The development of scientific literacy-based physics learning module on direct current circuit material

S Susdarwati*, A Dimas and F Hannum
Science Education, STKIP Modern Ngawi, Jl. Ir. Soekarno Grudo Ngawi 63214, Indonesia

*Susdarwati88sains@gmail.com

Abstract. This research and development aim to describe the characteristics, determine the feasibility, and determine the Scientific Literacy-based physics learning module's effectiveness on direct current circuit material. The development procedure uses the Research and Development model by Thiagarajan with 4-D stages (define, design, develop, and disseminate). The subjects of this study were students of class XII at SMA Negeri 1 Jogorogo Ngawi. Data collection techniques using observation, interviews, and questionnaires. Data analysis was carried out quantitatively and descriptively qualitatively. The results of the research and development concluded that 1) a physics learning module based on Scientific Literacy on direct current circuit material was 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 physics learning in an excellent category, the average percentage of validation results is a) material components: 91.46% b) media components 92.99% c) scientific literacy components 93.75%; and 3) a useful module for improving critical thinking skills including Interpretation, analysis, 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 must 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 opportunity 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 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 to solve problems and understand scientific concepts. Necessary thinking skills can think rationally and reflectively, emphasizing beliefs and decisions that will be taken [3]. Various methods can be used to develop students' scientific literacy through teaching and learning activities, two of which are learning techniques and teaching materials such as modules that support scientific literacy competencies [4].

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 must have the capability of scientific literacy to answer global challenges filled with issues. Scientific literacy is multidimensional and comes in a variety of types and degrees [5]. 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 [6].

Based on the background description, this study aims to describe the characteristics, determine the feasibility, and determine the Scientific Literacy-based physics learning module's effectiveness on direct current circuit material.

2. Research methods
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 [7]. 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 the sampling technique was carried out by random sampling techniques. The field trial was 32 students of Class XII MIA-1 SMAN 1 Jogorogo, and the sampling technique was 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 validator available in the assessment instrument; b) Calculating the total average score of each component; c) Converting the average score into criteria with four scales.

3. Analysis and discussion

3.1. Results of the defining stage
The defining stage in the form of literature studies is used to determine guidelines in developing a physics learning module. The study material for this development was the Direct Current Circuit material. Critical thinking can be taught to students through various learning media, models, and methods [8]. One of the efforts to improve students' necessary thinking skills is to apply a physics learning module based on Scientific Literacy. This is in line with research conducted by A Rusalowati...
et al. It shows that textbooks, learning models, worksheets, and evaluation tools that develop based on scientific literacy can improve the students' 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 linking concepts with another one [9].

Constructivism learning theory states that learning activities are active activities in which students build their knowledge [10]. This learning theory is in accordance with the implementation of Scientific Literacy-based learning in that students carry out the process using scientific evidence in accordance with the framework that has been in their minds. In this case, students have the ability to think critically in solving problems. The ability of scientific literacy requires a student's mastery of an adequate concept. This will facilitate students in the learning process [11].

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.

3.2. 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 [6].

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 [12]. 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.

3.3. Results of the development stage
The validation phase of the first draft of the Module to determine the feasibility of the Module based on the material, media and relevance components of Scientific Literacy was carried out by two lecturers as material experts and media experts and two high school physics teachers. The results of the module validation analysis on the material component by expert lecturers obtained an average score of 90.42% and the teacher's 92.5%. So that the module validation on the material component received an average total score of 91.46% with the outstanding category [13]. The material component includes three aspects, namely the feasibility of content, language, and presentation. The results of the module validation analysis on the media component by expert lecturers obtained an average score of 91.67% and 94.32% for teachers. So that the module validation on the media component received a total average score of 92.99% with the outstanding category [13]. The media component includes three aspects, namely the feasibility of module size, module skin design, and module content design. The results of the module validation analysis on the relevance of the scientific literacy component to the component of the scientific process obtained an average score of 93.75%; the science process component received an
average score of 87.5%. The science context component got an average score of 100%. The validation on the relevance of the Scientific Literacy component in the Module obtained a total average score of 93.75% in the outstanding category [13]. 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, 2) the learning activity section, the application of daily life is added according to the subject matter, 3) after the thinking ability test Critical added feedback: if the critical thinking ability test score is more than 75 can continue to the next learning activity.

The limited trial phase was carried out on eight students of class XII MIA-2 SMAN 1 Jogorogo. The little trial was conducted 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, but some suggestions and improvements are related to writing.

The field trial phase 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 out of a maximum score of 20 in the perfect 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 1. 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 1 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 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. This proves that students’ critical thinking skills have increased after using e-modules oriented to science literacy [14].

![Figure 1. Data description aspects of students’ critical thinking ability.](image-url)
Aspects of critical thinking skills include Interpretation (stating the meaning of information, pictures, 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 a further explanation), 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 92.75 and the lowest is Self Regulation of 41 from a maximum score of 100. This shows that students can express the meaning of information, pictures, or events very well. Still, students are less able to check answers in inquiries, confirmations, validations, or corrections. Interpretation is an aspect of critical thinking skills, namely stating the meaning of information, pictures, or events. Interpretation aspects included in the Module in the form of images in everyday life contain the concept of direct current material. The following is a case in the Module that contains aspects of Interpretation.

Table 2. A case in the Module that contains aspects of interpretation.

| Case | Student Answer |
|------|----------------|
| Why is the bird standing above cables with high voltage not electrocuted? | Birds that stand on a high voltage PLN cable not electrocuted because there is no potential difference. If the wire breaks and is on the ground, standing on the wire will be electrocuted |

Table 2 show that students have an excellent ability to state the information presented in the Module. Based on students' answers, students can explain the correct concept. The picture above is one part of everyday life application to measure students' critical thinking skills. Using photographs to convey information is done to determine students' ability to understand student concepts [15,16]. The results showed that their daily life experiences influenced the idea of students.

The aspect of analysis with a score of 79% is already in the excellent category. One of the higher-order thinking categories is analyzing, evaluating, and creating [17]. But overall, the average score of students' critical thinking skills is 76.25%. During the learning process, it is using a physics learning module based on Scientific Literacy on the Direct Current Circuit material, an increase of 17.56%. This is in line with the research by Feriyanto et al. that the results of this study are mathematics module-based literacy to train critical thinking ability that meets the validity criteria with good categories [18].

3.4. 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.

4. 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%; and 3) module is effectively used to improve critical thinking skills includes interpretation, analysis, evaluation, inference, explanation and self regulation with an increase of 17.56%.

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