The Development of Scientific Literacy-Based Physics Learning Module on Direct Current Circuit Material

Susdarwati1, Farida Hannum2, Arifian Dimas3

123Science Education, STKIP Modern Ngawi, Indonesia

Susdarwati88sains@gmail.com

**Abstract**. This research and development are aimed to describe the characteristics, determine the feasibility, and determine the effectiveness of the Scientific Literacy-based physics learning module on direct current circuit material. The development procedure uses the Research and Development (R&D) model developed by Thiagarajan et al. with 4-D stages covering defining, designing, developing, and disseminating. The subjects in this study were students of class XII at SMA Negeri 1 Jogorogo Ngawi. Data collection technique in this research used observation, interview, and questionnaire. Data analysis carried out quantitatively and descriptively qualitatively. The results of the research and development concluded that 1) a physics learning module base on Scientific Literacy on direct current circuit material developed based on the Scientific Literacy component, namely a) the scientific process includes explaining scientific phenomena, using scientific evidence, identifying scientific questions, b) scientific content includes understanding phenomena, and c) the context of science includes solving problems in everyday life; 2) the module is feasible to use in learning physics in a very good category, the average percentage of validation results is a) material components: 91.46% b) media component: 92.99% c) scientific Literacy component: 93.75% 3) module is effectively used to improve critical thinking skills includes interpretation, analisys, evaluation, inference, explanation and self regulation with an increase of 17.56%.

1. Introduction

Regulation of the Minister of Education and Culture number 22 of 2016 concerning the standard of primary and secondary education processes explains that the Learning Process in academic units is held interactively, is inspiring, fun, challenging, motivates students to participate actively, and provides sufficient space for the initiative, creativity, and independence according to the talents, interests, and physical and psychological development of students. Therefore, teachers are required to carry out lesson planning, implement the learning process, and assess the learning process in increasing the efficiency and effectiveness of the achievement of graduate competencies.

One thing that supports the success of the learning process is preparing learning strategies and teaching materials. If the teacher uses the right learning strategy, the learning objectives will be maximally achieved. Teachers need teaching materials that can teach students to learn independently, one of which is using modules. Modules are learning materials arranged systematically in language that students easily understand according to their age and level of knowledge to learn independently with minimal guidance from educators [1]. The benefits of the module for students include: a) students have the opportunity to train themselves to learn independently; b) learning becomes more interesting because known outside the classroom and class hours; c) have the chance to express learning methods according to their interests and abilities; d) have the chance to test one's abilities by doing the exercises provided in the module, and develop students' ability to learn and interact with the environment and other learning resources [2].

Based on a needs analysis at SMAN 1 Jogorogo, learning still prioritizes product aspects and has not optimized process aspects. The teacher explains the material on the blackboard then the students work on the practice questions. Students learn from the summary of the notebooks submitted by the teacher. Students have not been allowed to gain experience in the scientific process through practicum or scientific investigation to lack critical thinking skills. Students do not have a learning module for independent learning. Students have difficulty learning the concepts in Direct Current Circuit material. With this, it is necessary to develop a module that is accompanied by a learning model that supports students to improve their critical thinking skills so that they are able to solve problems and understand scientific concepts. Various methods can use to develop students' scientific literacy through teaching activities, two of which are learning techniques and teaching materials such as modules that support scientific literacy competencies [3].

The fundamental reason for scientific literacy is significant for the world of education. It is one of the PISA survey assessment materials, namely the idea that every individual as a citizen is required to have the capability of scientific literacy to answer global challenges filled with issues about the rapid development of work products. Scientific and scientific advances (Science and Technology). Scientific literacy is multidimensional and comes in a variety of types and degrees [4]. The components of Scientific Literacy Learning based on PISA are: 1) The scientific process includes a) explaining scientific phenomena, b) using scientific evidence, and c) identifying scientific questions; 2) science content includes understanding phenomena; 3) the context of science includes solving problems [5].

Based on the background description, this study aims to: 1) describe the characteristics of a physics learning module based on Scientific Literacy on direct current circuit material 2) determine the feasibility of a Scientific Literacy-based physics learning module on explicit current circuit material 3) assess the effectiveness of a Scientific Literacy-based physics learning module on current circuit material unidirectional.

1. Research method

This type of research is a Research and Development (R&D) research using the 4-D model, including the stages of define, design, develop, and disseminate [6]. The research site at the teacher needs analysis stage was carried out at SMAN 1 Karangjati, SMAN 1 Ngawi, and SMAN 1 Jogorogo. Analysis of student needs, limited trials, and field trials were carried out at SMAN 1 Jogorogo, located at Jl. Raya Jogorogo, Jogorogo sub-district, Ngawi Regency, East Java. The research subjects consisted of limited trial subjects were eight students of class XII MIA-2 SMAN 1 Jogorogo, and random sampling techniques carried out the sampling technique. The field trial was 32 students of Class XII MIA-1 SMAN 1 Jogorogo, and the sampling technique is done using cluster sampling.

Data collection techniques by observation, questionnaires, and interviews. The data analysis technique for the questionnaire consisted of a module feasibility questionnaire by a material and media expert lecturer and a physics teacher and a student response questionnaire on product trials. Data obtained from module validation and student responses were analyzed to determine a Scientific Literacy-based physics module's feasibility. The data analysis technique for the feasibility of the module is carried out in the following steps: a) Tabulating all data obtained from the validators available in the assessment instrument; b) Calculate the average total score of each component using the equation:

$\overbar{X }=\frac{\sum\_{}^{}X}{n}$ (1)

with : $\overbar{X}$ as an average score, $\sum\_{}^{}X$ as the total score, and $n$ as the number of appraisers; c) Converting the average score into criteria with the following four scales:

**Table 1.** Average Score Criteria

|  |  |  |
| --- | --- | --- |
| Score Range (i) | Score | Criteria |
| $$Mi+1,5SDi\leq \overbar{M}\leq Mi+3SDi$$$$M\leq \overbar{M}\leq Mi+1,5SDi$$$$Mi-1,5SDi\leq \overbar{M}\leq M$$$$Mi-3SDi\leq \overbar{M}\leq Mi-1,5SDi$$ | ABCD | Very GoodGoodEnoughLess |

with: *Mi* as mean ideal and *SDi* as the ideal Standard deviation [7].

1. Analysis and discussion
	1. *Results of the Defining Stage*

The defining stage in the form of a literature study is used to determine guidelines in developing a physics learning module. The study material for this development was the Direct Current Circuit material. One of the efforts to improve students' critical thinking skills is to apply a physics learning module based on Scientific Literacy. This is in line with research conducted by A Rusilowati et al. if Textbooks, learning models, worksheets, and evaluation tools developed based on scientific literacy can improve the student's scientific literacy. The profile of students' scientific literacy, which is The final trial results showed that the category of science as a way of thinking is the highest among the other types is 72. This category requires students to think critically, interpret data, and link concepts with another [8].

Constructivism learning theory states that learning activities are active activities in which students build their knowledge [8]. This learning theory is by the implementation of Scientific Literacy-based learning in that students carry out the process using scientific evidence by the framework that has been in their minds. In this case, students can think critically in solving problems. The power of scientific literacy requires a student's mastery of an adequate concept. This will facilitate students in the learning process [9].

 The field survey's defining stage showed that the results of the questionnaire analysis of teacher need consisting of 4 respondents stated that they needed teaching materials that could help teach Direct Current Circuit material and agreed with the development of a Scientific Literacy-based physics learning module on Direct Current Series material. The results of the analysis of the student need questionnaire consisting of 6 respondents. 100% of respondents use textbooks and worksheets, 67% of respondents are looking for other teaching materials in the form of the internet to understand the material of Direct Current Circuits, 100% of respondents have never experimented with Direct Current Circuits, 83% of respondents have difficulty learning material on Direct Current Circuits from books they own and the learning model that has been applied by the teacher, 100% of respondents need other teaching materials that can help to understand the Direct Current Circuit material and agree with the development of teaching materials in the form of a Scientific Literacy-based physics learning module on Direct Current Circuit material.

* 1. *Results of the Design Stage*

The module design stage is developed following the Scientific Literacy learning component based on PISA, namely: 1) The scientific process includes a) explaining scientific phenomena, b) using scientific evidence, and c) identifying scientific questions; 2) science content includes understanding phenomena; 3) the context of science includes solving problems [5].

The module format is adopted and adapted to the module components. Module components consist of an introduction, learning activities, evaluation and answer keys, and a glossary [10]. The introduction includes a description, prerequisites, instructions, final objectives, and an outline of the module content. I am learning activities consisting of learning activity objectives, Student Worksheets (Simple Series, electrical resistance, power, and energy), applications and effects on the environment, material descriptions (electric current, electrical circuits, power, and energy), test questions on critical thinking skills. The closing section consists of evaluation, glossary, bibliography, and answer keys.

* 1. *Results of the Development Stage*

**Table 2.** Results of Module Validation Analysis on Material Components

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Validator |  To- |  Scor | Average | Percentage (%) | Criteria |
| Expert Lecturer |  | 1 | 107 | 108.5 |  90.42 | Very Good |
|  | 2 | 110 |
| Teacher |  | 1 | 110 | 111 |  92.5 | Very Good |
|  | 2 | 112 |
|  | Total Average | 109.75 | 91.46 |  Very Good |

Table 2 shows the module's validation on the material components obtained by a total average score of 109.75 from a maximum score of 120 with an outstanding category, which includes three aspects, namely the feasibility of content, language, and presentation.

**Table 3.** Results of the Media Component Module Validation Analysis

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Validator |  To- |  Scor | Average | Percentage (%) | Criteria |
| Expert Lecturer |  | 1 | 122 | 121 | 91.67 | Very Good |
|  | 2 | 120 |
| Teacher |  | 1 | 124 | 124.5 | 94.32 | Very Good |
|  | 2 | 125 |
|  | Total Average |  122.75 |  92.99 | Very Good |  |  Very Good |

Table 3 shows the module validation on the media components obtained by a total average score of 122.75 from a maximum score of 132 with an excellent category, including three aspects: the feasibility of module size, module skin, and module content design..

**Table 4.** Relevance of Scientific Literacy Components in Modules

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Scientific Literacy Components | Expert Lecturer | Teacher  | Scor | Criteria |
| 1 | 2 | 1 | 2 |
| Science process | 4 | 3 | 4 | 4 | 15 | Very Good |
| Science contest | 3 | 4 | 4 | 3 | 14 | Very Good |
| Science context | 4 | 4 | 4 | 4 | 16 | Very Good |
| Total Average |  |  |  | 15 | Very Good |

Table 4 shows the relevance of the Scientific Literacy learning component with an average score of 15 out of a maximum score of 16 in perfect criteria. Validation of the first draft of the module can be concluded that it is feasible to be tested on a limited basis by making several improvements, including 1) the introduction to the syllabus is added, 2) the learning activity section is added to the application of daily life according to the subject matter, 3) after the thinking ability test critically added feedback. The limited trial phase was on eight students of class XII MIA-2 SMAN 1 Jogorogo.

The little trial phase was carried out in one meeting by dividing eight students into two groups to participate in the learning using the Scientific Literacy-based physics learning module on the Direct Current Circuit material. The module readability analysis results in the limited trial showed that the overall appearance, writing, language, benefits of the module in learning, and supporting images were good, attractive, clear, and easy to understand. Table 4.9 shows that the average total score obtained is 17.88 from the maximum score of 20, so the module can be categorized as very good. However, there are some suggestions and improvements related to writing.

The field trial stage was carried out on 32 students of class XII MIA-1 SMAN 1 Jogorogo to determine the increase in critical thinking skills. Field trials were carried out for three meetings. For practicum divided into eight groups. Table 4.15 shows that the student response questionnaire data obtained an average score of 18 from a maximum of 20 in the outstanding category. There is no revision of the draft III modules after field trials. Furthermore, a Scientific Literacy-based physics learning module is obtained, which is ready to be disseminated.

**Table 5**. Description of Student's Critical Thinking Ability Achievement

| Activities | Science process | Mean | Standard Deviation | Minimum | Maximum | Percentage (%) |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | 32 | 16.72 | 2.30 | 12 | 21 | 69.67 |
| 2 | 32 | 18.31 | 2.45 | 15 | 22 | 76.29 |
| 3 | 32 | 19.72 | 3.25 | 17 | 23 | 82.17 |
| Average |  18.25 | 76.04 |

Table 5 shows that students 'critical thinking skills during the learning process using a physics learning module based on Scientific Literacy on Direct Current Series material achieve the results of students' necessary thinking abilities obtained an average score of 18.25 from a maximum score of 24 or 76.04 from a top score of 100 in right criteria. This is in line with Kusumawati's research if the results of effectiveness based on the pre-test and post-test results are as follows: the scientific literacy competence to explain the phenomenon scientifically increased by 52% and the scientific literacy competence to interpret data and scientific evidence. Raised by 59%. The results of this effect are included in the relatively good category [11].

**Figure 1.** Data Description Aspects of Students' Critical Thinking Ability

Aspects of critical thinking skills include Interpretation (stating the meaning of information, images, or events), Self Regulation (checking answers in the form of questions, confirmation, validation, or correction), analysis (identifying intentions with precise and logical reasons and providing further explanations), evaluation (assessing the correct statement), inference (collecting information to conclude with the right reasons), and description (presenting arguments supported with the right reasons). The highest critical thinking ability results are Interpretation of 3.71, and the lowest is Self Regulation of 1.64 from a maximum score of 4. This shows that students can express the meaning of information, pictures, or events very well. Students are less able to check answers in question form, confirmation, validation, or correction. But overall, the average score of students' critical thinking skills was 3.05. Using a physics learning module based on Scientific Literacy on the Direct Current Circuit material, 17.56% increased during the learning process. This is in line with research by Bella Oktari et al. that the results of the independent sample t-test analysis obtained a significance value of 0.026 <0.05, and for the experimental class, a matter of 77.2% was obtained, including the very high category. This proves that students' critical thinking skills have increased after using e-modules oriented to scientific literacy [12].

* 1. *Results of the Disseminate Stage*

The final stage of this research is disseminating the product in the form of a Scientific Literacy-based high school physics module on the Direct Current Series material, which was conducted on ten high school physics teachers teaching class XII students in Ngawi district. The questionnaire responses from 12 physics teachers obtained an average score of 27.2 from a maximum score of 28 with perfect criteria.

1. Conclusion

The results of the research and development concluded that 1) a physics learning module base on Scientific Literacy on direct current circuit material developed based on the Scientific Literacy component, namely a) the scientific process includes explaining scientific phenomena, using scientific evidence, identifying scientific questions, b) scientific content includes understanding phenomena, and c) the context of science includes solving problems in everyday life; 2) the module is feasible to use in learning physics in a very good category, the average percentage of validation results is a) material components: 91.46% b) media component: 92.99% c) scientific Literacy component: 93.75% 3) module is effectively used to improve critical thinking skills includes interpretation, analisys, evaluation, inference, explanation and self regulation with an increase of 17.56%.

References

1. Andi Prastowo 2012 *Panduan Kreatif Membuat Bahan Ajar Inovatif* (Yogyakarta: Diva Press)
2. Hamdani 2011 *Strategi Belajar Mengajar* (Bandung : Pustaka Setia)
3. Wati F, Sinaga P, Priyandoko D 2017 Science Literacy: How do High School Students Solve PISA Test Items? *J. Phys.: Conf. Ser.* **895** p.012166.
4. Wenning J. C. 2007 Assessing Inquiry Skills As A Component of Scientific Literacy *Journal of Physics Teacher Education Online*, 4 (2), 91-100.
5. Uus Toharudin 2011 *Membangun Literasi Sains Peserta Didik* (Bandung: humaniora)
6. Thiagarajan, Sivasailam, dkk 1974 *Instructional Development for Training Teachers of Exceptional Children* (Washinton DC: National Center for Improvement Educational System)
7. Direktorat Pembinaan SMA 2010 *Panduan Pengembangan Bahan Ajar Berbasis TIK* (Jakarta: Direktorat Pembinaan SMA)
8. A Rusilowati1, B Astuti1 and N A Rahman 2019 How to improve student’s scientific literacy *J. Phys.: Conf. Ser.* **1170** 012028
9. Sardiman 2011 *Interaksi dan Motivasi Belajar Mengajar* (Jakarta: PT Raja Grafindo Persada)
10. Parno, L Yuliati and N Munfaridah 2018 The profile of high school students’ scientific literacy on fluid dynamics *J. Phys.: Conf. Ser.* **1013** 012021
11. Sukiman 2012 *Pengembangan Media Pembelajaran* (Yogyakarta:PT Pustaka Insan Madani)
12. A T Kusumawati, Wasis, I G M Sanjaya, and Abd. Kholiq 2020 Elite (E-Book Literacy) for Junior High School Student’s Scientific Literacy in Solar System Material *J. Phys.: Conf. Ser.* **1491** 012070