and reliable (Mulyana & Desnita, 2023). Next, students' scientific literacy data was analyzed using the N-gain value.

N-Gain test aims to determine the effectiveness of the use of a method or treatment. N-Gain Score test is done by calculating the difference between posttest value and pretest value. Mathematically written through equations:

$$\langle g \rangle = \frac{S_{posttest} - S_{pretest}}{S_{max} - S_{pretest}} \tag{1}$$

Notes: $S_{pretest}$ = score pretest, $S_{posttest}$ = score posttest, and S_{max} = score max

Table 1. Criteria N-Gain Score

Limitation	Criteria
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Medium
$g > 0.3$	Low

Meltzer (Suprpto et al., 2018)

Table 2. Criteria for the Percentage Level of the N-Gain Score

Percentage (100%)	Interpretation
< 40	Ineffective
40-50	Less effective
56-75	Effective enough
>76	Effective

(Hake, 1999)

Guidelines for conducting this research are presented in the following research flow.

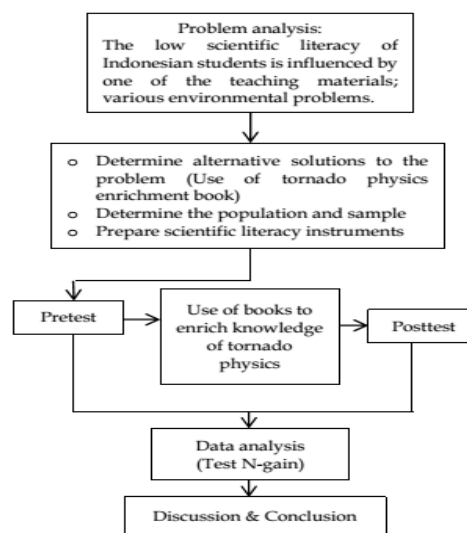


Figure 1. Research flow

Result and Discussion

Effectiveness is the impact arising from an action. In this study, the impact of the use of physics enrichment book entitled tornado on students' scientific literacy. The effectiveness test is used to see the level of success in physics learning which can be said to be effective if the enrichment book can have an impact on student science literacy.

The impact of using the book is seen by calculating between the value before and after using the book. The results of student science literacy can be seen in Table 3 and Table 4.

Table 3. Pretest and Posttest Scores

	Mean	Std. Deviation
Pretest	46	2.8
Posttest	87	2.7

Table 4. Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Ngain_Score	60	.63	.89	.7640	.05317
Ngain_Percentage	60	63.27	88.89	76.4002	5.31735
Valid N (listwise)	60				

Based on Table 4 there is a minimum value, maximum value, mean, and standard deviation of the calculation of the value of science literacy of students against the use of tornado physics enrichment books. A total of 32 samples get a minimum value of 63.27 and a maximum value of 88.89 with an ideal score of 100. For N-gain score, the mean value obtained is 0.76 which is categorized as medium. Then for the N-gain percentage obtained a value of 76% which is categorized as effective. It can be interpreted that the use of tornado physics enrichment books is effective in improving students' science literacy.

The purpose of physics learning is to deliver students to master physics concepts, and be able to relate them so that they can solve physics problems in everyday life (Ubaidillah, 2018). Disaster integration can provide direct experience to students so that they are able to see the phenomenon as a whole and meaningfully (Latupeirisa, 2020). In addition, learning through the surrounding nature makes students able to observe directly and easily understand what they see and what they experience (Mayuni, 2021). People who have scientific literacy can appropriately use science concepts, principles, laws, and theories in interacting

with their environment (Rohman et al., 2017). Students who are able to associate and apply the concepts learned with the real situation in the environment, it can understand the concept of learning as well as being able to train reasoning scientifically through scientific literacy (Widiana et al., 2020). This is in accordance with the findings of researchers where there has been an increase in the ability of students in the aspect of science literacy through the use of physics enrichment books related to the surrounding nature, namely the tornado disaster.

From the calculation results in Table 3, it is known that the value of the use of tornado physics enrichment books for scientific literacy students get the average value of students before using physics enrichment books is 56 with a standard deviation of 2.8 and after using physics enrichment books is 87 with a standard deviation of 2.7. From the results of the pretest and posttest students look to get different results. Pretest was given with the aim to determine the ability of early science literacy before being treated with a physics enrichment book entitled tornado, while posttest was given with the aim to determine the ability of science literacy after being given treatment in the form of the use of physics enrichment books.

The N-gain test results are calculated using equation (1). The obtained N-gain score coefficient and N-gain percentage are presented in table 4.

In addition, many studies have developed and reviewed the implementation of teaching materials on the topic of a disaster on the scientific literacy of students. In this study, analyzed several research articles that discuss the impact of the use of a non-text teaching materials enrichment type with the theme of disaster or the natural environment on learning outcomes, especially scientific literacy. This analysis was conducted to increase the knowledge and references of researchers in observing the shortcomings and advantages of previous research. Table 4 contains the results of the analysis of various relevant studies.

Table 5. Relevant Research

Author	Research Objective	Research Results
(Wafiah, 2017)	Developing enrichment materials for Physics subjects to improve students' scientific literacy skills on the concept of flood disaster.	There is an increase in scientific literacy on the concept of flood disaster after being given enrichment materials with quite effective categories.
(Juwita, 2020)	Developing teaching materials of physics knowledge enrichment type on forest fire disaster mitigation to improve scientific literacy	The results of the trial of teaching materials obtained an increase in scientific literacy of students on the concept of Disaster Mitigation physics forest fires in the medium category.
(Fadilah, 2021)	Developing earthquake natural precursor textbooks with the aim of improving literacy in science learning and disaster preparedness	Through the application of online learning salama textbooks, it has been proven to significantly improve disaster literacy in science and moderate levels of effectiveness. Increases in disaster literacy in science were also found in all three aspects of knowledge, where epistemic knowledge increased more than content knowledge and procedural knowledge.
(Qismawa & Jumini, 2020)	Analyzing the need for the development of disaster mitigation-based teaching materials in the form of comics as a science learning resource to improve students' science literacy skills	After conducting a review of various related articles, this study concluded that the need for the development of Disaster Mitigation teaching materials such as comics, in order to improve students' scientific literacy because comics are considered effective in learning.
(Chanifah, 2021)	Measuring the effect of problem based learning e-module on students' science literacy skills on global warming	Through the use of E-module global warming material with PBL model there is an influence on the ability of science literacy students, where the ability of science literacy students in the experimental group increased higher than the control group.
(Kamala et al., 2015)	Developing integrated science module teaching materials based on inquiry lesson with the theme of environmental pollution to improve science literacy	Through the application of integrated science modules based on Inquiry lessons, it can significantly improve students' science literacy, meaning that there is a significant positive relationship between students' science literacy when students use the modules.
(Della Islami et al., 2018)	Measuring the effect of teaching materials local content of natural disasters on student learning outcomes	There is an influence on the use of teaching materials local content of natural disasters on cognitive learning outcomes of students.
(Permatasari, 2013)	Developing integrated science teaching materials webbed type with the theme of disaster response	Through the use of teaching materials obtained an increase in student learning outcomes by 100%.
(Arif Kurniawan & Aly, 2015)	Measuring the effectiveness of the use of enrichment teaching materials "fun way to know disaster" in learning materials on the state of Indonesia's climate	The results of the trial of teaching materials show that disaster teaching materials how to get to know disasters are effectively used in learning to improve student knowledge.
(Sinurat, 2020)	Utilizing local potential-based student electronic supplement books in an effort to improve environmental context science literacy	The results showed an increase in the ability of science literacy students' environmental context. The local potential-based student electronic supplement book can be used as an additional textbook in the learning process.

Some previous research described in Table 5 shows that teaching materials that integrate natural disasters in a subject can improve students' scientific literacy skills and even student learning outcomes. Floods, earthquakes, forest fires, global warming and so on are disasters that have been integrated into a teaching material to see an increase in scientific literacy and wider learning outcomes. In this study, the researchers only tested the effectiveness of physics enrichment books that have been developed and have been declared valid and practical in tornado disasters. Previous research on the theme of tornado disaster has also existed, for example

(Azhar et al., 2020). However, it is not associated with scientific literacy and does not prove whether the integration of tornado disasters into a subject can improve students' scientific literacy.

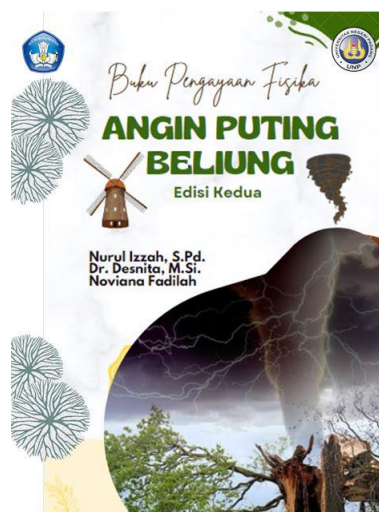


Figure 2. Tornado enrichment book

A tornado is a disaster that can be viewed from the point of view of physics. The essential concepts of this disaster include energy, heat, dynamic fluids, and global warming (Mulyana & Desnita, 2023). With the availability of tornado-based teaching materials, it can be a support for students' scientific literacy skills to increase. This is in line with the opinion (Retno et al., 2017), which states that learning resources that present readings related to phenomena in everyday life make learners more clearly understand them, so that if the category of scientific literacy indicators is presented in teaching materials, it could be that students' interest in the subject will increase. So, from the research that has been done, it can be used as a reference that teaching materials based on natural disasters including tornadoes that are integrated into science subjects including physics can improve student science literacy.

Conclusion

Based on the results of the study, it was concluded that the effectiveness of the tornado physics enrichment book was effective in improving students' science literacy with an N-gain score of 0.76. This is also supported by the analysis of several relevant studies which show that many previous studies prove that disaster-based teaching materials are effectively used in learning to improve students' scientific literacy skills. Through learning that is associated with real conditions, including disaster phenomena, can make abstract physics more meaningful and easy to understand.

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Author Contributions

The author's contributions to this paper are as follows: conception of the ideas presented, conception of the study, design: Desnita. Data collection and manuscript drafting: Nurul Izzah. All authors analyzed and interpreted the results and approved the final version of the manuscript.

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Conflicts of Interest

No Conflicts of interest.

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