JIPF (JURNAL ILMU PENDIDIKAN FISIKA)
p-ISSN: 2477-5959 | e-ISSN: 2477-8451 *Vol. 10 No. 1, January 2025, Page 36-56*

Development of the Physics Knowledge Enrichment Book "Lightning" to Improve High School Students' Science Literacy and Environmental Literacy

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Received: August 10th, 2024. Revised: September 8th, 2024. Accepted: September 10th, 2024

Keywords :
Enrichment Book; Physics; Science Literacy; Environmental Literacy

ABSTRACT
The independent curriculum emphasizes literacy skills as the most important learning objectives. The two literacies that are greatly needed in the 21st century are science literacy and environmental literacy. However, these two literacies among high school students in Indonesia are still relatively low. The subject that is able to achieve both literacies in an integrated manner is physics. The purpose of this development research is to produce a physics knowledge enrichment book "lightning" to improve science literacy and environmental literacy of high school students that is valid and practical. This type of research is research and development (R&D) with the ADDIE model. The subjects of the study were physics teachers and grade XI high school students. Data were collected through questionnaires. Data analysis techniques include calculating the average score and Aiken validity index. The results of the study showed that: 1) The enrichment book was stated in the valid category in terms of material, language, presentation, and graphics; 2) The enrichment book by teachers and students was stated in the practical category in terms of ease of use, learning effectiveness, and benefits. Therefore, the physics knowledge enrichment book "lightning" that was developed is valid and practical as a solution to improve science literacy and environmental literacy of high school students.

INTRODUCTION

Education is one of the main pillars in forming a young generation who is intelligent, critical and cares about the environment. The independent curriculum is a breakthrough in Indonesian education in the 21st century which gives students the freedom to learn independently emphasizes literacy and numeracy skills as reference point for learning outcomes [1]. Literacy skills are basic abilities that can influence the success of a person's life because literacy is a provision for students to face real-world problems and complex global challenges [2]. The two literacy skills that are most needed currently are

scientific literacy and environmental literacy [3] [4] [5]. Scientific literacy involves the ability to understand scientific concepts, think critically, and apply knowledge in everyday life [6]. Meanwhile, environmental literacy includes an understanding of environmental issues, awareness of the impact of human activities on nature, and the ability to act with attention to the environment [7]. Scientific literacy and environmental literacy are two important components in modern education that are interrelated and are equally important for forming a young generation who is knowledgeable and responsible for the environment [8] [9] [10]. However, various studies show that scientific literacy and environmental literacy among high school students in Indonesia are still low [11] [12]. This is exacerbated by the lack of specific and interesting learning materials that can motivate students to learn science in more depth and contextually [13].

Indonesia is one of the countries with a very low scientific literacy rating based on results of the PISA (Program for International Student Assessment*) survey* over the last 20 years. PISA is a global evaluation held every three years by the OECD (Organization for Economic Cooperation and Development) which aims to measure students' core competencies in reading, mathematics, and science literacy in students aged 15 years [14]. The scientific literacy abilities of students in Indonesia are shown in the PISA rankings over the last 20 consecutive years (2003-2021) with student scientific literacy scores of 393, 383, 382, 403, 396 and 383. Indonesia has never reached the PISA average score of 500 [15]. This figure indicates that many students in Indonesia have difficulty understanding basic science concepts, analyzing scientific data, and applying their knowledge in everyday life [16]. Inadequate supporting teaching materials are one of the causes of low scientific literacy and environmental literacy skills among students [17].

Environmental literacy among students is indeed a serious problem. This does not only occur in developing countries, but also in developed countries. Research in 15 countries, including Brazil, Chile, Croatia, Dominican Republic, Georgia, Germany, Hong Kong, Ireland, Italy, Korea, Macau, Malta, Mexico, Panama, and Portugal, shows that most students are less interested in studying environmental issues, which are closely related to scientific literacy [18]. This indifference indicates a gap in the education system and a lack of attention to the importance of understanding the environment, which is essential for global survival. This study also strengthens the correlation between environmental awareness and scientific literacy. Based on one of the study results, out of 25 countries studied, students who have low environmental awareness tend to have low scientific literacy as well [19]. This means that scientific understanding and concern for environmental issues are interrelated; lack of awareness of one aspect will affect the other. This phenomenon shows a global challenge in creating a generation that is more aware of environmental impacts through better science education.

Specifically in Indonesia, the issue of environmental literacy is also a concern. Indonesia, as one of the ASEAN countries, is among the countries whose students have low levels of environmental literacy [20]. High school students in Indonesia still have limitations in understanding environmental issues as a whole. Factors such as a curriculum that does not yet emphasize environmental issues, lack of educational facilities, and minimal practical discussions in the field may be the causes of low environmental literacy among students. This is a big challenge for Indonesia to improve environmental literacy so that students not only understand these issues theoretically, but are also able to apply them in everyday life.

The Adiwiyata program initiated by the Ministry of Environment and Forestry has helped increase environmental awareness in several schools, however the implementation of this program has not been evenly distributed throughout Indonesia [21]. Many students still lack awareness of the importance of protecting the environment and how their daily actions can affect the balance of the ecosystem [22]. Although environmental issues such as climate change, pollution and deforestation are increasingly discussed, in-depth understanding of the impacts and ways to overcome these problems is still limited [23]. The environment is included in one of five science and technology applications in which there is a PISA science assessment context with details of categories, environmental quality, environmentally

friendly actions, use and disposal of materials and tools, waste disposal, environmental impacts of biodiversity, ecological sustainability, pollution control, production and soil/biomass loss [24].

Students who have good scientific literacy are able to explain scientifically, evaluate and design scientific investigations, interpret data, and prove scientifically [25]. Meanwhile, students who have good environmental literacy will be able to be responsible for the environment through knowledge, skills and awareness of environmental problems [26]. One of the subjects in high school that can foster these two literacies in an integrated manner is physics. If scientific literacy and environmental literacy are not mastered, students only understand knowledge theoretically but cannot apply their knowledge in real life and do not care about the environment [27] [28]. Therefore, it is important to improve students' scientific literacy and environmental literacy skills simultaneously because these two literacies have a strong relationship [29].

Indonesia has 200 days of thunder, compared to the USA 100 days, Brazil 140 days and Africa 60 days [30]. This data indicates that Indonesia has a fairly high vulnerability to danger due to lightning strikes. Apart from having a fairly high vulnerability to the dangers of lightning and the need for knowledge about lightning and how to avoid the danger of lightning, the lightning phenomenon is also one of the environmental themes that is widely integrated into physics and various benefits that can be studied therein [31] [32]. Lightning is a natural phenomenon that occurs frequently and has a significant impact on daily life and the environment [33]. An in-depth understanding of the mechanisms by which lightning forms, its physical processes, and its impact on ecosystems and humans, can provide valuable insight for students. In fact, learning material about lightning often does not receive adequate attention in the school curriculum, so that students' understanding of lightning physics is not optimal [34]. This is caused by a lack of quality teaching materials that thoroughly examine lightning. Existing science textbooks often only provide brief and in-depth explanations of this phenomenon [35]. Therefore, lightning is an interesting and relevant natural phenomenon to study in the context of scientific and environmental literacy.

The development of a physics knowledge enrichment book about lightning for high school students is an innovative solution to overcome the low level of science and environmental literacy, which is caused by the lack of adequate learning resources [36]. This book is designed comprehensively, covering the mechanism of lightning, its impact on the environment, and how to reduce the risk, complete with relevant illustrations and case studies. With this understanding, students not only learn physics theory, but can also apply this knowledge in everyday life, while increasing awareness of the importance of protecting the environment. This book also aims to enrich learning resources that can be accessed by teachers and students, and integrate environmental literacy into science learning. Through this approach, it is hoped that students' science and environmental literacy will increase, preparing them to become a generation that cares and is responsible for preserving nature.

METHOD

This research and development (R&D) uses the ADDIE model which consists of five stage namely analysis, design, development, implementation, and evaluation [37]. Each stage in the ADDIE model will be evaluated, this aims to ensure that each stage is completed, improvements are made periodically from the first stage to the last stage [38]. *The analysis* stage aims to identify specific learning needs. This stage includes needs analysis, student analysis, as well as concept and material analysis. Product development needs analysis is an important thing to do to ensure that the product being developed meets user needs. At this stage, interviews were conducted with physics teachers and questionnaires were distributed to student in SMAN 5 Jambi City, SMAN 10 Jambi City and SMAN 11 Jambi City are related with the curriculum and teaching materials used, learning systems, learning models and their impact on students' scientific literacy and environmental literacy.

Analysis on student was carried out by distributing scientific literacy and environmental literacy

questionnaires to high school students. The scientific literacy questionnaire is in accordance with scientific literacy indicators, namely scientific knowledge, investigation of the nature of science, science as a way of thinking, and interactions between science, technology and society. Meanwhile, the environmental literacy questionnaire is in accordance with environmental literacy indicators, namely caring for the environment, awareness of the environment, providing solutions to environmental problems, taking real action towards the environment, protecting the environment and preserving the environment. Concept and material analysis was carried out by first examining the curriculum that applies in the three high schools. Based on the CP (Capaian Pembelajaran/ Learning Outcomes) and TP (Tujuan Pembelajaran/ Learning Objectives) analysis in the independent curriculum physics learning and the lightning phenomenon as the theme of the enrichment book, the material taken as integration in the book is changes in the state of matter, sound waves and light waves, temperature, static electricity and frictional forces. The five physics materials chosen are a distribution of physics materials from classes X, XI and XII.

The design stage is intended to design effective learning structures and strategies. This stage produces a format or framework for a knowledge enrichment book that is developed. The framework shows a general overview of the presentation content of the enrichment book and the components contained in the book being developed. The *development* stage aims to produce enrichment books based on designs that have been designed and adapted to the curriculum, CP (Capaian Pembelajaran/ Learning Outcomes) and TP (Tujuan Pembelajaran/ Learning Objectives) as well as appropriate physics learning materials. as well as evaluating the validity of the product, thereby producing a revised product I. This stage also aims to carry out trials by teachers and students who produce product II. The *implementation* stage aims to implement the learning program for students in accordance with the plans that have been made.

The evaluation stage aims to assess the overall effectiveness of the learning program. Evaluation is carried out both formatively during each stage of the process for immediate improvement, and summatively after implementation to assess the achievement of learning objectives. Data is collected through questionnaires to measure learning outcomes and impacts. The aim of this stage is to identify areas that need improvement and provide feedback for continuous improvement, so that the learning program can continue to be improved and adapted to the needs of students.

The research subjects at the analysis stage were 2 physics teachers, 46 students at SMAN 5 Jambi City, 84 students at SMAN 10 Jambi City, and 164 students at SMAN 11 Jambi City. The research subjects at the development stage consisted of 5 validators, namely FMIPA UNP physics lecturers to determine product validity. The research subjects at the implementation stage, namely the practicality test, were 2 physics teachers and 62 students at SMAN 11 Jambi City.

The research instrument at the analysis stage used interview sheets and questionnaires. The instrument at the development stage was tested for validity using an expert validation questionnaire instrument. The instrument at the implementation stage uses a teacher and student practicality test questionnaire. The interview data analysis technique was carried out qualitatively. The results of teacher interviews conducted at this analysis stage will be concluded to determine problems in the learning process that occur at school. The practicality of enrichment book products and instruments were assessed for their suitability before being used in trials by experts in an FGD (Focus Group Discussion). The assessment results via a validity questionnaire use the Aiken 's V formula which is calculated using Equation 1.

$$V = \frac{\sum s}{[n(c-1)]} \quad (1)$$

With $s = r - I_0$

Information:
I_0 = Lowest validity assessment number (1)
c = Highest validity assessment number (5)
r = Number given by the validator
n = Number of validators (5)

The range of Aiken V calculation results uses a scale of 1 to 5 with 5 validators, so the coefficient is set at 0.80 [39]. If the value obtained is ≥ 0.80, it can be concluded that the enrichment book is valid. Furthermore, data on practicality results were obtained from the assessments of class XI teachers and students to assess the practicality of the enrichment books developed through questionnaires. The percentage value of the practicality of the enrichment book is obtained using Equation 2.

$$P = \frac{f}{n} x\ 100\% \quad (2)$$

P = Final Value
f = Score Acquisition
n = Maximum Score (5)

The practicality categories of enrichment books based on equations can be seen in Table 1.

Table 1. Product practicality category

Percentage (%)	Category
0 - 20	No Practical
21 - 40	Not enough Practical
41 - 60	Enough Practical
61 - 80	Practical
81 - 100	Very Practical

RESULTS AND DISCUSSIONS

Based on the results of research, a book has been developed to enrich knowledge of lightning physics to increase students' scientific literacy and literacy. Based on the stages of the ADDIE development model, at the analysis stage observations, interviews and analysis of product development needs were carried out to ensure that Products will be developed according to user needs. Analysis activities were carried out at SMAN 5, SMAN 11, and SMAN 11 in Jambi City. Specifically, needs analysis consists of analysis of students' needs, analysis of scientific literacy and environmental literacy abilities, and material analysis. The results of the analysis of student needs are presented in Figure 1.

Figure 1 shows data from three high schools related to the use and need for books in physics learning. This graph consists of five categories that measure various aspects of the use of physics books by students in each school. First, regarding the use of printed books in the physics learning process, the percentage of students who use them is quite high in the three schools. SMAN 5 has a percentage of 87%, SMAN 10 is 89%, and SMAN 11 is 91%. This shows that the majority of students in these three schools still rely on printed books as the main source for learning physics.

Second, in terms of the adequacy of handbooks as learning resources, there was a decrease in the percentage at SMAN 5 (83%) and SMAN 10 (81%), while SMAN 11 showed an increase of up to 93%. This data indicates that students at SMAN 11 feel that their handbook is more adequate than students at SMAN 5 and SMAN 10. Third, related to students' knowledge of physics enrichment books, SMAN 5 and SMAN 10 show the same percentage of 87%, while at SMAN 11 has a lower percentage, namely 83%. This shows that the majority of students in the three schools are not aware of the existence of enrichment books for physics.

Fourth, students' desire to try learning using the "lightning" physics knowledge enrichment book is very high in all three schools. SMAN 5 has a percentage of 95%, SMAN 10 is 97%, and SMAN 11 is 89%. This high percentage shows students' enthusiasm for using additional learning materials that may offer a different or deeper approach to physics learning. Fifth, regarding students' need for teaching materials that can be used to complement and broaden their insight in studying physics concepts in natural phenomena, all schools show a very high percentage. SMAN 5 has a percentage of 95%, SMAN 10 is 97%, and SMAN 11 is 98%. This data indicates a strong need from students for more comprehensive additional material to support their learning in understanding physical phenomena in nature. One of the effective supporting teaching materials in learning physics is enrichment books [40].

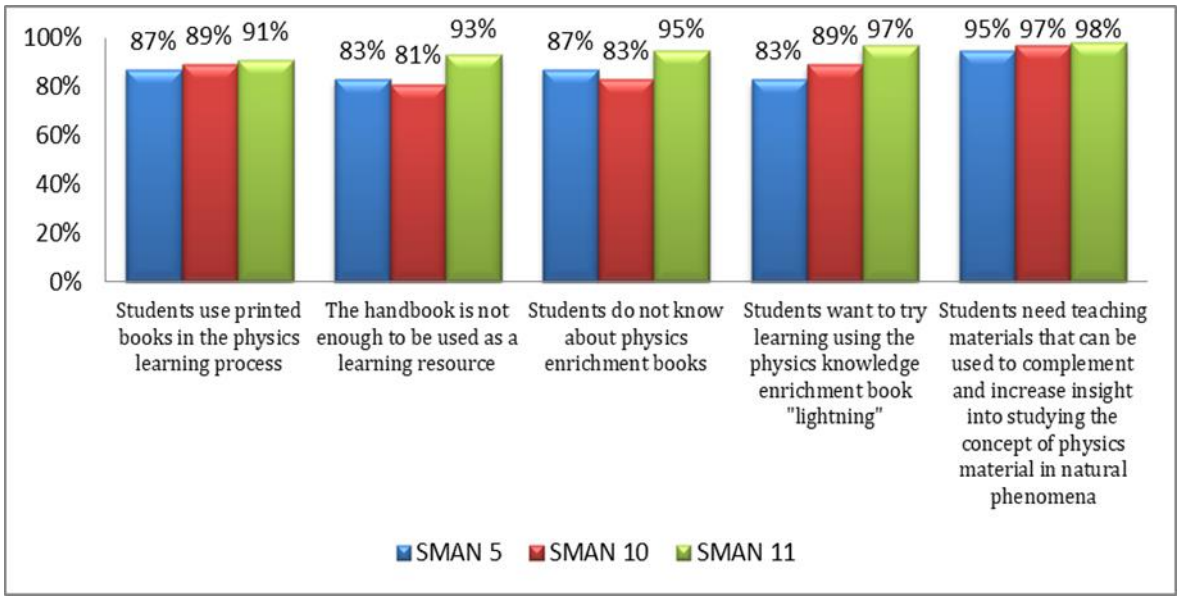


Fig 1. *Results of Student Needs Analysis*

Based on the results of the analysis of student needs, it is known that scientific literacy and environmental literacy skills are not optimal simultaneously. Although on average students have high environmental literacy skills, their scientific literacy is relatively low. This is a question for researchers, why students who have high environmental literacy do not improve their scientific literacy skills. In fact, sans literacy and environmental literacy have a positive correlation, which means that if environmental literacy increases, scientific literacy also increases [41]. The results of the analysis of student needs are presented in Figure 2.

Figure 2 shows a comparison between environmental literacy and scientific literacy in three different high schools. At SMAN 5, the level of environmental literacy reached 82%, higher than scientific literacy which only reached 58%. This shows that students at SMAN 5 are more aware of environmental issues compared to their understanding of science in general. Furthermore, at SMAN 10, the environmental literacy level is slightly lower, namely 79%, while scientific literacy is higher than at SMAN 5, reaching 69%. This comparison shows that there are differences in interest or emphasis in the curriculum or school activities that may be more supportive of science education at SMAN 10. This highlights the need for better integration between these two fields in the educational curriculum [42].

At SMAN 11, the environmental literacy level remains at the same figure as at SMAN 10, namely 79%. However, scientific literacy at SMAN 11 is lower than at SMAN 10, namely 61%. This shows that although both schools have the same environmental awareness. there are differences in the level of science understanding between them. These differences can be caused by various factors, including

teaching approaches, available facilities, or students' interest in certain subjects [43]. These data provide an idea of how environmental and scientific literacy may vary between schools, although in general, environmental literacy appears to be more dominant in the three schools.

This graph highlights that across all three schools, environmental literacy is consistently higher than scientific literacy. This indicates a greater concern for environmental issues among students, or a school curriculum that places more emphasis on environmental education. Differences between levels of environmental and scientific literacy in individual schools may also reflect differences in teaching approaches or educational priorities. To improve the balance between environmental and scientific literacy, schools may need to consider integrating more science education in their curriculum. Thus, students can have a more comprehensive and balanced understanding of scientific and environmental issues that are relevant to their daily lives [44] [45] [46]. The results of the concept and material analysis show that students have a good average physics score. Some students achieve the KKM score and others exceed the KKM score. However, students do not have good scientific and environmental literacy skills, such as throwing rubbish in desk drawers, not turning off the toilet light after leaving, and not turning off the fan after learning is finished. Apart from that, students have not applied physics concepts well in everyday life, such as not wearing shoes with ridged soles when playing football so they often fall, and still have difficulty converting temperatures to the Kelvin scale at the UKS (Unit Kesehatan Sekolah/ School Health Unit) .

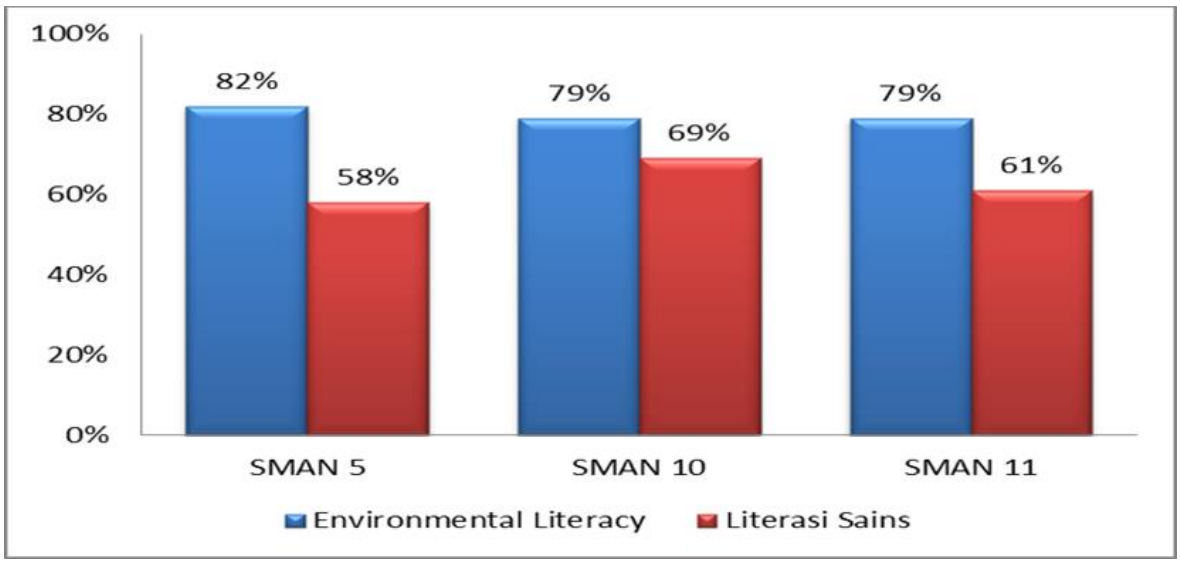


Fig 2. *Analysis Results Average scores of students' initial scientific literacy and environmental literacy abilities*

Stage design obtained in accordance with results analysis Which has done. The knowledge enrichment book that will be developed in this research is designed based on the format or framework of the knowledge enrichment book which results in *a draft* enrichment book. The general format or framework for the knowledge enrichment book developed for greater clarity can be seen in Table 2 and Table 3.

Table 2. Developed Enrichment Book Format

No	Format	Information
1	Cover	UNP and education logo The title of the devotional book Educational level Writer University name Images related to the material

No	Format	Information
2	Foreword	Contains information about the role of books to enrich physics knowledge in the learning process
3	List of contents	Contains the outline of the enrichment book
4	list of Figures	Loading list of enrichment book images
5	List of Tables	Loads a list of enrichment book tables
6	Instructions for Using the Book	Contains the icons contained in the book and their explanations
7	Material Description	Chapter 1 Introduction) CHAPTER 2 (Clouds) CHAPTER 3 (Lightning) CHAPTER 4 (Lightning Rod) CHAPTER 5 (The Biggest Lightning Incident) CHAPTER 6 (Impact and Prevention of Lightning) CHAPTER 7 (Closing)
8	Glossary	Contains an explanation of the meaning of each term, difficult and unfamiliar words used and arranged in alphabetical order
9	Bibliography	All references/libraries used as references when compiling the book.

Table 3. Developed Enrichment Book Framework

No	Enrichment Book	Book Features	Scientific Literacy Indicators	Environmental Literacy Indicators
1	Cover	-	Science knowledge	Environmental awareness
2	Foreword	-	Science knowledge	Environmental awareness
3	List of contents	-	Science knowledge	Environmental awareness
4	list of Figures	-	Science knowledge	Environmental awareness
5	List of Tables	-	Science knowledge	Environmental awareness
6	Instructions for Using the Book	-	Science knowledge	Environmental awareness
7	Material Description CHAPTER 1- CHAPTER 7	Material Map	Science knowledge	Environmental awareness
		Learning objectives	1. Science knowledge	1. Care about the environment 2. Environmental awareness
		Related verses of the Qur'an	1. Science knowledge 2. Science as a way of thinking	1. Care about the environment 2. Environmental awareness 3. Providing solutions to environmental problems
		Small Info	An inquiry into the nature of science	Real action towards the environment
		Scientific Literacy	1. Science knowledge 2. An inquiry into the nature of science 3. Science as a way of thinking 4. Interaction between science, technology and society	-
		Environmental Literacy		1. Care about the environment 2. Environmental

No	Enrichment Book	Book Features	Scientific Literacy Indicators	Environmental Literacy Indicators
			-	awareness 3. Providing solutions to environmental problems 4. Real action towards the environment 5. Protecting the environment 6. Preserving the environment
		Check your scientific literacy skills	1. Science knowledge 2. An inquiry into the nature of science 3. Science as a way of thinking 4. Interaction between science, technology and society	-
		Check your environmental literacy skills	-	1. Care about the environment 2. Environmental awareness 3. Providing solutions to environmental problems 4. Real action towards the environment 5. Protecting the environment 6. Preserving the environment
	Material Description CHAPTER 1-CHAPTER 7	Physics Here	1. Science knowledge 2. An inquiry into the nature of science 3. Science as a way of thinking	Real action towards the environment
		Essence	Science knowledge	Environmental awareness
8	Glossary	-	Science knowledge	Environmental awareness
9	Bibliography	-	Science knowledge	Environmental awareness

The development stage involves making a book and validating it by experts to find out whether the product being developed is suitable or not suitable for use. The general design of the enrichment book which has been validated and has been revised based on the validator's assessment and suggestions can be seen in Figure 3, Figure 4, Figure 5, Figure 6, Figure 7, Figure 8, Figure 9, Figure 10, Figure 11, Figure 12, Figure 13, Figure 14, Figure 15, Figure 16, and Figure 17.

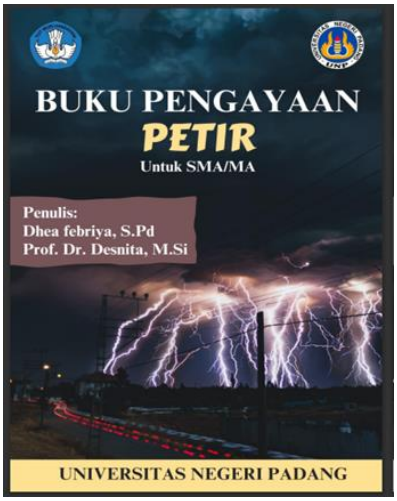


Fig 3. *Front Cover of the Enrichment Book*

Fig 4. *Back Cover of the Enrichment Book*

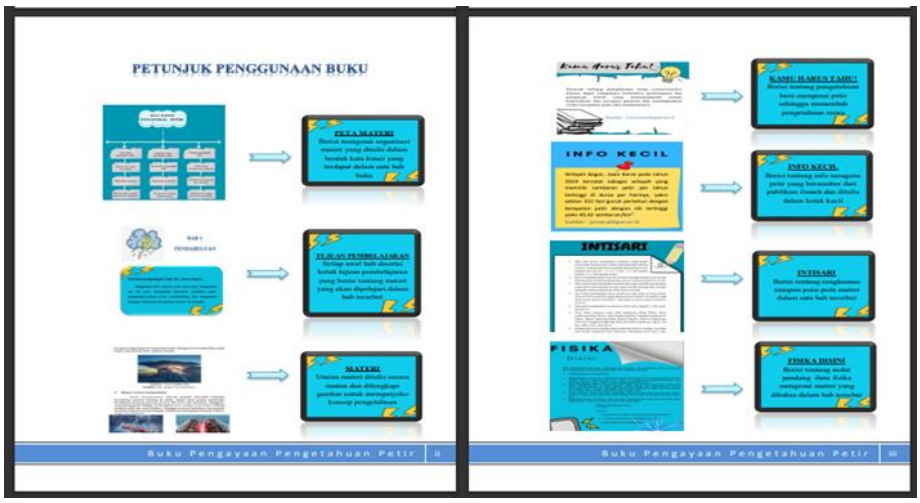


Fig 5. *Instructions for Using Enrichment Books*

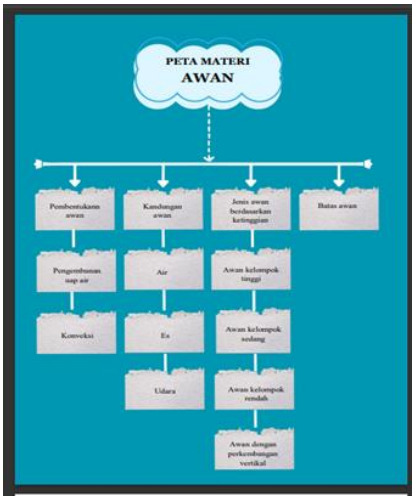


Fig 6. *Enrichment Book Concept Map*


potensial listrik, cuaca ekstrem, ketidakseimbangan muatan di bumi dan pola geografis (Rakov & Uman, 2003).

Q.S. Al-Baqarah [2] ayat 19

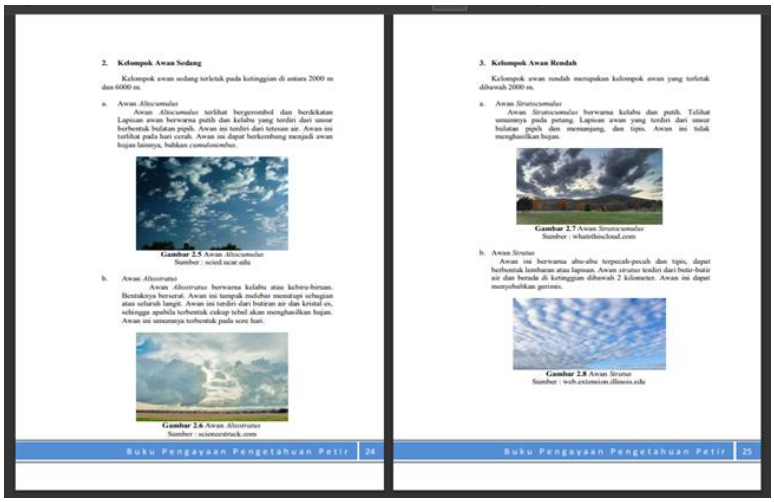
أَوْ كَصَيِّبٍ مِّنَ السَّمَاءِ فِيهِ ظُلُمَاتٌ وَرَعْدٌ وَبَرْقٌ يَجْعَلُونَ أَصَابِعَهُمْ فِي آذَانِهِم مِّنَ الصَّوَاعِقِ حَذَرَ الْمَوْتِ ۚ وَاللَّهُ مُحِيطٌ بِالْكَافِرِينَ

Artinya: Atau seperti (orang yang ditimpa) hujan lebat dari langit, yang disertai kegelapan, **guruh**, dan **kilat**. Mereka menyumbat telinga dengan jari-jarinya, menghindari suara **petir** itu karena takut mati. Dan Allah meliputi orang-orang yang kafir.

Dahulu ada dua orang munafik dari kalangan penduduk Madinah yang kabur dari Rasulullah menuju orang-orang musyrik, lalu kedua orang itu ditimpa hujan lebat disertai **guruh** yang kuras, **petir**, **kilat** dan diantara mereka mendengar suaranya disertai ketakutan hingga sampai menutup telinganya dengan jarinya. Akibat dari ketakutan tadi akhirnya mereka menghadap kepada Rasulullah untuk dibuat komudian mereka menyatakan masuk islam. Kala itu kebiasaan orang munafik tatkala mereka menghadiri majelis Nabi, mereka selalu menutup telinganya dengan jari dikarenakan mereka takut akan sabda-sabda yang disampaikan oleh Nabi tentang hal yang menyangkut dengan perkara orang munafik. Mereka hanya takut mati, namun tidak takut kepada Allah dan Rasulullah.

Buku Pengayaan Pengetahuan Petir 7

Fig 7. *Al-Qur'an verses in the Enrichment Book*


2. Kelompok Awan Sedang

Kelompok awan sedang terletak pada ketinggian di antara 2000 m dan 6000 m.

a. Awan *Altocumulus*

Awan *Altocumulus* terlihat bergerombol dan berdekatan. Lapisan awan berwarna putih dan kelabu yang terdiri dari unsur berbentuk bulatan pipih. Awan ini terdiri dari tetesan air. Awan ini terlihat pada hari cerah. Awan ini dapat berkembang menjadi awan hujan lainnya, bahkan *cumulonimbus*.

Gambar 2.5 Awan *Altocumulus*
Sumber : nciesd.ucar.edu

b. Awan *Altostratus*

Awan *Altostratus* berwarna kelabu atau kebiru-biruan. Bentuknya berserat. Awan ini tampak melebar menutupi sebagian atau seluruh langit. Awan ini terdiri dari butiran air dan kristal es, sehingga apabila terbentuk cukup tebal akan menghasilkan hujan. Awan ini umumnya terbentuk pada sore hari.

Gambar 2.6 Awan *Altostratus*
Sumber : sciencestruck.com

Buku Pengayaan Pengetahuan Petir 24

3. Kelompok Awan Rendah

Kelompok awan rendah merupakan kelompok awan yang terletak dibawah 2000 m.

a. Awan *Stratocumulus*

Awan *Stratocumulus* berwarna kelabu dan putih. Telihat umumnya pada petang. Lapisan awan yang terdiri dari unsur bulatan pipih dan memanjang, dan tipis. Awan ini tidak menghasilkan hujan.

Gambar 2.7 Awan *Stratocumulus*
Sumber : whatsthecloud.com

b. Awan *Stratus*

Awan ini berwarna abu-abu terpecah-pecah dan tipis, dapat berbentuk lembaran atau lapisan. Awan stratus tendiri dari butir-butir air dan berada di ketinggian dibawah 2 kilometer. Awan ini dapat menyebabkan gerimis.

Gambar 2.8 Awan *Stratus*
Sumber : web.extension.illinois.edu

Buku Pengayaan Pengetahuan Petir 25

Fig 8. *Description of Enrichment Book Material*

Fig 9. *Scientific Literacy Enrichment Book*

Fig 10. *Environmental Literacy Enrichment Book*

Fig 11. *Physics Here on Enrichment Books*

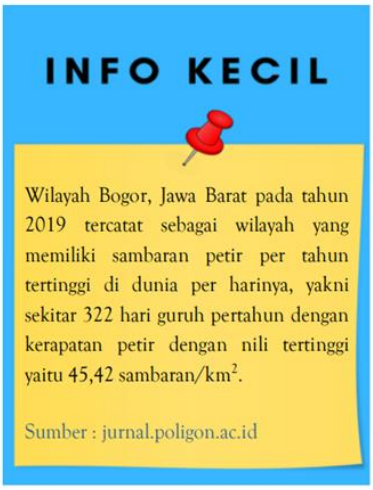


Fig 12. *Small Info Enrichment Book*

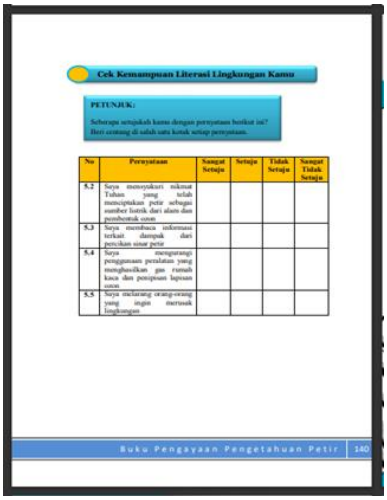


Fig 13. *Check your Environmental Literacy Ability on the Enrichment Book*

Fig 14. *Check your Science Literacy Ability on Enrichment Book*

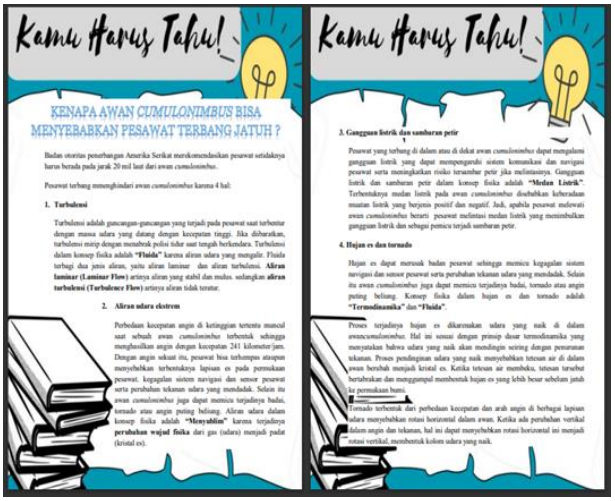


Fig 15. *You Should Know on Enrichment Book*

Fig 16. *Digest Enrichment Book*

Fig 17. *References Enrichment Book*

Figures 3 and 4 are the front and back covers of the enrichment book being developed. The front cover of the enrichment book contains the UNP logo, education logo, title of the enrichment book, level of

education, author's name, image related to the title, and name university. Meanwhile, the back cover of the enrichment book contains a summary in the form of questions from the contents of the book and the same pictures as the front cover and adds the closing sentence "Happy Reading" so that readers are interested in knowing the contents of the book. Figure 5 is an instruction for using the book which consists of book components and an explanation box marked with arrows to make it easier for readers. This section is the most important thing to read before reading the enrichment book, so that readers can easily understand it well.

Figure 8 is a description of the material which contains facts, knowledge, concepts and principles regarding competence according to the book chapter title. In this section there are also several pictures to make it easier for students to understand the material. Figure 9 is a scientific literacy box which presents the application of the concept of lightning in physics, written in a blue box accompanied by physics formulas. Meanwhile, Figure 10 is an environmental literacy box which presents the application of the concept of lightning in the environment, written in a green box accompanied by pictures about environmental literacy to make it interesting to read. Figure 11 is physics here which contains physics material related to the chapter discussed. Physics material. described in this chapter include, among other things, sound energy and light energy, physical changes, sound waves and light waves, temperature, static electricity, and frictional forces.

Figure 12 is a small info that presents important and brief information contained in each chapter. Small information is designed in the box and placed on the right or left side of the material description. Small information is taken from accurate sources in the form of national and accredited articles. Figure 13 is a check of scientific literacy skills which is a written assessment as checking material for students and teachers to find out the extent of mastery of scientific literacy that students have achieved as a basis for carrying out subsequent activities. Physics questions are made in the form of essay questions in the form of events related to the chapter being discussed and quoted from reputable journals with indicators of scientific literacy. Students are trained to read texts, analyze images, and interpret. Figure 14 is a check of environmental literacy skills which is a written assessment as checking material for students and teachers to find out the extent of mastery of environmental literacy that students have achieved as a basis for carrying out subsequent activities. The questions are made in the form of a questionnaire with indicators of environmental literacy in the form of responsible attitudes and behavior.

Figure 15 is a box you should know, where this section is unique information related to lightning facts circulating in society, so that by reading this section students are able to explain the phenomenon of lightning facts from a physical science perspective. The titles presented in each chapter are also different, including, You Must Know: Why does the sound of thunder appear after a flash of lightning? , You Must Know: Why Can *Cumulonimbus* Clouds Cause Airplanes to Crash?, You Must Know: Why Does Lightning Shape a Zig-Zag?, You Must Know: Who First Invented the Lightning Rod?, You Must Know: Why Does Lightning Strike Humans?, and You Need to Know: Is it Dangerous to Play Cell Phones During Lightning? Figure 16 is the essence of the enrichment book which is a summary of the reading content in the material description of the enrichment book which was developed with an effort to minimize the content and take several important points to make it easier for readers to more quickly understand the meaning of the material description. Figure 17 is a reference for an enrichment book which contains all the sources used as a reference in preparing a book to enrich physics knowledge. References used in preparing enrichment books consist of books, international journals, national journals, news about lightning on internet pages. The bibliography is arranged in alphabetical order.

Assessment of the physics knowledge enrichment book "lightning" to increase scientific literacy and environmental literacy of high school students assessed using validated instruments. Instrument validation Which used consists from aspect material, language , presentation and graphics [47]. Before the product validity assessment was carried out, the instrument in the form of a questionnaire was used to test the validity of this research. The validity test of the research instrument was first

carried out by three validators, both the validity and practicality of the instruments used. So a questionnaire instrument to assess the validity and practicality of this enrichment book can be used in research. The results of product validation are: the physics knowledge enrichment book "lightning" to increase high school students' scientific literacy and environmental literacy is valid. On the validity questionnaire sheet, there are several components or assessment indicators which can be seen in Table 4.

Table 4. Components of Enrichment Book Validity Assessment

No	Component	Indicator
1	Material	The material in the "Lightning Physics Knowledge Enrichment Book" supports the achievement of national education goals Material Accuracy Accuracy of Material Recency of Material The material is contextual The material maximizes the use of sources that are appropriate to Indonesian conditions and closely related to the Indonesian context The material does not cause racial discrimination or gender discrimination The material presented is beneficial for students Physics material is presented with appropriate readability
2	Language	The language used is effective The language used does not have double meaning The terms used are standard
3	Presentation	Presentation of material is coherent, straightforward and easy to understand The presentation of material increases scientific literacy and environmental literacy The presentation of material develops knowledge and fosters motivation to think further The presentation of material develops skills and motivates creativity and innovation Presentation of a complete description of the material and according to the theme Enrichment book illustration Enrichment book data Attractiveness of presentation Uniqueness of presentation Enrichment book summary Enrichment book reference
4	Graphics	Color Set Layout Proportions and Sizes

The results of the validity assessment of the enrichment book which were assessed by 3 expert validators were obtained, then analyzed using the Aiken's V equation. The results of the analysis of the validity of the enrichment book can be seen in Table 5.

Table 5. Validation Results of Physics Knowledge Enrichment Books by Experts

No	Aspect Which Rated	Mark Aiken'V	Criteria
1	Material	0.86	Valid
2	Language	0.91	Valid
3	Presentation	0.89	Valid
4	Graphics	0.94	Valid
Average		**0.88**	**Valid**

In Table 5, the book has been validated by experts and shows valid results in all aspects assessed, namely material, language, presentation and graphics. The Aiken's V scores for each aspect are quite high, with an average of 0.88, indicating that the book is considered valid as a whole. This validation indicates that this enrichment book meets quality standards in terms of content and presentation,

making it a suitable resource for use in learning.

After carrying out the validity test and the process of revising the enrichment book, in accordance with suggestions and comments from the validator, the next stage can be carried out, namely the implementation stage. At this stage, the physics enrichment book that has been developed will be implemented in class XI at SMAN 11 Jambi City in the first semester. In the implementation process, teachers and students will use this physics enrichment book in the learning process. After using it, teachers and students will assess the practicality of using the physics enrichment book through a practicality questionnaire. There are several components or practicality indicators used on the practicality questionnaire sheet, these components can be seen in Table 6.

Table 6. Components of Enrichment Book Practicality Assessment

No	Component	Indicator
1	Ease of Use	- Easy for students to use - Instructions for using the enrichment book are easy to understand - The contents of the enrichment book used are easy to understand - The language used is easy to understand - The letters used are easy to read
2	Learning Effectiveness	- Enrichment material content - Time
3	Benefit	- Expanding students' horizons for independent learning - Helping students to understand knowledge about lightning - Helping students to understand the physics concepts of lightning - Motivate students to carry out disaster mitigation - The "Small Info" box helps improve students' memory skills - The "You Should Know!" helps improve students' curiosity abilities - Enrichment books increase students' scientific literacy - Enrichment books increase students' environmental literacy

The results of the enrichment book practicality test assessment obtained by teachers and students were then analyzed and calculated in the form of a percentage. The results of the practicality test of the enrichment book can be seen in Table 7 and Table 8.

Table 7. The practical results of the enrichment book are based on the teacher's response

No	Aspect Which Rated	Mark (%)	Criteria
1	Convenience Use	91.25	Very Practical
2	Learning Effectiveness	93.33	Very Practical
3	Benefit	93.33	Very Practical
	Average	**92.63**	**Very Practical**

Table 7 shows the results of the practicality of enrichment books based on responses from teachers, which include aspects of ease of use, learning effectiveness, and benefits. The practicality value of all aspects was assessed as very high, with an average of 92.63 %, which was categorized as "very practical." This shows that teachers feel this book is easy to use, effective in helping the learning process, and provides significant benefits for students. This very positive assessment confirms that the book can be used effectively in an educational setting.

Table 8. The Practical Results of the Enrichment Book are based on student responses

No	Component Practicality	Mark (%)	Criteria
1	Convenience Use	80.61	Very Practical
2	Learning Effectiveness	76.67	Practical
3	Benefit	80.75	Very Practical
	Average	**79.35**	**Practical**

Table 8 displays the results of the practicality of enrichment books based on responses from students. Even though the results are slightly lower than the teacher's assessment, this book is still considered very practical. The average value obtained was 79.35 %, which was categorized as "practical." Students rated the ease of use and usefulness of the book as "very practical," but learning effectiveness was rated slightly lower, with the category "practical." This difference may reflect differences in perceptions between students and teachers regarding how the book helps the learning process.

Overall, this physics knowledge enrichment book received a very positive response from experts, teachers and students. High validity from experts shows that this book has good content quality, while practicality assessments from teachers and students show that this book can be used easily and effectively in learning. Although there are slight differences in practicality ratings between teachers and students, this does not detract from the overall quality of the book. In addition, differences in practicality assessments between teachers and students can be a basis for further improvement. For example, if students feel that the effectiveness of learning can still be improved, then the book author can evaluate and improve the method of delivering the material or provide more relevant examples for students. Feedback from end users, such as teachers and students, is very important in the process of developing learning materials to better suit user needs and expectations. In conclusion, this physics knowledge enrichment book has very good quality in terms of validity and practicality. The validation results and practicality assessment show that this book is suitable for use in physics learning.

The final stage in the ADDIE development model is the evaluation stage. This stage takes place from the analysis stage to the implementation stage. After each stage is carried out, until revisions are carried out according to input from expert validators, it can be concluded that the lightning physics knowledge enrichment book can be used by teachers and students in the physics learning process and can facilitate increasing students' scientific literacy and environmental literacy. The results of this research are in line with research by Putri & Fauzi [48] that the use of physics e-books integrated with lightning disaster material based on Discovery Learning is an effective teaching material used to improve students' attitudes, knowledge and skills in the physics learning process.

The use of physics learning tools integrated with scientific literacy e-books can be stated to be very valid in learning dynamic material [49]. Apart from that, the use of physics teaching materials on heat and gas kinetic theory integrating new literacy and disaster literacy for class XI SMA is valid and practical for use in physics learning [50]. Application of physics enrichment books in the learning process provides an increase in students' scientific literacy and environmental literacy [51] [52]. Related research also explains that the textbooks in circulation do not yet contain aspects of science literacy in a balanced manner, only integrating one aspect, namely science knowledge [53]. Therefore, developing enrichment books by integrating two literacies is the right solution to do.

CONCLUSION AND SUGGESTION

Based on the results and discussion, it can be concluded that the Lightning Physics Knowledge Enrichment Book developed in this research is proven to be valid and practical for use in learning as a solution to increase the scientific literacy and environmental literacy of high school students. The validity of the enrichment book was tested through a series of evaluations by education and physics experts, who stated that the book's content was accurate, in accordance with the curriculum, and able to explain lightning physics concepts clearly and comprehensively. The practicality of this book was also measured through a trial in one of the schools, involving teachers and high school students as the main users. The trial results show that this book is easy to use and prepares students to have better knowledge of science and care for the environment, as well as supporting learning activities in the classroom. Teachers involved in the trial also provided positive feedback, stating that the book helped them convey complex material in a way that was more interesting and easy for students to understand.

ACKNOWLEDGMENTS

The autors would like to Thank Lembaga Penelitian dan Pengabdian Masyarakat Universitas Negeri Padang for funding this work with a contract number : 1692/UN35.15/LT/2024.

REFERENCES

[1] Yasmansyah, Y. (2022). Konsep merdeka belajar kurikulum merdeka. *Jurnal Penelitian Ilmu Pendidikan Indonesia*, *1*(1), 29-34.
[2] Syazali, M., & Putra, G. P. (2023). Pengembangan Asesmen Literasi Sains Berbasis PISA untuk Siswa Sekolah Dasar. *BADA'A: Jurnal Ilmiah Pendidikan Dasar*, *5*(2), 240-250.
[3] Henukh, A., Simbolon, M., Astra, I. M., & Rosdianto, H. (2021). Analysis of Students' Science Literacy Ability on Heat Concept. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *6*(2), 178-184.
[4] Irmawanty, I. (2022). Hubungan Kecerdasan Naturalis Dengan Literasi Lingkungan Siswa Kelas XI SMAN 5 Barru. *Hybrid: Jurnal Pendidikan dan Pembelajaran Sains*, *1*(2), 19-28.
[5] Putra, D. J., Simbolon, M., & Ekasari, A. (2023). Analysis of Scientific Literacy Ability of Students of The Physics Education Study Program at Musamus University. *Technium Social Sciences Journal*, *49*, 417-422.
[6] Suárez-Mesa, A. M., & Gómez, R. L. (2024). Does teachers' motivation have an impact on students' scientific literacy and motivation? An empirical study in Colombia with data from PISA 2015. *Large-scale Assessments in Education*, *12*(1), 1.
[7] Chaerunisa, R., & Mariningsih, P. (2023). Pengembangan E-Modul Pembuatan Pupuk Organik Cair (POC) Berbasis SETS (Science, Environment, Technology, Society) untuk Meningkatkan Literasi Lingkungan Pada Konsep Perubahan Lingkungan Kelas X SMA. *Pedagogi Biologi*, *1*(02), 94-107.
[8] Elhai, J. (2023). Science literacy: a more fundamental meaning. *Journal of Microbiology & Biology Education*, *24*(1), e00212-22.
[9] Niemi, K. (2021). 'The best guess for the future?'Teachers' adaptation to open and flexible learning environments in Finland. *Education Inquiry*, *12*(3), 282-300.
[10] Svobodová, S., & Kroufek, R. (2022). Environmental literacy of ISCED 2 pupils in the Czech Republic and Slovakia. *European Journal of Science and Mathematics Education*, *10*(4), 519-528.
[11] Angreani, A., Saefudin, S., & Solihat, R. (2022). Virtual laboratory based online learning: Improving environmental literacy in high school students. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *8*(1), 10-21.
[12] Sutrisna, N. (2021). Analisis kemampuan literasi sains peserta didik SMA di Kota Sungai Penuh. *Jurnal inovasi penelitian*, *1*(12), 2683-2694.
[13] Alivernini, F., & Manganelli, S. (2015). Country, school and students factors associated with extreme levels of science literacy across 25 countries. *International Journal of Science Education*, *37*(12), 1992-2012.
[14] *PISA 2022 Assessment and Analytical Framework | OECD*. (n.d.). Retrieved September 10, 2024, from https://www.oecd.org/en/publications/pisa-2022-assessment-and-analytical-framework_dfe0bf9c-en.html
[15] Kemendikbudristek. (2023). *PISA 2022 dan Pemulihan Pembelajaran di Indonesia*.
[16] Nurhasanah, N., Jumadi, J., Herliandry, L. D., Zahra, M., & Suban, M. E. (2020). Perkembangan penelitian literasi sains dalam pembelajaran fisika di Indonesia. *Edusains*, *12*(1), 38-46.
[17] Sulaihah, S., Mulia, M., Widodo, W., Sukarmin, S., & Dalee, A. D. (2024). Enhancing Scientific

Literacy Through Guided Discovery with SELWAN Application in Science Learning. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, *12*(1), 205-215.

[18] Özkan, U. B. (2021, May). Interest in Environmental Issues as a Determinant of Science Literacy: A Multinational Review with Artificial Neural Network Analysis. In *FIRE: Forum for International Research in Education* (Vol. 7, No. 1, pp. 115-131).

[19] Nunez, M. B., & Clores, M. A. (2017). Environmental Literacy of K-10 Student Completers. *International journal of environmental and Science education*, *12*(5), 1195-1215.

[20] Schulze, S., & Van Heerden, M. (2015). Learning environments matter: Identifying influences on the motivation to learn science. *South African Journal of Education*, *35*(2), 1-9.

[21] Aprilianti, A. N. M., & Suratsih, S. (2023). Pengaruh Implementasi Program Adiwiyata Terhadap Literasi Lingkungan Peserta Didik SMA Negeri 10 Yogyakarta. *Jurnal Edukasi Biologi*, *9*(1), 46-62.

[22] Astuti, D., & Aminatun, T. (2020). Student's environmental literacy based on Adiwiyata and non-Adiwiyata at senior high school in Sleman, Yogyakarta. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *6*(3), 375-382.

[23] Afrianda, R., Yolida, B., & Marpaung, R. R. T. (2019). Pengaruh program adiwiyata terhadap literasi lingkungan dan sikap peduli lingkungan. *Jurnal Bioterdidik: Wahana Ekspresi Ilmiah*, *7*(1), 32-42.

[24] *PISA for Development Assessment and Analytical Framework | OECD*. (n.d.). Retrieved September 10, 2024, from https://www.oecd.org/en/publications/pisa-for-development-assessment-and-analytical-framework_9789264305274-en.html

[25] Tuttle, M. J., Cejas, D., Kang, D., Muchaamba, F., Goncarovs, B., Ozakman, Y., ... & Orelle, A. (2023). Promoting science literacy and awareness across the globe: the role of scientists as science ambassadors. *Journal of Microbiology & Biology Education*, *24*(2), e00041-23.

[26] Siswanto, S., Karimullah, K., Prasetyawati, R., & Nurhayati, N. (2019). Environmental cultured education and its implication on the student's competencies in an Adiwiyata school. *Jurnal Cakrawala Pendidikan*, *38*(3), 552-564.

[27] Hermawan, I., Suwono, H., Paranit, A. A. I., & Wimuttipanya, J. (2022). Student's Environmental Literacy: An Educational Program Reflections for a Sustainable Environment. *Journal of Biological Education Indonesia (Jurnal Pendidikan Biologi Indonesia)*, *8*(1), 1-9.

[28] Sadoglu, G. P. (2018). Engineering Students' Opinions on Science Literacy. *Universal Journal of Educational Research*, *6*(8), 1819-1830.

[29] Febriya, D., & Desnita, D. (2024). Correlation Study Between Scientific Literacy And Environmental Literacy Of Jambi City High School Students In The Subject Of Physics. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *14*(1).

[30] Gunawan, T., & Pandiangan, L. N. L. (2014). Analisis Tingkat Kerawanan Bahaya Sambaran Petir dengan Metode Simple Additive Weighting di Provinsi Bali. *Jurnal Meteorologi dan Geofisika*, *15*(3), 193-201.

[31] Holle, R. L. (2008, April). Annual rates of lightning fatalities by country. In *20th International lightning detection conference* (Vol. 2425).

[32] Rakov, V. A., & Uman, M. A. (2003). *Lightning: physics and effects*. Cambridge university press.

[33] Harsono, B. B. S. D. A., Surya, A. S., Mangunkusumo, K. G. H., & Purnomoadi, A. P. (2021). Karakteristik Petir Indonesia Dan Penggunaannya Dalam Evaluasi Unjuk Kerja Saluran Udara 150 Kv Saat Terjadi Sambaran Petir. *Jurnal Technopreneur (JTech)*, *9*(1), 46-53.

[34] Yusliani, E., & Desnita. (2021, April). Mapping environmental curriculum in physics learning at senior high school grade X semester 2. In *Journal of Physics: Conference Series* (Vol. 1876, No. 1, p. 012040). IOP Publishing.

[35] Harsani, A. C., Desnita, D., Asrizal, A., & Darvina, Y. (2020). Kajian keterampilan proses sains

pada buku teks pelajaran fisika SMA kelas XII semester 1. *Pillar Of Physics Education*, *13*(1).

[36] Serevina, V., Lipikuni, H. F., & Maulana, D. (2023, September). Development of a tectonic earthquake knowledge enrichment digital book to improve students' critical thinking skill. In *Journal of Physics: Conference Series* (Vol. 2596, No. 1, p. 012059). IOP Publishing.

[37] Branch, R. M. (2009). *Instructional design: The ADDIE approach*. Springer Science & Business Media.

[38] Allen, M. (2012). The Successive Approximation Model (SAM). In *Trends and Issues in Instructional Design and Technology* (pp. 67-81). Routledge.

[39] Aiken, L. R. (1985). Three coefficients for analyzing the reliability and validity of ratings. *Educational and psychological measurement*, *45*(1), 131-142.

[40] Kamila, S. W., & Louise, I. S. Y. (2021, March). Development of story of atom enrichment book apply four steps teaching material development (4S TMD). In *Journal of Physics: Conference Series* (Vol. 1806, No. 1, p. 012202). IOP Publishing.

[41] Frøyland, M., Remmen, K. B., Mork, S. M., Ødegaard, M., & Christiansen, T. (2015). Researching science learning from students' view–the potential of headcam. *Nordic Studies in Science Education*, *11*(3), 249-267.

[42] Olsen, R. V. (2005). An exploration of cluster structure in scientific literacy in PISA: Evidence for a Nordic dimension?. *Nordic Studies in Science Education*, *1*(1), 81-94.

[43] Salchegger, S., Wallner-Paschon, C., & Bertsch, C. (2021). Explaining Waldorf students' high motivation but moderate achievement in science: is inquiry-based science education the key?. *Large-scale assessments in education*, *9*(1), 14.

[44] Loubser, C. P., Swanepoel, C. H., & Chacko, C. P. C. (2001). Concept formulation for environmental literacy. *South African Journal of Education*, *21*(4), 317-323.

[45] Puig i Baguer, J., & Maria y Casas Jerico. (2017). Environmental impact: an ethical awakening of interest for education. *Teoria de La Educacion*, *29*(1), 101-128.

[46] Swanepoel, C. H., Loubser, C. P., & Chacko, C. P. C. (2002). Measuring the environmental literacy of teachers. *South African Journal of Education*, *22*(4), 282-285.

[47] Hidayat, Z., & Sarmi, R. S. (2020, March). Validity of science student books with the theme of energy in life based integrated local materials using integrated models for 21st century learning. In *Journal of Physics: Conference Series* (Vol. 1481, No. 1, p. 012116). IOP Publishing.

[48] Putri, G. E., Ayu, F., & Fauzi, A. (2020). Validitas E-Book Fisika Terintegrasi Materi Bencana Petir Berbasis Model Discovery Learning. *Jurnal Eksakta Pendidikan (JEP)*, *4*(2), 163-170.

[49] Khoiriah, M., & Kholiq, A. (2020). Validitas perangkat pembelajaran fisika berbantuan e-book literasi sains pada materi fluida dinamis. *Inovasi Pendidikan Fisika*, *9*(1), 1-4.

[50] Fitri, H. R., Mufit, F., & Asrizal, A. (2020). Validitas dan praktikalitas bahan ajar fisika materi kalor dan teori kinetik gas mengintegrasikan literasi baru dan literasi bencana untuk kelas XI SMA. *Pillar of Physics Education*, *13*(1).

[51] Tran, H. U., LePage, B. A., & Fang, W. T. (2022). Environmental Literacy and Teaching Activities of Preschool Teachers in Vietnam. *European Journal of Educational Research*, *11*(4), 2356-2371.

[52] Yuniar, R. E., Suprapto, N., & Mubarok, H. (2020, March). Triggering students' scientific literacy through static fluid scrapbook. In *Journal of Physics: Conference Series* (Vol. 1491, No. 1, p. 012057). IOP Publishing.

[53] Sahriani, S., Samsudin, A., & Sinaga, P. (2021, November). Analysis of physics textbook reviewed from the aspects of scientific literacy in the Bandung city. In *Journal of Physics: Conference Series* (Vol. 2098, No. 1, p. 012005). IOP Publishing.