Design of STEM-based learning devices in direct current circuit section

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Abstract. This study aims to design learning tools developed based on STEM (science, technology, engineering, and mathematics). The learning tools are learning media in the form of Virtual Laboratories (VLAB) and Student Worksheets. Physics learning presented is limited only to the direct current series. VLAB components are the starting page, instructions for use, brief material on direct current circuit, direct-current circuit practicum using PhET interactive simulations equipped with worksheets, innovative videos for making flashlights and evaluations in the form of multiple-choice questions. The student worksheet section consists of two student worksheets, the first is a scientific worksheet that completes practicum activities in VLAB, and the second is an engineering worksheet in the form of student project worksheets to be able to create an innovative flashlight. The learning kit is measured through a validation process. VLAB is validated by 3 experts namely 2 content experts and 1 media expert. Student worksheets are validated by 3 experts, 2 content experts, and 1 language expert. The results of this study indicate that STEM-based learning tools namely VLAB and Worksheets are valid and can be applied in learning.
Keywords: *device design, STEM, direct current electricity*

1. Introduction

Based on observations at the engineering faculty of Majalengka University, from year to year, students' understanding of concepts, process skills, and scientific literacy is low. the low value of scientific literacy is evidenced from the results of scientific literacy tests, the average student answers incorrectly when filling in questions, especially in basic Physics courses [1], [2], [3] Article 26 paragraph 4 regarding the purpose of higher education which says to get students into a society of noble character, needs help, is useful, is independent [4], [5].

Therefore learning at this time needs to keep abreast of the times in the era of globalization by integrating Science, Technology, Engineering, and Mathematics (STEM)[6]. The benefits of the STEM approach make students able to solve problems better, innovators, inventors, independent, logical thinkers, and technological literacy [7]. This is effective if supported teaching materials in the form of student worksheets [8]. This study aims to produce STEM student worksheets to find out the characteristics, validity, and effectiveness of the product being developed.

We include this student worksheet in a virtual laboratory practicum (VLAB) to measure the student's scientific process. VLAB serves to overcome the limitations of laboratory equipment. Thus learning with VLAB media can improve student competence, understanding student concepts, learning

achievement and learning independence [9]. Therefore, researchers develop or design STEM-based learning tools of the form of VLAB and student worksheets. This research is limited to the direct current electricity section because the concept cannot be separated from everyday life. science learning will be meaningful and beneficial if students are able to apply for their lives [10].

In this research, we develop or design STEM-based learning tools in the form of VLAB and student worksheets. This research is limited to the direct current electricity section because the concept cannot be separated from everyday life. Science learning will be meaningful and beneficial if students can apply it to their lives [10]. In the concept of direct current electricity, there is a need for simulations and animations that support to show abstracts. Therefore, researchers use PHET to show things that are visible and abstract. With advances in accessibility and technological sophistication, interactive computer simulations have emerged as very powerful tools to support learning [11]. As Wieman said, PHET can be used in many different educational environments, including lectures, individual or small group inquiry activities, homework, and laboratories [12].

2. Research method

The research method used is the Research and Development method. Educational research and development (R&D) is the process used to develop and validate educational products[13]. The steps of this process are usually referred to as the R&D cycle, which consists of studying research findings related to the product to be developed, developing a product based on these findings, testing it where it will be used eventually, and revise it to correct deficiencies found at the proposed testing stage. In a more rigorous R&D program, this cycle is repeated until field test data shows that the product meets the behavioral goals.

The steps of research development (R&D) are a) Research and Data Collection, b) Planning, c) Initial Product Development, d) Initial product trials / Limited Trials, e) Product Improvements Initial, f) Wider Field Trials, g) Improvement of Wider Field Product Results, h) Final Product Trials, i) Revision or Refinement of Final Products, j) Dissemination and Implementation[14]. The steps of developing learning tools are made only until the initial product development is to study the feasibility of the product in terms of expert validity.

2.1. Research and data collection

In addition to the study of literature review that is approved in articles from journals, books, and other documents that describe theories and information both past and present organizing literature into topics and documents that are needed[15]. Literature study is a method used to collect data or sources relating to the topics raised in a study [16].

2.2. Planning

Based on the preliminary studies that have been carried out, product planning is made which includes: a) the purpose of using the product; b) who are the users of the product; c) description of the product components and their use.

2.3. Initial product develompent

Early product development is a rough concept of the product to be made. However, the concept of the product must be prepared as completely and perfectly as possible. Initial drafts or products developed by researchers collaborating with or asking for help from experts and/or by their field of expertise (trial at the back table/evaluation table). Trials or evaluations by experts to estimate or judge, based on the analysis and consideration of researchers and experts. Field trials will receive micro, case by case to then conclude in general or generalized.

Validation Analysis of STEM learning tools:

$$P\% = \frac{n}{N} \times 100\%$$

Information : p % = percentage of eligibility score, n = number of scores obtained, N = maximum number of scores [17].

The validation sheet follows the Likert scale scoring rules [18]. Based on these calculations, the eligibility criteria for STEM learning tools are descriptive.

3. Results and Discussion

3.1. Research and data collection

This study is a follow-up study or developed from previous research conducted by Jannati regarding Virtual Laboratory Learning Media Development to improve the science of literacy skills of mechanical engineering students on basic physics concept of material measurement[9]. In this study, it was developed with STEM-based learning and developed in the direct current electricity section. STEM education is a top priority in solving global issues and problems facing the world today [6]. Because of the importance of future STEM as revealed by future studies aimed at raising awareness of STEM can be given a reflection of the curriculum installed on classroom practice [19].

3.2. Planning

Based on the preliminary studies that have been made, a product design is made which includes:This study aims to create a STEM-based learning device design, the learning device is the Virtual Laboratory media to create innovative flashlights and Student Worksheets. It is expected that with the development of STEM-based learning tools students will be able. This research is an advanced study or developed from previous research conducted by Jannati regarding virtual laboratories[9].

Table 1. Product planning.

Product Planning	STEM-Based VLAB	STEM Based Student Worksheet	
		Student worksheet I (Scientific process)	Student worksheet II (Engineering process)
The purpose of using the product	Students can solve the problem of direct current series in daily life.	Students can arrange series and parallel electrical circuits Students can use electric measuring instruments	Students can create a flashlight with their innovation
Product User	Mechanical Engineering student in the second semester of Majalengka University		
Description of the components	Components in VLAB: - The main page contains the title and identity of the researcher - Instructions for use - Material, contains concise material about direct current electrical circuits (scientific and mathematical processes) - Practicum in a virtual lab using PHET as	It's components: -Purpose: Students can use electric measuring devices, Students can collect direct current electric circuits, Students can solve electrical problems in everyday life. Activities: given the challenges of electricity in daily life that is designing electrical	It's components: -Purpose: students can identify the components of a flashlight system, analyze circuits on a flashlight, analyze the workings of a flashlight, design a flashlight from the results of the analysis of the work of a flashlight, design a creative and innovative flashlight.

	directed in Student Worksheet 1 (scientific, technological, mathematic processes) - Video contains a limited video about examples of arranging a flashlight (Engineering process)	installations that have been determined the number of lights, then students solve these problems by determining themselves connecting variables, hypotheses, practical steps, connection design, data, and selection.	Activities: Identifying the problem, students open the contents of the flashlight system to find out the components and systems of the flashlight work; students redesign a flashlight and then present it to the class.

3.3. Initial product development

3.3.1. STEM-based VLAB

The following is a STEM-based VLAB figure 1.

Figure 1. Virtual laboratory display.

Figure 1 above is the initial display of a STEM-based virtual laboratory. can be seen there are several important points, namely: instructions for use, material, virtual practicum, video and evaluation.

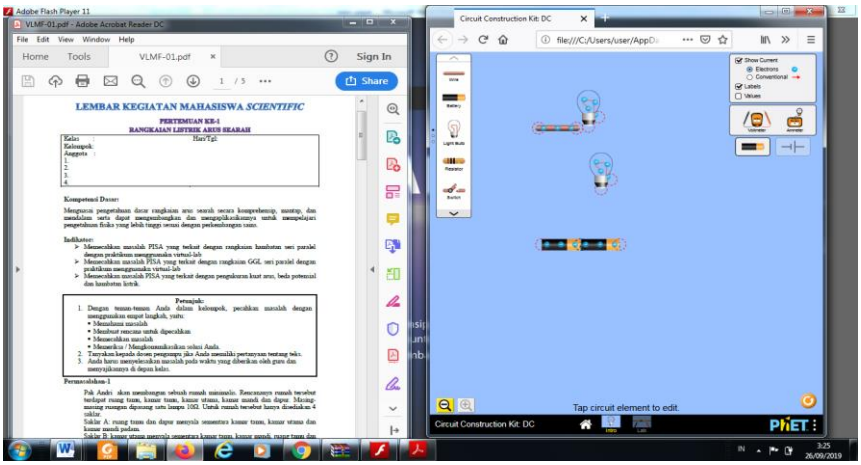

Figure 2. Display lab work in a virtual laboratory.

Figure 2 above is a picture of a virtual lab, students do a practicum with the right virtual lab using PHET and the left is a student worksheet on a DC circuit construction kit. With a screen display as in

figure 2. Facilitate students in practicing with the guidance of student worksheets. This is an advantage of this product.

Based on the results of VLAB media validation by one media expert and two content experts the data in the following table 2.

Table 2. Validation data of VLAB media by experts.

No	Expert	Percentage (%)	Remarks
1.	Media	80,36	Very decent
2.	Content-1	64,28	Eligible
3.	Content-2	82,14	Very feasible
	Average	75,59	Eligible

The results of the average validation of STEM-based VLAB media that is with a percentage of 75.59%, this shows that STEM-based VLAB media is feasible to be applied in learning. Before it was applied in learning there were several revisions. The revision is a suggestion from the validator so that the VLAB media is more suitable to be applied in learning.

Media experts suggest improving writing and in the Evaluation section, multiple-choice should be in the form of buttons. Not only hyperlink text. Content experts provide suggestions for adding animation to the material section and completing the material.

3.3.2. STEM-based student worksheet

Student worksheets are divided into two: scientific process worksheets and process engineering worksheets. The scientific process worksheet is a student worksheet that contains the scientific process, besides the scientific worksheet is a worksheet to complete the practicum in a virtual laboratory. In it students are given problems with the electrical circuit in the house, it is expected that students can assemble the electrical resistance. Questions in the form of open-ended, students can identify problems, hypothesize, determine practical steps, and design a series, and provide conclusions.

Process engineering student worksheets are a real guide for students in practicum. Students were asked several questions about the flashlight, why did the flashlight come on? How is the circuit in the flashlight? What components makeup it? How does the principle work? Then students redesign flashlights according to their ideas. At the next meeting, students presented the results of an innovative flashlight design.

The next step is the student worksheet validated to determine the level of eligibility. Following are the validation results:

Table 3. Validation of student worksheet data by experts.

No	Expert	Percentage (%)	Remarks
1.	Language	90.0	Very decent
2.	Content-1	83.33	Very decent
3.	Content-2	79.17	Very decent
	Average	84.17	Very decent

The validation results in the table above show that student worksheets are very feasible to be applied in learning with an average validation score of 84.17%. In contrast to the findings by Serene, worksheets may not play an important role in improving student learning [20]. While STEM will be realized if it has a good or project-based worksheet. STEM becomes important in life. Like research conducted by Kuo Hung Tseng(2013), students recognize the importance of STEM in scientific and engineering disciplines; They send interviews that reveal professional knowledge that is useful for their future and that makes technology able to improve our lives and our society, making the world a more comfortable and efficient place [21].

4. Conclusion

The results of the validation of STEM learning tools are viable VLAB and student worksheets are very feasible to be applied in learning.

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