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The effectiveness of wetland environment static fluid e-module to train learners' science literacy

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Abstract

This study aims to produce an electronic module (e-module) of static fluid material in a wetland environment that is effectively used to train students' science literacy. This research is a type of development using the ADDIE *model (Analyze, Design, Develop, Implement, Evaluate). The trial* project was ten students of class XI senior high school. Data are obtained through learners' science literacy test instruments. The data are analyzed in descriptive qualitative and quantitative. The results of data analysis show that e-modules are effective because of the high n-gain of science literacy. It was concluded that the e-module developed was effectively used to train students' science literacy on static fluid materials in wetland environments. The novelty of this research lies in the material associated with the wetland environment to introduce science literacy. The implications of this study serve as a reference for teachers and students in improving science literacy skills.

Keywords: Electronic modules, physics learning, science literacy, static fluids, wetland environment;

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1. Introduction

1.1. Conceptual or theoretical framework

The development of man as a social being in society at this time depends on the nature of education. It is essential to know and master the methods and techniques of education. Experience has proven that deliberate and organized things are always more successful and produce the desired results in less time than without planning and designing the beginning and end (Ferdosipour & Safar, 2021). Education and technology are two things that cannot be separated in the 21st century. Education is centered on mastering superior knowledge, skills, and character skills to form a society ready to face the Asian Economic Community (AEC). This can be realized by improving education policies, developing teacher competencies, and using technology in the learning process. Along with the rapid development of technology, education may also be affected by these technological developments. The development of technology can be utilized in the world of education, namely preparing learning media that suits the needs of students, namely electronic modules, which are said to be E-modules (Maisaroh et al., 2020).

E-modules, also known as electronic modules, are systematically written books that are presented in electronic form to assist students in learning independently using a computer or electronic reader. E-modules are a good example of how technology is being used in education to support the teacher's learning process (Dwiyanti et al., 2021). One lesson that needs to be made in the form of an e-module for teaching materials is physics (Vitrianingsih et al., 2021).

Physics is part of Natural Science (IPA), a science that studies a symptom, event, or natural phenomenon. It reveals all the secrets and laws of the universe. Physics problems are often encountered daily (Vitrianingsih et al., 2021). Science has a critical role as a basic science supporting science and technology. In studying science, science literacy skills are needed. Science literacy is essential to master in life, requiring scientific information and methods of thinking to make decisions. Many people's interests must be informed and increase the capacity of learners to become novice workers who are ready to become a business society in the future. Other countries have invested substantially to create a scientifically and technologically *"literate*" work motivation. This is done to survive in the global market, as each country needs citizens with the same capabilities (Budiyanto et al., 2019). Science literacy is defined as the ability to use scientific knowledge to identify questions and draw conclusions based on evidence to comprehend and make decisions about nature and the changes that occur in nature as a result of human activity. (OECD, 2016).

Based on the results of the latest science literacy assessment conducted by *PISA (Programme for International Students Assessment)* in 2018, Indonesia occupies a position that is still very low compared to other Asian countries, which is in 71st place out of 79 participants. The science literacy score obtained by Indonesia is 396 (Wahab et al., 2021). *PISA's* focus in 2012, 2015, and 2018 was on the math, science, and learner reading skills, respectively. Indonesia is again getting results that are not encouraging. Indonesia achieved a score below the OECD (Organization for Economic Cooperation and Development) average, which was 371, 379, and 396, respectively, in reading, mathematics, and science, demonstrating the need for improvement in Indonesian students' ability to compete on a global scale (Zahid, 2020).

Factors causing the low level of science literacy of learners are several factors. First, learning activities involving science activities are still less and more focused on physics concepts and formulas. Second, the teaching materials used only contain subject matter and examples of problems with their completion while not requiring students to find learning concepts and solve the problems they face

(Deswita & Hufri, 2018). By mastering science literacy, it is hoped that students will have a high sensitivity to themselves and their environment in solving problems in everyday life and making decisions based on the knowledge of science that they have understood (Muzijah et al., 2020).

In science literacy, learning can be done with interactive, innovative, creative and fun methods. Teachers can apply science literacy in learning by utilizing the environment as a learning resource. Students are invited to make observations and simple science activities using the environment because students can interact directly and use the environment as a learning resource. The objectives of science literacy learning can be perfectly absorbed through simple learning and observation now in nature. Students can also identify questions, discover new knowledge, describe scientific occurrences, and draw conclusions in response to what they observe (Kristyowati & Purwanto, 2019).

Based on the results of interviews obtained from physics subject educators at SMAN 12 Banjarmasin, the teaching materials used by educators still use printed books and present teaching materials sourced from the internet, such as *Google* and *YouTube*. The textbooks that students use to learn physics are still uninteresting and stiff, both in writing and visually. The physics books used so far have also not been able to improve the knowledge and investigation of natural science, the oral and written vocabulary students need to understand science, and the relationship between science, technology, and society. In addition, educators have also not applied science literacy to the material provided to students. This makes students untrained with science literacy-based materials and questions.

This problem aims to develop unique teaching material in the form of an electronic module to hone students' science literacy skills. The module will also be combined with using electronic devices such as cell phones or laptops as access using media so that the use of cell phones is not only used to find learning information but also as a learning resource and train science literacy. Learning media that uses gadgets has the opportunity to assist in raising the standard of student performance as measured by learning outcomes. Learning media using Android allows learning not limited by time and place with exciting applications. Teaching materials that are felt to be able to help students and teachers in the learning process are electronic modules (Muzijah et al., 2020). In physics subjects, especially high school class XI, there is a topic of static fluid that can be related to wetland conditions in South Kalimantan. This will be more interesting and better when compared to providing problems of a textual nature in the book.

1.2. Relevant research

Previous research relevant to current research is (Mahardika et al., 2022), which illustrates how the effectiveness of electronic modules in enhancing student learning outcomes can be said. One of the factors that cause electronic modules to be practical is that the science literacy content presented is very relevant to life and current science issues. Hence, it affects students' learning outcomes or learning achievements. Research by (Himmah, 2019) explained that electronic modules made with professional PDF flip applications could be applied to the learning process in the classroom.

The results of (Nurdini et al., 2018) showed that the physics textbooks in circulation have an unbalanced aspect of science literacy. (Prastika et al., 2019) results obtained sufficient criteria for students' science literacy skills. And the results of (Riskawati et al., 2021), which shows an increase in science literacy skills, are still classified as moderate. From some of the results of this study, it can be concluded that the science literacy ability of students in Indonesia is still relatively low.

The research results by (Kristyowati & Purwanto, 2019) show that students' science literacy skills are increasing through the utilization of the environment as a resource for learning. Teaching materials suitable for teaching and learning activities associated with daily life that follow the environment around students, namely the wetland environment, are still unavailable in schools. Teaching materials that contain daily activities in a wetland environment are expected to help students understand the material they are studying and get to know the surrounding environment better (Aini et al., 2018). Research by (Anissa et al., 2020) states that learning devices charged with wetland environments are said to be valid and can be used for the learning process in the classroom.

1.3. Research objectives

Research on the development of electronic modules (e-module) to train students' science literacy is very important to do, given that science literacy is essential to master in life that requires scientific information and thinking to make decisions and interests of many people and increase the capacity of students to become novice workers who are ready to become a business society in the future. The ability of Indonesian students to compete at the global level still needs to be improved. Therefore, researchers aim to produce e-modules of static fluid matter in wetland environments that are effectively used to train learners' science literacy. The formulation of the problem to be studied is the effectiveness of the electronic module in introducing students' science literacy on static fluid materials in wetland environments based on the results of students' science literacy.

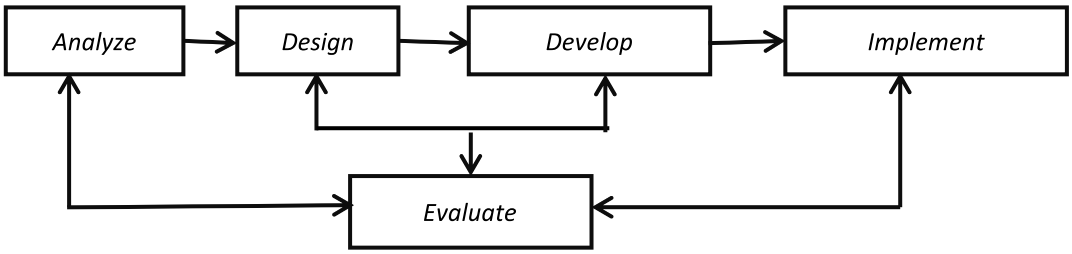
2. Research methods

2.1. Research model

This research is a research and development (R&D) with an ADDIE development model (Analyze, Design, Develop, Implement, and Evaluate). The reason for choosing this development model is that it is considered reasonably practical and able to solve complex learning problems. Here are the steps from the ADDIE development model used in this study:

Figure 1

Stages of the ADDIE model



(Tegeh et al., 2014)

2.2. Participants

The implementation of the electronic module as research data collection was carried out at SMA Negeri 12 Banjarmasin, which is located at Alalak Utara, North Banjarmasin District, Banjarmasin City, South Kalimantan, Indonesia. The sample used in this study consisted of 10 students of class XI senior high school. The development and trial of electronic module before the research performed was conducted at the Faculty of Teacher Training and Education, Lambung Mangkurat University, which was addressed at Banjarmasin City, South Kalimantan.

2.3. Data collection tools

The initial data was gathered through a survey and interviews with subject teachers using a list of interview questions. These questions were related to the characteristics of students, teacher attitudes, students' science literacy skills, the facilities used by teachers and students in learning at school, and the material used. The E module was designed beforehand so that it could be tested for validity and reliability using a validity test sheet. The validity test results were then reviewed by three experts in terms of three aspects: content, display, and science literacy. The results of the validity tests show that the electronic module developed is of very high category. After the electronic module had been tested for its validity and reliability from material and media experts, it can be inferred that the e-module is ready to be tested in schools.

Based on the reliability results, the electronic module had a high degree of reliability and was reliable in terms of content and construction. It means that the three validators' assessment results indicated a high level of trust in the electronic module developed. Furthermore, the e-module testing was created using science literacy test questions comprised of 8 essay-style questions. The science literacy indicators used in the questions were presenting facts and concepts in questions 1 and 2, presenting ideas in questions 3 and 4, showing laws in questions 5, 7, and 8, and presenting facts and rules in question 6.

2.4. Data collection process

The research procedure consisted of preparing interview questions for the subject's teacher, accompanied by permission to conduct research in the school. In addition, the researcher designed and built an electronic module with various features and questions to train science literacy until it was ready to be used in the learning process. The readily available modules were then hosted to create electronic modules with novelty value that can be accessed via smartphones and PCs of various types that can be used in the learning process. Following the application of electronic modules with a discovery learning model, as many as two meetings were held to obtain quantitative data on the results of student science literacy.

2.5. Data analysis

The trial design of this study compared the conditions before and after the use of a constructed electronic module (pretest-posttest).

Figure 2

Pre-test post-test design

$$O_1 \quad \times \quad O_2$$

Information:
O_1 = science literacy results before using the developed electronic module (*pre-test*)
O_2 = science literacy results after using the developed electronic module (*post-test*)
x = learning using electronic module

The effectiveness of the electronic module was measured by comparing science literacy test scores at O_1 and O_2. When the value of O_2 was more significant than O_1, then the electronic module developed was practical.

Science literacy tests were used to measure the achievement of students' science literacy results in the form of mastery of the material and show the level of effectiveness of the products developed. By calculating the difference between the post-test and the pre-test (normality gain test), the data on the outcomes of the science literacy test of students were then assessed and compared with the effectiveness criteria in Table 1.

$$< g > \equiv \frac{\%<G>}{\%<G>_{max}} = \frac{(\% <S_f> - \% <S_i>)}{(100 - \% <S_i>)} \quad (1)$$

Information:

$<g>$: *N-gain*

$\%<S_f>$: average *post-test* value

$\% <S_i>$: average *pre-test* value

Table 1

Criteria for the effectiveness of electronic modules

No.	*Gain Score*	Category
1.	$(<g>) > 0.7$	High
2.	$0,7 \geq (< g >) \geq 0.3$	Moderate
3.	$(< g >) < 0.3$	Low

(Hake, 1998)

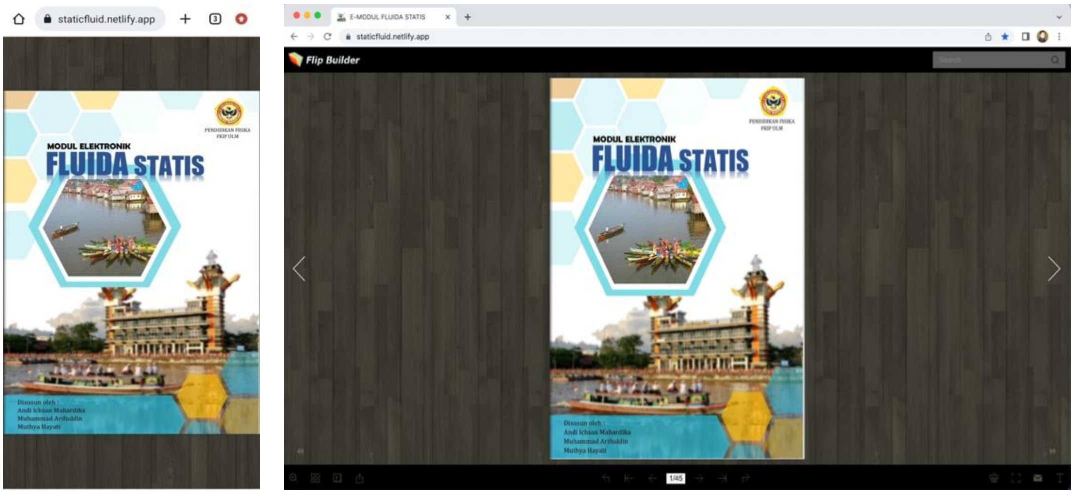
3. Results

The electronic module developed contained several components, namely the front cover (*cover*), instructions for use, concept maps, keywords, glance info that includes information on teaching materials charged with the wetland environment and to train science literacy, learning indicators, learning materials, wetland science literacy boxes, practicum activities using Phet Simulation, explanatory videos about materials and practicum activities connected to YouTube, animated videos, character info containing figures of physics scientists, examples of questions equipped with completion stages, practice questions, QR code boxes containing links connected to *google form* collection of practice assignments and practicum reports, conclusions, bibliography, glossary, and author biodata.

This electronic module was developed through professional PDF flip software that is very responsive (optimal) and easily adapt to the device's screen size. The font size, images, layout, and presentation of the material did not change even after accessed by various devices. This is an electronic module that all device users can access, whether computer, iPad, iPhone or Android, without needing additional software or hardware. It can also be accessed for free without time restrictions through *https://staticfluid.netlify.app* website page. Here is the front view for the electronic module that is opened through *mobile phones* and *laptops*.

Figure 3

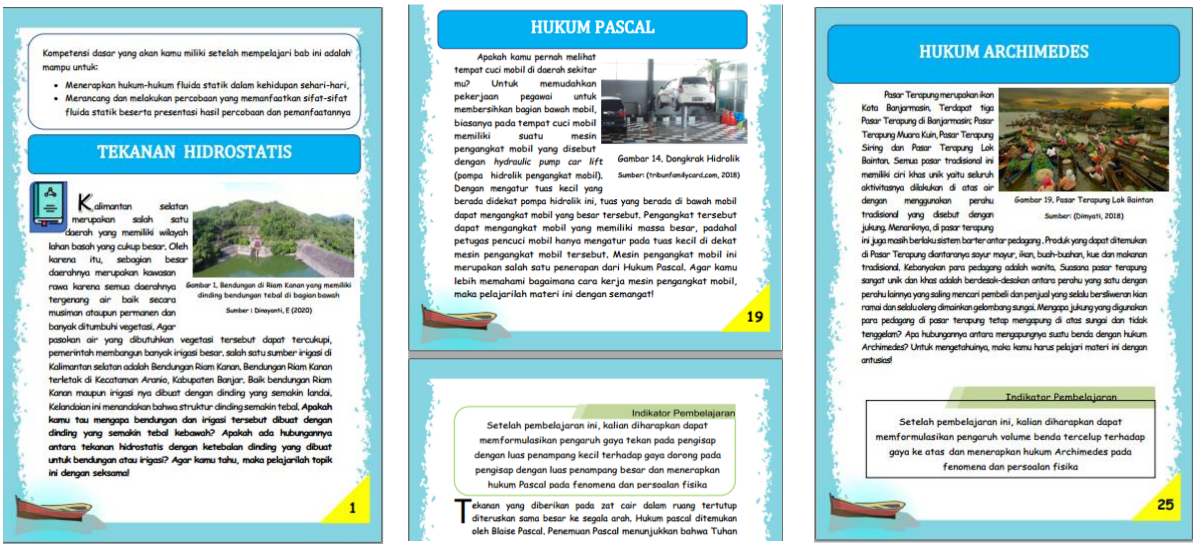
Electronic module display accessed via mobile phone (left) and laptop (right)



This electronic module contains teaching materials designed to reference the revised version of the 2013 Curriculum, divided into three sub-materials: hydrostatic pressure, Pascals' Law, and Archimedes' Law. Each sub-chapter contains indicators at the beginning that students must achieve in the learning process, examples of questions and stages of completion, practice questions that must be completed individually, and practicum activities to explore the material. There is a preliminary look at the sub-chapters in this module.

Figure 4

Display of teaching materials on electronic module



This electronic module's development aims to train students' science literacy. Science literacy in this module refers to 4 components and 16 predetermined indicators. The components of science literacy are as a *body of knowledge*, science as a *way of investigating*, science as a *way of thinking*, and interaction *between science, technology, and* society. The science literacy presented in this module relates to a static fluid matter in wetland environments.

Table 2

Science Literacy in electronic modules

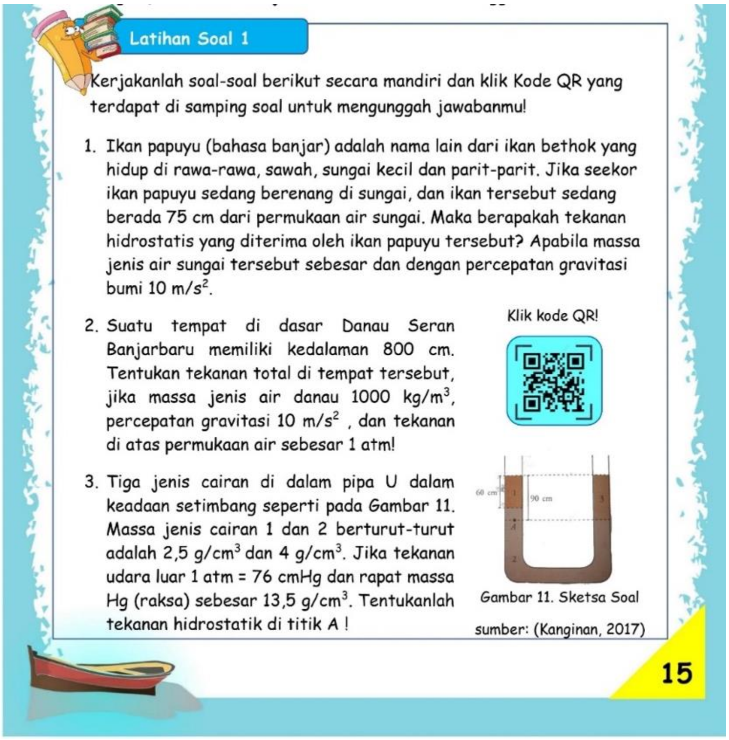
No.	Components of the payload Science Literacy	Indicator
1	Science as a body of knowledge	Presenting facts Presenting principles Presenting concepts Presenting the law Presenting the model Asking learners questions to remember informational knowledge
2	Science as a way to investigating	Requiring learners to answer questions through the use of materials Requiring learners to answer questions through the use of tables Requiring learners to make calculations Requiring learners to explain answers Engaging learners in thinking activities
3	Science as a way of thinking	Describing how scientist experiment Showing the historical development of an idea Providing a causal relationship
4	Interaction of science, technology, and society	Describing the use of science and technology for society Mentioning of careers and jobs in the field of science and technology

The novelty of this research lies in the material associated with the wetland environment to train science literacy. Science literacy information is presented at the beginning of each sub-chapter. The hydrostatic pressure sub-chapter is given information about the dam on the Right Cascade, which has a thick dam wall at the bottom. In the sub-chapter, Pascals' Law presents hydraulic jacks used in car washes, and information about the Lok Baintan Floating Market at the beginning of the Archimedes Law sub-chapter. This is a type of stimulus that increases student learning motivation by presenting facts that students are already familiar with, and this electronic module section also includes a wetland environment science literacy box that presents facts and concepts to increase students' knowledge. The goal is to pique learners' interest and raise their awareness that these phenomena are examples of science that are part of the body of knowledge.

This module presents several questions at the beginning of each sub-chapter, sample questions, practice questions, the "brain teaser", and "let's observe around!" sections. Through the questions asked, students are required to use the material, read the reading material carefully, make mathematical calculations, draw conclusions, and put forward the answers obtained because the physics material is closely related to theory and calculation. This is part of the motivation for learning and a stimulus to increase students' interest in the material to be taught. This is a science literacy training in the science literacy component as a *way of investigating.*

Figure 5

Exercises on wetland environmental science literacy in electronic module



Latihan Soal 1

Kerjakanlah soal-soal berikut secara mandiri dan klik Kode QR yang terdapat di samping soal untuk mengunggah jawabanmu!

1. Ikan papuyu (bahasa banjar) adalah nama lain dari ikan bethok yang hidup di rawa-rawa, sawah, sungai kecil dan parit-parit. Jika seekor ikan papuyu sedang berenang di sungai, dan ikan tersebut sedang berada 75 cm dari permukaan air sungai. Maka berapakah tekanan hidrostatis yang diterima oleh ikan papuyu tersebut? Apabila massa jenis air sungai tersebut sebesar dan dengan percepatan gravitasi bumi 10 m/s^2.
2. Suatu tempat di dasar Danau Seran Banjarbaru memiliki kedalaman 800 cm. Tentukan tekanan total di tempat tersebut, jika massa jenis air danau 1000 kg/m^3, percepatan gravitasi 10 m/s^2 , dan tekanan di atas permukaan air sebesar 1 atm!
3. Tiga jenis cairan di dalam pipa U dalam keadaan setimbang seperti pada Gambar 11. Massa jenis cairan 1 dan 2 berturut-turut adalah 2,5 g/cm^3 dan 4 g/cm^3. Jika tekanan udara luar 1 atm = 76 cmHg dan rapat massa Hg (raksa) sebesar 13,5 g/cm^3. Tentukanlah tekanan hidrostatik di titik A !

Klik kode QR!

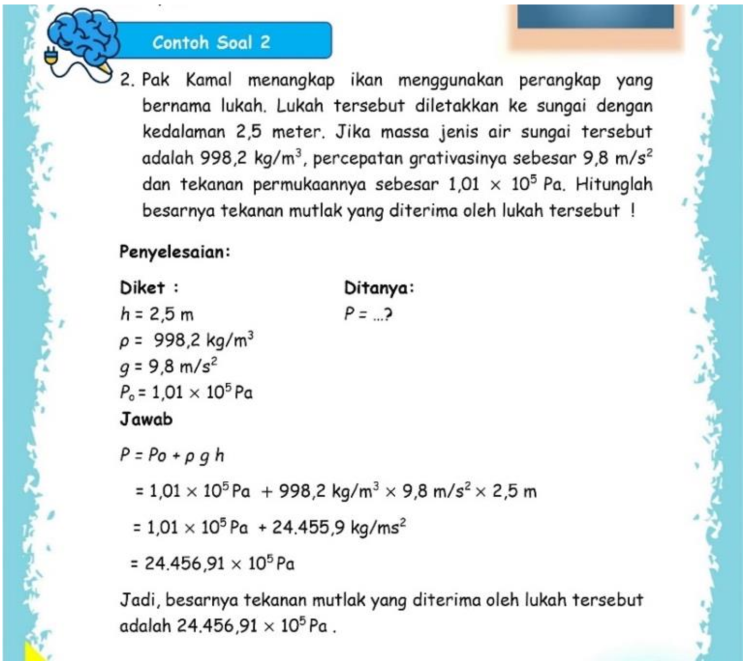
Gambar 11. Sketsa Soal

sumber: (Kanginan, 2017)

15

Figure 6

Examples of wetland environmental science literacy problems in electronic module



Contoh Soal 2

2. Pak Kamal menangkap ikan menggunakan perangkap yang bernama lukah. Lukah tersebut diletakkan ke sungai dengan kedalaman 2,5 meter. Jika massa jenis air sungai tersebut adalah 998,2 kg/m^3, percepatan grativasinya sebesar 9,8 m/s^2 dan tekanan permukaannya sebesar 1,01 × 10^5 Pa. Hitunglah besarnya tekanan mutlak yang diterima oleh lukah tersebut !

Penyelesaian:

Diket :

h = 2,5 m

ρ = 998,2 kg/m^3

g = 9,8 m/s^2

P_o = 1,01 × 10^5 Pa

Ditanya:

P = ...?

Jawab

$P = Po + \rho\, g\, h$

$= 1{,}01 \times 10^5\ \text{Pa} + 998{,}2\ \text{kg/m}^3 \times 9{,}8\ \text{m/s}^2 \times 2{,}5\ \text{m}$

$= 1{,}01 \times 10^5\ \text{Pa} + 24.455{,}9\ \text{kg/ms}^2$

$= 24.456{,}91 \times 10^5\ \text{Pa}$

Jadi, besarnya tekanan mutlak yang diterima oleh lukah tersebut adalah 24.456,91 × 10^5 Pa .

Science literacy also plays a role in describing how scientists do experiments. This module briefly depicts a physics figure named Blaise Pascal, who discovered Pascal's Law from his experiments playing with water. Another physics figure presented in this module is Abdurrahman Al-Khazini, an inventor of the barometer tool, who later thought inspired Galileo to create a thermometer. This explains the role of science literacy which shows the historical development of an idea. In addition, students are also assigned with conducting a practicum on hydrostatic pressure to train the ability to think to explain causal relationships. The practicum uses *Phet Interactive Simulations,* which can be accessed on *laptops* or *androids*, with applications or directly through the https://phet.colorado.edu/sims/html/under-pressure/latest/under-pressure_in.html *website*. This is the science literacy section for science as a *way of thinking*.

The last component of science literacy describes the interaction between science, technology, and society, closely related to social aspects (*interaction of science, technology, and society*). This component serves as an overview of how science and technology can benefit society, specifically how hydrostatic pressure, Pascal's Law, and Archimedes' Law can be used in practical applications. In addition, students also obtain information about employment opportunities in research and technology. This module briefly describes the information of physics figures Abdurrahman Al-Khazini and Blaise Pascal.

The role of electronic modules in effectiveness is through sample questions equipped with solving and practice questions that allow students to practice independently. Students who are called self-learning are those who can find or solve problems with ideas they find themselves, choose and assess credible information in solving problems, and choose the suitable learning method for themselves and evaluate it (Rachman et al., 2022). Examples of questions and practice questions aimed at guiding students in facing the static fluid material science literacy test in a wetland environment can be seen from the results of the *N-gain score* calculation obtained based on the student's science literacy test. The test given was a science literacy question of static fluid matter in a wetland environment with as many as eight questions in the form of an essay and was carried out twice, namely pre-test and *post-test* to 10 students of class XI MIPA 2 SMAN 12 Banjarmasin. The following is the result of calculating the *N-gain score*.

Table 3

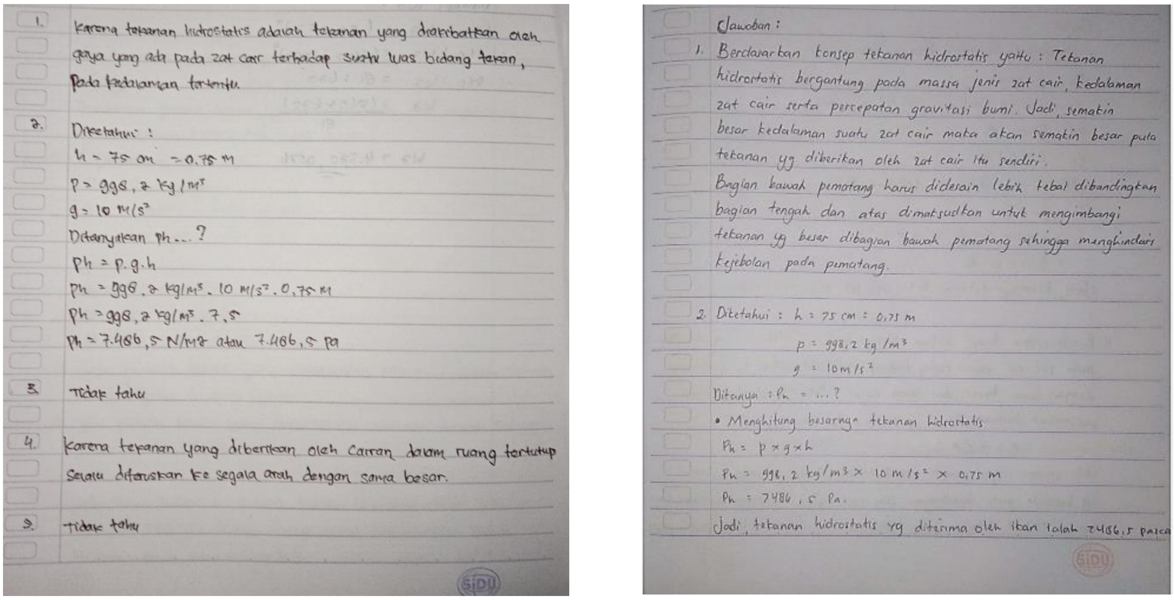
N-gain score results

No	Pre-test	Post-test	N-Gain
1	79	91	0.57
2	48	97	0.94
3	51	81	0.61
4	57	89	0.74
5	58	97	0.93
6	72	93	0.75
7	51	72	0.43
8	65	81	0.46
9	59	93	0.83
10	53	97	0.94
Average	59.3	89.1	0.72
	Category		High

Calculation results for values *pre-test* students showed that only 10% of students obtained scores above the minimum completion criteria (KKM), which was more than equal to 73. This was because students had not been given electronic modules and material explanations. Students admitted that they did not understand the content of the questions related to concepts and did not know what physics equations should be used in solving problems. After performed the *pre-test*, on the same day, learners got an electronic module to learn independently before learning at the next meeting. Learning was carried out in two sessions with equal treatment between students. After that, students were given post-test questions. Here are the answer sheets for students doing pre-test and post-test.

Figure 7

Student answer sheets: (a) pre-test and (b) post-test.



(a) (b)

From the picture, it is explained that in picture (a) or pre-test, students were still unable to answer all the questions, and question number 3 and 5 were answered with "*tidak tahu*" (not knowing). While in picture (b) post-test, the students were able to respond and provide elaboration in answering the question. The results of the average post-test scores carried out by students after learning using electronic modules provided relatively good results with a significant increase in scores and scores above the Minimum Completion Criteria set by the school. This increase also indicates that students' physics problem-solving ability has increased.

4. Discussion

Based on the results obtained on the pre-test and post-test values, the N-gain test value reached a high category. This category corresponds to the theory of effectiveness according to (Hake, 1998); if the N-gain result is worth more than 0.7, then it is declared a high category. Thus, the results have proved that electronic modules to train students' science literacy on static fluid materials in wetland environments are effectively used by students in the learning process.

According to (Shanti et al., 2022), learning is the process through which people make a conscious effort to go from ignorance to knowledge, from having the wrong attitude to being correct, and from being unskilled to being skilled in doing things. From these results, it can be stated that electronic modules to train students' science literacy on static fluid materials in wetland environments can be one of the means of online and offline learning. The results obtained cannot be separated from the aspects of ease and benefits students feel while using this electronic module. Thus, the electronic module developed effectively improves learning outcomes and students' independent learning abilities. Electronic modules can also be said to be effective if they can help students in learning, help them carry out independent learning, measure the level of students' comprehension ability, and improve student learning outcomes (Laili et al., 2019).

Science literacy contained in modules is one of the factors for the effectiveness of modules. The science literacy presented can improve student learning outcomes or achievements because it is the subject of learning by combining the material with science literacy indicators. These results are consistent with the research of (Armas et al., 2019), which found that science literacy has a positive relationship with student learning achievement. In addition, the presented science literacy is highly relevant to life and actual examples of the wetland environment in which the learners of the research subject life.

The weakness of this study is that the process of taking pre-test and post-test scores can only be taken from 10 students due to the limited time given by the school to researchers. The time for the pre-test, post-test and filling out the response questionnaire is carried out outside learning hours due to limited time for online learning meetings using google meet. Training on the science literacy component of the interaction between technology, science, and society for indicators mentioning careers and jobs in the field of science and technology only briefly depicted the careers of ancient physical scientists, not explained those that exist today. Consequently, there are still many students who are not interested in careers related to science and technology.

5. Conclusion

Based on the results of the development and trials, it was inferred that the electronic modules developed were effectively used to train students' science literacy on static fluid materials in wetland environments due to the high n-gain of science literacy. The limitation of this research is the research data taken from only ten students and the absence of modules that explain current careers in science and technology. The novelty of this research lies in the material associated with the wetland environment to train science literacy. The implications of this study serve as a reference for teachers and students in improving science literacy skills. We are all aware that Indonesian students still need to work on their ability to compete internationally.

6. Recommendation

Based on the limitations of research on static fluids, it is recommended to develop scientific literacy on other physics topics by using technology-based learning. It is also expected that it will be able to implement scientific literacy-based physics learning to a wider range of students.

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