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Developing digital teaching material on basic electricity based on problem-based learning in vocational education

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ABSTRACT

The electrical topic is considered a material that is difficult to understand because electricity is a substance that is not seen but can be felt. The objectives of this study were 1.) to develop digital textbooks for basic electricity materials based on problem-based learning; 2.) to analyze the feasibility of digital textbook products for basic electricity materials based on problem-based learning. This research is development research using the 4D model, namely define, design, develop, disseminate. This study involved language, material, and media experts in validating research products. The research subjects were students of technical engineering vocational education in one of the public universities in Indonesia who took Basic Electrical and Electronics courses, namely 25 students. The data collection technique used interviews, document analysis, and questionnaires. The data analysis technique used descriptive statistical analysis. Based on the research results that have been done, it has resulted in several conclusions, namely; 1.) Development of digital textbooks on basic electricity materials based on problem-based learning is carried out by referring to the 4D model development steps, namely define, design, develop, and disseminate; 2.) The appropriateness of digital textbooks according to the media expert's assessment of getting a mean score of 3.61 is declared very good, the material expert's assessment is 3.52, which is declared very good, and the user response gets an assessment of 3.51, which is declared very good Theoretically developed digital textbooks are able to increase student interest and motivation to learn basic electrical materials in an easy way.

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INTRODUCTION

The use of digital technology in learning is increasingly in demand by teachers nowadays, especially in this covid-19 outbreak situation such as WhatsApp, Google Classroom, Google Classroom, Edmodo, and Zoom (Pratama & Mulyati, 2020). Digital technology is a very important element for the success of learning. Many studies have proven that digital technology positively impacts learning (Balanskat et al., 2013; Dawson, 2008; Ditzler et al., 2016). Learning digital

technology can increase student motivation and help teachers to organize more interesting learning (Walan, 2020). With the rapid development of digital technology at this time, students should have many skills, be able to adapt, and be ready to face the challenges and competency needs of the future which are always changing very quickly (Anthonysamy et al., 2020).

One of the digital technologies developed in the world of education is digital material to support learning. The rapid development of computer technology has resulted in increasingly compact, small, fast, cheap, and interconnected devices (Sargeant, 2015). This is in line with digital material, which is always increasing in digital books' quality, production, and consumption (Yokota & Teale, 2014). The research found that digital teaching materials are useful for learning success, making the learning process more interesting and fitting well with current technological developments (Demirkan, 2019).

Digital teaching materials can be in the form of online textbooks, videos, and assessment platforms that can help student learning success (Moro, 2018). However, both print and digital book formats will likely continue to coexist for some time (Yokota & Teale, 2014). Digital picture books not only feature narration and photographs but can also contain various media elements (Sargeant, 2015). Digital books can be added to videos or web addresses for students to understand difficult material so that they can gain comprehensive knowledge of narrative explanations and complementary explanations in videos presented in digital books. The results of Setiyani's (Setiyani Setiyani et al., 2020) research show that digital modules can increase students' independence in learning because their use is not limited to the classroom. The selection of learning media must consider the suitability of the material and the appropriateness of using learning media (Ramdani et al., 2019). It can be concluded that digital teaching materials have far greater advantages and benefits than printed teaching materials.

The development of digital teaching materials requires technical expertise and scientific field expertise. When compared to traditional learning sources, digital teaching materials require technical skills regarding the use of more complex digital equipment and technology. In addition, the development of digital learning resources requires large costs and investments (Ling & Ze, 2011). One of the interesting materials to study is electricity. Students have a high interest in studying electricity. The problem that occurs is when they study electrical material, especially direct current electricity, they have difficulty understanding the material (Gunstone et al., 2009). In addition, the electrical material is abstract, complex, and requires detailed and comprehensive explanations. Electrical materials should be presented in stages and sequentially with clear content (Mulhall et al., 2001).

There are two very important problems regarding the transfer of knowledge in electricity, namely: 1.) Models, metaphors, or explanations that are in accordance with the development of students; and 2.) Detailed explanations in accordance with the conceptual understanding of students (Mulhall et al., 2001). One of the ways to increase student understanding to study electricity material is by applying a variety of learning methods. One well-known and continuously implemented knowledge-based learning model is coaching over problem-based learning (PBL) (Dawilai et al., 2021). The problem-based learning model is an instructional learning model that is specifically designed to assist students in learning new information more effectively, with the aim of stimulating students' ability to solve problems and to increase learning motivation and deepening knowledge (W. Gijselaers, 1995).

The use of problem-based learning models greatly helps students in making learning easier because this model focuses on a student-centered pedagogical approach that allows students to do research in practice and integrate it theoretically (Savery, 2006). The problem-based learning model has been applied in several fields of education. This model is widely applied by different disciplines such as engineering, medicine, architecture, business, economics, administration, social work, geology, law, and other fields for age levels. different and in different content fields since the 1990s, and applied to different layers of schools such as elementary schools, junior high schools, senior high schools, vocational schools (Xian & Madhavan, 2013)

The problem-based learning model is very in accordance with the characteristics of students in deepening their abilities. Students will be guided in solving the problems faced, namely between

beliefs, doubts, and even the uncertainty of phenomena in the face of learning. The syntax for problem-based learning consists of five phases. Phase one is the orientation of students on problems, phase two is organizing students to study or research, phase three is guiding or assisting investigations independently, or in groups, phase four is developing and presenting the work, phase five is analyzing and evaluating the problem-solving process (Arends, 2009). The end result of this learning is that students are expected to be able to find the right solution to the problem or phenomenon that will be worked on later. In determining how to find a solution to a problem, students will study in groups so that learning can motivate each other more and build solutions together (Ding & Zhang, 2018).

The Center of Teaching and Learning at Stanford University has studied the effectiveness of group learning, in its journal states that solving problems in group learning will be able to improve student learning outcomes, problem-based learning shows that students are able to implement their knowledge in solving new problems, and it is also a much more effective strategy for learning in vocational education (Santharooban & Premadasa, 2015).

Over the past 40 years, Problem-based learning has been widely adopted in technical education due to its effectiveness which is expected to develop students' transferable professional knowledge and skills (Chen et al., 2021). PBL is a learning model that requires students to participate in learning activities and practice the material to support learning skills (Zotou et al., 2020). PBL is a method of teaching based on learning experience (Hmelo-silver, 2004). When PBL is strengthened by the use of collaborative Web technologies in mixed settings called PBL2.0 (Tambouris et al., 2012), Pupils can use a variety of tools to more effectively perform the tasks required to solve their problems in learning (Ünal, 2019).

Some teachers have difficulty implementing problem-based learning methods because they need data for the progress of learning and the decisions of each step. In addition, another problem is that teachers still find it difficult to change conventional teaching habits into PBL format learning. However, the application of PBL is increasing at every level of education. This shows that the application of PBL is considered effective in preparing students who have the knowledge and practical skills they have acquired based on their experiences (Chen et al., 2021).

Based on the description of the problems above, a solution is needed to solve the problems of students who have difficulty understanding electrical materials by developing problem-based learning-based digital teaching materials. This is considered important because students need a condition where they can carry out interesting learning activities and can be used digitally via cellphones or other electronic devices. To address it, this research aims to develop digital textbooks for basic electricity materials based on problem-based learning and to analyze the feasibility of digital textbook products for basic electricity materials based on problem-based learning.

RESEARCH METHOD

This research and development study uses a 4-D model (Define, Design, Develop, Disseminate). The research stage defined the initial conditions, namely front-end analysis, learner analysis, task analysis, concept analysis, and specifying instructional objectives. The design stages are criterion-test construction, media selection, format selection, and initial design. The development stages are an expert appraisal and developmental testing. The dissemination stage is the dissemination stage. The research and development model chosen is a development model that is considered the most appropriate and relevant to the research objectives, namely developing digital textbooks for basic electricity materials based on problem-based learning. The research location is the Faculty of Teacher Training and Education (FKIP) of one of the public universities in Indonesia, to be precise, in the department of Mechanical Engineering Vocational Education (PVTM). The object of this research was 25 students. The sampling technique used a purposive sampling technique with the criteria of students who have taken basic electricity and electronics courses as well as electrical vehicle theory.

Data collection techniques in this study consisted of three techniques, namely: 1.) The interview aims to produce data about the problems and conditions of students in learning. Interviews were conducted in an unstructured manner to explore information about problems or important points

freely without any interview guidelines, but only specifically on the information that students wanted to extract; 2.) The questionnaire is a data collection method that providing a collection of statements or questions to respondents. The questionnaire developed is an open questionnaire; 3.) Document analysis, namely data collection in the form of documents related to the object of research. Research instruments have a very important role in the development of digital textbooks based on problem-based learning. The data collection instruments in this study were textbook assessment sheets and student response questionnaires. The grid of assessment sheets for material experts and media experts can be seen in Tables 2 and 3. The user response assessment sheet can be seen in Table 4.

Table 1. Material Expert Assessment Sheet Grid

Indicator	Sub Indicator
I. Content Feasibility Aspects	1. Suitability of the material with the RPS 2. Accuracy of material 3. Up-to-date material 4. Encourage curiosity
II. Presentation Feasibility Aspects	1. Presentation technique 2. Serving support 3. Presentation of learning 4. Coherence and sequential thought
III. PBL implementation	1. Problem orientation 2. Organizational problems 3. Investigation 4. Develop 5. Present 6. Analyze
IV. Contextual assessment aspects	1. Nature of contextual

Table 2. Media Expert Assessment Sheet Grid

Indicator	Sub Indicator
I. Graphic Feasibility Aspects	1. Product size 2. Product cover design 3. Product layout 4. Layout of indicators 5. Use of letters 6. Use of terms / meanings
II. Aspects of Language Eligibility	1. Straightforward 2. Communicative 3. Dialogical and interactive 4. Conformity with the development of students. 5. Conformity with language rules 6. Use of terms, symbols or icons

The data analysis technique used descriptive statistical analysis techniques. Data presentation in the form of tables, graphs, diagrams, histograms, calculation of the mean, median, mode, data distribution, calculation of the average, standard deviation, and calculation of the percentage. Validity analysis is used to ensure that the textbook developed meets the valid criteria. The scoring of the assessment results using a 1-4 Likert scale can be seen in Table 3.

Table 3. Scale of Digital Textbook Assessment Results

Criteria	Score
Very Good	4
Good	3
Less	2
Very less	1

Table 4. User Response Assessment Sheet

Indicators	Sub Indicators
A. Interest	This Textbook appearance is attractive.
	This Textbook can increase enthusiasm for learning
	This Textbook makes the learning process not boring.
	This Textbook supports me to master the material in the lesson.
	The existence of illustrations can provide motivation to learn basic electrical material
	With the simulation, it makes it easier for me to understand basic electrical material.
B. Material	The delivery of basic electrical material is related to everyday life.
	In this textbook, there are several sections for me to find my own concept
	The delivery of the material in this textbook is easy for me to understand and interesting to learn.
	The presentation of the material in this textbook encourages me to discuss it with other friends.
	This textbook encourages me to be more active in learning.
C. Language	The language used in this textbook is interesting to read and easy for me to understand.
	The sentences and paragraphs used in this textbook are clear and easy for me to understand.
	The letters used are simple and easy to read.

Calculate the average score for each aspect using Formula 1. Changing the average score obtained into a qualitative value according to the four scale assessment criteria as shown in Table 5, then classified according to the digital textbook assessment classification guidelines, which can be seen in Table 6.

$$\bar{x} = \frac{1}{number\ of\ validators} \times \frac{\sum_i^n x}{n}$$

$\bar{x}$ = the average score for each aspect
$\sum_i^n x$ = the total score for each aspect
n = number of items in each aspect statement

Tabel 5. Guidelines for Assessment Classification

Interval			Category
Mi + 1,5 SD	< X ≤	Mi + 3 SD	Very Good / Very High
Mi	< X ≤	Mi + 1,5 SD	Good / High
Mi - 1,5 SD	< X ≤	Mi	Less / Low
Mi - 3SD	≤ X ≤	Mi - 1,5 SD	Very Less / Very Low

Information:
SMi = maximum ideal score
Mi is the ideal mean = 1 / 2SMi
SDi is the Ideal Standard Deviation = Mi / 3

Table 6. Guidelines for Classification of Digital Textbook Assessment

Interval			Category
3,25	< X ≤	4	Very good
2,5	< X ≤	3,25	Good
1,75	< X ≤	2,5	Less
1	≤ X ≤	1,75	Very less

RESULT AND DISCUSSION

Result

The implementation of research on the development of basic electrical digital textbooks based on problem-based learning uses 4D stages, namely define, design, develop, and disseminate. Based on the implementation of the research, the following results were obtained.

Define Stages

The results obtained at the defining stage for the front-end analysis stage were: 1.) Students experienced difficulties in basic electrical electronics courses. The material presented is still abstract when the practitioner is not done directly; 2.) The learning method is still monotonous, causing students to be less motivated; 3.) The media used are only power points and reference books, so that the basic concepts of electricity still lack references, and students still experience problems; and 4.) Digital textbook for basic electricity based on problem based learning refers to the Semester Learning Plan (RPS) for basic electronics courses. The learner analysis stage resulted in data that in the basic electrical electronics course, the average midterm test score was 64.14, and the final semester score was 77.45. Based on the values obtained, it can be concluded that students still experience problems regarding the basic electrical component material. In addition, learning methods that are still monotonous cause students to be less motivated.

The third stage, the concept analysis of the Semester Learning Plan (RPS), produces information that basic electricity and electronics courses consist of nine basic competencies: 1.) Able to understand and explain basic electrical concepts; 2.) Able to understand and explain current, voltage, resistance, power; 3.) Able to understand and explain AC and DC currents; 4.) Able to understand and explain electronic components; 5.) Able to understand and assemble simple circuits using diodes, transistors; 6.) Able to understand and make logic circuits; 7.) Able to understand and make simple circuits using a microcontroller; 8.) Able to understand and explain transformer; and 9.) Able to understand and explain the concept of an electric motor. The nine basic competencies must be mastered by students who take basic electricity and electronics courses. Based on the results of interviews and document analysis, it was concluded that the basic concepts of electricity lacked in reference, and students still experienced problems.

The fourth stage is task analysis. Based on the problems and possible solutions to the problems that have been studied, it can be concluded that there must be an effort to solve the obstacles in learning by developing a teaching material that refers to the semester learning plan (RPS) that is relevant to the needs and characteristics of students in today's digital era. The final stage is specifying instructional objectives, which aims to summarize the results of the front-end analysis, learner analysis, concept analysis, and task analysis stages. Based on the information obtained and several other considerations, it was concluded that there was a need for the development of a digital textbook for basic electricity based on problem based learning, focusing on the components of resistors, capacitors, inductors, diodes, and transistors as a reference for developing digital textbooks. Based on the problem description and analysis presented above, this study developed a problem-based learning digital textbook, which was developed in accordance with the competencies and rules of textbook development.

Design Stages

The design stage has the objective of designing or designing a product in the form of a basic electrical digital textbook based on problem based learning. The design stages consist of four stages, namely criterion-test construction, media selection, format selection, and initial design. Criterion-test construction is the first stage in designing a digital textbook that will be developed as for the results of this stage, namely analyzing the identification results of the defined stage related to the type or specification of the test, which will later become the basis for developing problem-based basic digital textbooks based learning.

The media selection stage is carried out to identify the determination of learning media to be developed, adapting to current developments that utilize digitalization in the daily life of researchers to develop a basic digital book based on problem-based learning. Format selection is the third stage, wherein this selection format, the selection of formats in the development of learning media, is intended to design or design the content of learning media. In contrast, the format chosen meets the criteria for basic electrical competence and rules in developing basic digital electricity-based textbooks problem-based learning. The fourth stage is the initial design, where at this stage, the objective is to design in detail or comprehensively before developing a basic digital electricity textbook based on problem-based learning. Based on the information obtained, the following is the cover design for the digital textbook being developed.

Figure 1. Basic Electrical Digital Textbook Cover Design Based on Problem Based Learning

Develop Stage

The stages at the development stage in this research are expert or practitioner assessments of the products developed as a result of these assessments, such as input from experts whether or not the basic digital electricity textbook based on problem-based learning is developed or not. This stage consists of three steps, namely validation of media experts, materials, and user responses. Media expert validation conducted an assessment of 9 indicators to assess basic digital electricity textbooks based on problem-based learning by involving five media expert validators. The results of media expert validation can be seen in Table 7.

Table 7. Average Results of Media Expert Validation

No.	Assessment Indicators	Average Score	Percentage	Criteria
A	Graphic Feasibility Aspects			
	1 Module Size	3,80	95%	Very good
	2 Module Cover Design	3,65	90%	Very good
	3 Module Content Design	3,68	88%	Very good
B	Aspects of Language Eligibility			
	1 Straightforward	3,47	85%	Very good
	2 Communicative	3,50	85%	Very good
	3 Dialogical and Interactive	3,50	90%	Very good
	4 Suitability with the Development of Students	3,70	85%	Very good
	5 Conformity with Language Rules	3,70	95%	Very good
	6 Use of terms, symbols or icons	3,50	90%	Very good
	Average	3,61	90%	Very good

This stage of development consists of being carried out carefully and thoroughly. This is because the validator provides input and suggestions that are very important for improving the textbooks being developed. The validators provide input to use the page design of each chapter with an attractive appearance. This is intended to increase the motivation and interest in learning of students.

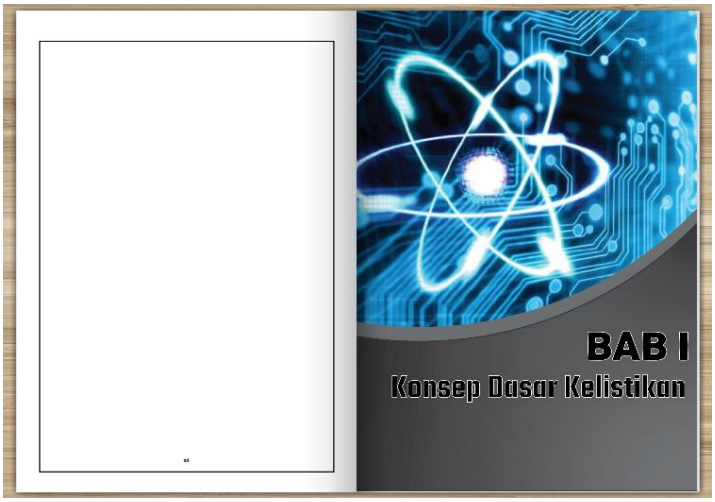
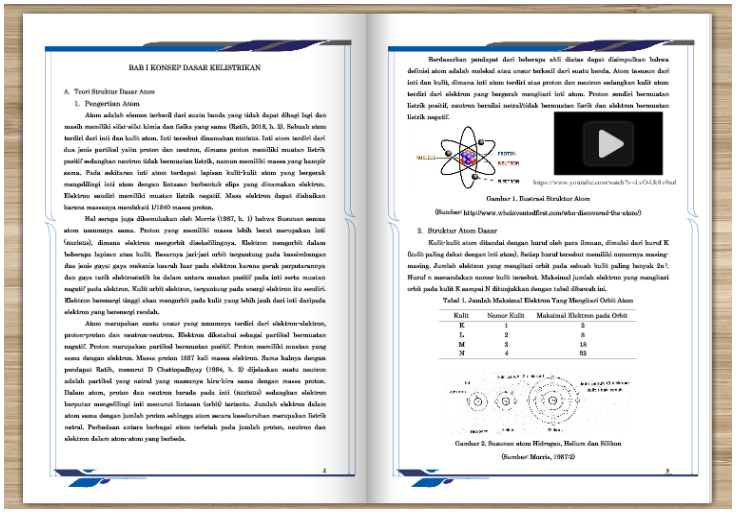


Figure 2. Pages of Each Chapter in Textbook

In addition, the validator provides input regarding the material presentation added with video elements. This aims to increase understanding and deepen the material being studied. Students can watch videos directly in digital textbooks, making it easier to strengthen knowledge and skills in the context of problem-based learning.



The addition of the video has a positive effect and gives the impression of digitizing the material encapsulated in one digital teaching material equipped with video. This shows that the material in PDF form can be made as attractive as possible to produce a unique textbook and attract readers' attention. The stages of validating material experts in digital textbooks use 14 indicators involving five material expert validators. The validator involved is someone who has met the criteria to be able to provide input and suggestions for improving the digital textbook. The results of material expert validation can be seen in Table 8.

Table 8. Average Results of Material Expert Validation

No.	Assessment Indicators	Average Score	Percentage	Criteria
A	Content Feasibility Aspects			
	1 Material Conformity with RPS	3,47	87%	Very good
	2 Accuracy of Material	3,60	90%	Very good
	3 Material up-to-date	3,36	84%	Very good
	4 Encourages Curiosity	3,80	95%	Very good
B	Presentation Feasibility Aspects			
	1 Presentation Technique	3,60	90%	Very good
	2 Serving Support	3,40	85%	Very good
	3 Presentation of Learning	3,40	85%	Very good
	4 Coherence and Sequence of Thought Plains	3,80	95%	Very good
C	Implementation Problem Based Learning			
	1 Problem Orientation	3,50	88%	Very good
	2 Problem Organization	3,50	88%	Very good
	3 Investigating	3,30	83%	Very good
	4 Develop and present	3,50	88%	Very good
	5 Analysis and evaluation	3,40	85%	Very good
D	Contextual Assessment			
	1 Nature of Contextual	3,67	92%	Very good
	Average	3,52	88%	Very good

The material expert stage provides input related to the content or content of the material presented in digital textbooks. Some suggestions and improvements regarding the images and videos presented are less relevant, and it is recommended to replace them with clearer images. In addition, to anticipate and increase the possibility of video playback, textbooks are recommended to create a barcode version, as shown in Figure 4.

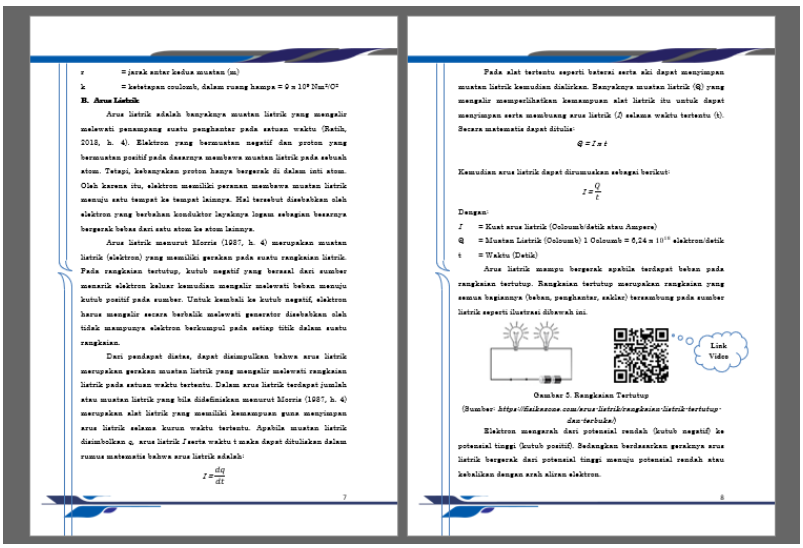


Figure 4. Textbook Equipped with Barcode for Video Link

User response trials were carried out on students of technical engineering vocational education in one of the public universities in Indonesia. The development of a textbook instrument consists of three indicators: interest divided into six indicators, the material divided into five items, and language divided into three items. The total number of items on the user response instrument is 14 items. User responses in this study consisted of 25 PVTM students. The results of the user response test are as follows. Third, a user response trial was conducted on students of technical engineering vocational education in one of the public universities in Indonesia. The development of

a textbook instrument consists of three indicators: interest divided into six indicators, the material divided into five items, and language divided into three items. The total number of items on the user response instrument is 14 items. User responses in this study consisted of 25 PVTM students. The average user response test results can be seen in Table 9. The dissemination stage in development aims to publish or promote problem-based learning-based digital electric textbook products that researchers have developed and have met the set eligibility criteria. This stage is carried out by publishing textbooks through publishing digital textbooks with ISBN and registering research products with Intellectual Property Rights (HKI).

Table 9. Test Average User Response

Assessment Indicators	Average Score	Percentage	Criteria
Interest	3,58	90%	Very good
Theory	3,50	87%	Very good
Language	3,45	86%	Very good
Average	3,51	88%	Very good

Discussions

Steps to Develop a Digital Textbook

The development step in this study uses the 4D (four-D) stage. Development of Digital Basic Electricity Textbooks Based on Problem Based Learning is to modify the 4-D model (Four D model) from Thiagarajan et al. (1974), which consists of stages define, design, develop, and disseminate. Four adapted development steps become the basis for the Development of Basic Electrical Digital Textbooks Based on Problem Based Learning. Each stage has its respective roles and functions for the creation of research products. Based on the stages that have been used, it can be concluded that the four D development model has clear stages in each research step. This is the basis for choosing this model to be used in the implementation of research.

Digital Textbook Eligibility

Feasibility analysis in research involves three ways based on the assessment of media experts, material experts, and user responses. The research product in the form of a problem-based learning-based digital electrical textbook that has been developed meets the valid criteria based on the assessment results by media experts and material experts.

The development of digital textbooks based on problem-based learning consists of five stages in each material presented, namely following the following stages: 1.) Orientation of students to problems; 2.) Organizing students to study or research; 3.) Guiding or assisting investigations independently or in groups; 4.) Develop and present the work; and 5.) Analyze and evaluate the process of solving a problem. The description of the research results that have been described previously describes the steps to develop basic digital electricity textbooks based on problem-based learning and the results obtained. The development results in the form of the final product have been tested for feasibility based on material experts and media experts.

The research product in the form of a digital textbook that has been developed meets valid criteria based on the results of assessments by media experts and material experts who come from mechanical engineering lecturers and have reached the minimum criteria well. According to media experts, the developed digital textbook has a mean score of 3.61 out of a maximum score of 4 with a very good classification. The average results of material expert validation can be seen in Figure 6.

Based on Figure 6 shows that textbooks still need to pay attention to the implementation of learning with the concept of problem-based learning, which is used as a guide for implementing learning. This is because every student must be able to apply the real problem-based learning stages through digital books as a guide for implementing these activities. Although theoretically, the digital textbook is considered capable of being implemented, it still needs in-depth research on the real implementation that will be carried out in the future. Theoretically, this textbook is declared to meet

valid criteria and can be used for learning basic electricity material. The results of user responses can be seen in Figure 7.

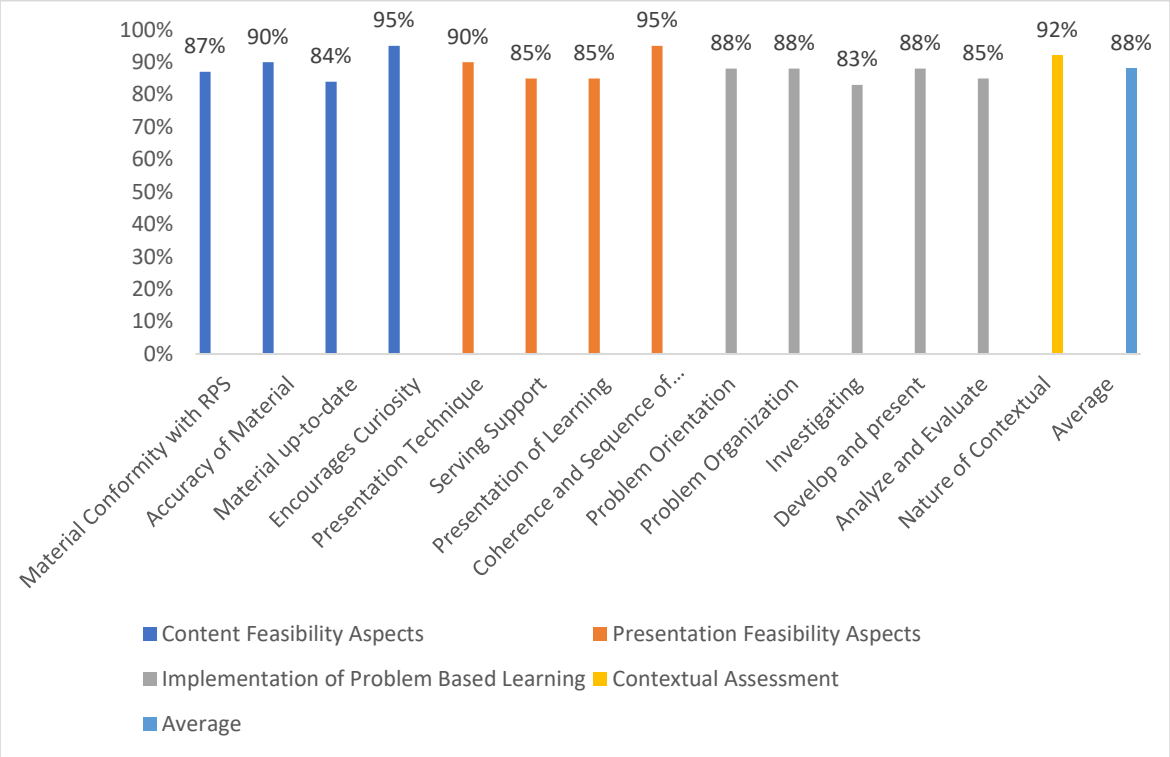


Figure 6. Diagram of Average Material Expert Validation Results

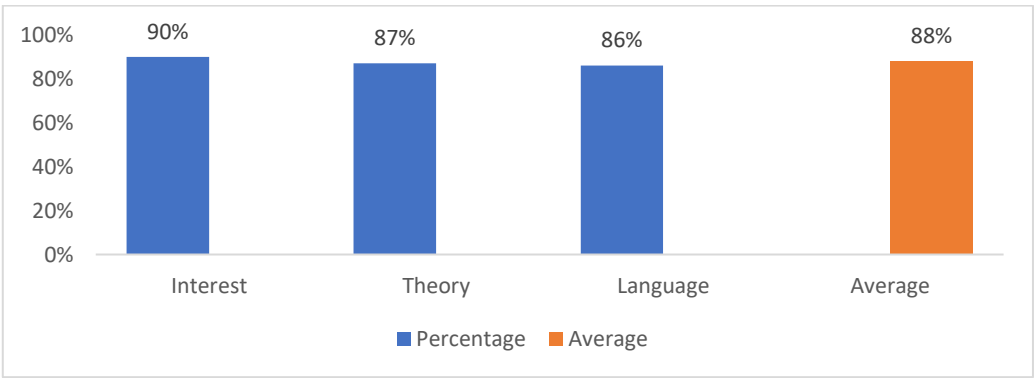


Figure 7. Results of Assessment of User Responses to Digital Textbooks

The results of the analysis, according to user responses, resulted in a mean score of 3.51, which fell into the very good category. This shows that students can use digital textbooks on basic electricity materials based on the developed problem-based learning. The highest aspect is the indicator of interest, and the lowest aspect is the element of language use. This shows that textbooks are considered to have met the valid criteria to be applied with several important points that need to be considered so that the application of this digital textbook can be useful for students and lecturers. This is in line with the results of research, which show that digital learning shows a positive effect and a significant effect on motivation and learning outcomes that are better than conventional learning (Lin et al., 2017). Therefore, the use of digital material theoretically and practically can increase students' motivation and learning outcomes.

CONCLUSION

Based on the research results that have been carried out until the development stage, it can be concluded that some important information is as follows: 1.) The steps for developing digital textbooks on basic electricity materials based on problem-based learning refer to the 4D (four D) model development steps, namely define, design, develop, and disseminate. The four stages are described in detail, starting at the stage of defining the initial conditions of the research object to look for problems and potentials that need to be developed so as to produce a decision at the end of the defined stage, which will be used as the basis for the development or design of research products. At the design stage, research products are developed based on the information presented at the defined stage, so that product development is in accordance with the needs of the research object. At the development stage, research products are developed and studied theoretically and practically to determine the quality and quality of the research products being developed. At this stage, the product is submitted to material experts, media, and users to be objectively assessed. The final stage is disseminating, which is disseminating research products within the scope of national scientific activities as well as journal publications and IPR; 2.) Feasibility of digital textbooks on basic electricity materials based on problem-based learning to obtain data, namely the media expert's assessment with a mean score of 3.61, which is declared very good, and the material expert's assessment of 3.52 is declared very good. User response to get a rating of 3.51 is declared very good.; and 3.) Based on the research results, it shows that the development of digital textbooks has benefits for students and lecturers in the process of acquiring knowledge and skills of basic electrical material, which are usually considered difficult for some people. Therefore, the research product in the form of problem-based learning digital teaching materials is theoretically feasible for use by lecturers and students.

The development of digital teaching materials, especially in basic electrical materials, has an important role to play in supporting the success of learning. The existence of increasingly sophisticated technological developments requires educators to innovate to produce teaching materials and develop learning methods that are more creative and in accordance with the times and technology. Further research can be done to develop teaching materials that use augmented reality and virtual reality technology to improve an in-depth understanding of electricity using up-to-date technology. Besides that, website-based digital teaching materials integrated with other relevant media can be an interesting topic going forward.

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