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Development of Teaching Modules for Operation and System Stability Courses as a Pilot Project for the Electrical Engineering Study Program Towards Independent Learning

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Abstract— The challenges of the future of education are increasingly complex. The position of educators in the era of the industrial revolution 4.0 tends to be a facilitator who provides the latest information regarding the development of science. Merdeka Learning is an independent and versatile higher education learning model designed to create an unrestricted creative learning community. This development research resulted in teaching material in the form of learning modules and videos for the Operations and System Stability course. The process of developing modules/teaching materials uses the ADDIE development model, namely Analysis, Design, Development, Implementation, and Evaluating. The teaching materials developed are suitable for students to use based on the results of the formative test data and the Likert scale with 86%-100% being very good criteria. In the one-on-one trial, the percentage of expert eligibility was 94.5% for digital modules, and 92% for learning videos. In a small group trial taken from 7 TE 2017 and TE 2018 students, the percentage of eligibility results was 94% for digital modules, and 94.5% for learning videos. Meanwhile, in the field trials taken from 76 students of TE 2017 and TE 2018 the results of the feasibility percentage were 91% for digital modules and 90% for learning videos.

Keywords: Industrial Revolution 4.0, Free Learning, Teaching Materials, Modules, ADDIE Development Model, Operations and System Stability, Merdeka Learning.

1 Introduction

The increasingly massive development of information technology in various sectors will be directly proportional to the development of innovation in teaching and learning activities in universities [1]. Meanwhile, educators as the main actors in learning activities are required to be versatile and master technology in this millennial era [2]. Educators as people who know are also mandated to be able to become facilitators, collaborators, motivators, and evaluators [3]. To answer this, the use of information technology becomes a necessity to be used as a compliment and learning resource to be able to improve understanding of the material which ultimately prepares students to face the challenges of the industrial revolution era 4.0 [4]. To be able to create a comprehensive understanding of the material, it is necessary to collaborate or innovate in the process of teaching and learning activities that facilitate learning objects and subjects to understand easily accessible teaching materials and teaching content.

The challenges of the future of education are increasingly complex. The future education system faces different challenges that require different approaches in the delivery of higher education. The challenge is no longer a competition for knowledge but a competition for creativity, a competition for imagination, a competition for learning, competition for free thinking. The situation in the future is also faced with various conditions of Volatility, Uncertainty, Complexity, and Ambiguity (VUCA). In the end, students must be able to adapt to every change, every condition, and remain independent people. The Ministry of Education and Culture responded to this by issuing several new policies on January 24, 2020, including the Merdeka Learning - Merdeka Campus policy. Merdeka Learn-Independence Campus is an independent and versatile higher education learning model designed to create an unrestricted creative learning community that meets the needs of students in the face of changing environmental conditions, full of uncertainty and complexity of problems [5].

Operations and system stability courses are courses taken by undergraduate students. The course consists of theoretical discussions and simulations. For theoretical discussion, students can learn through learning resources from reference books from course lecturers and also the use of simulation software available in the department's laboratory. Meanwhile, the current situation regarding the COVID-19 pandemic has caused distance learning to be carried out so that there is a need for learning innovations through media to support student needs, namely the need for teaching materials that can be accessed at any time such as learning videos and teaching modules.

The position of educators in the era of the industrial revolution 4.0 tends to be facilitators who provide the latest information regarding the development of science to students from various circles. resources, so educators must have

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competence in technology and digital (Setiawan et al. 2019). With the help of the media can simplify the complexity of the material presented to students [6]. Currently, technology-based learning media have been widely developed. This type of learning media can not only add value to the function and use of technology [7], it can also improve student academic achievement [8]. Academic achievement can include cognitive learning outcomes, learning motivation, and learning independence. One of the programs that can be developed into interesting learning media is learning videos, teaching materials/books with ISBN.

2 Research Methods

This research is included in the type of research and development, commonly called research and development (R&D). Sugiyono believes that research methods are used to produce products and test the effectiveness of these products [10]. [11] put forward another view that research and development aim to produce new products through the development process. In general, R&D is research that aims to produce new products and test the effectiveness of these products. This study uses the ADDIE development model, which is a development model consisting of five stages, namely Analysis, Design, Development, Implementation, and Evaluating, but this study is limited to the implementation stage. Because in this development study, only the feasibility of the product being developed is evaluated, the effectiveness of the learning media products/teaching materials is not evaluated.

Several sources of data in this study used questionnaires from media experts, material experts, and resource persons. According to [10] data collection is answered by providing a series of written questions to respondents. Questionnaires were used to measure the quality of the developed media. The questionnaire in this study was used to obtain data from media experts, material experts, and resource persons as an evaluation material for the developed learning media. Writing this questionnaire using a Likert scale. The use of qualitative and quantitative data in this study was used to develop data collection procedures in learning media. Qualitative data in the form of suggestions and input from media experts and material experts. Quantitative data in the form of assessment data about learning media based on audio studio media player from material experts, media, and respondents.

The data sources in this study were 2 experts, namely 1 material expert and 1 media expert as a one-on-one trial. Then continued trials in small groups which were used as many as 7 students for students and 76 students for large group field tests. The instrument used is a media assessment questionnaire for media experts, material experts, and students. The data collection technique used is the observation of undergraduate students in Electrical Engineering and provides expert validity questionnaires and student feedback. The quality of the learning media data based on audio media studio is in the form of percentage descriptive data.

The media validation and the resulting discussion were carried out by media expert validators and material experts and then analyzed using a descriptive percentage technique with the formula [9]:

$$V = \frac{TSe}{TSh}\ x100\% \quad (1)$$

V: Validation (expect1, expect2, student)
TSe: Total empirical score achieved
TSh: Total maximum score

To decide to determine whether or not the teaching materials developed are appropriate, the assessment qualification criteria are used. According to [9] the developer can determine the validity criteria personally which is adjusted to the number of items in the instrument. From this statement, validity and feasibility criteria can be determined using the following equations:

Value interval (IN) = $\frac{score\ different}{\sum Class\ interval}$
Score difference (SS) = $Maximum - Minimum\ score$
Maximum score = item x Highest score
Minimum score = item x Lowest score
Validity percentage interval (IV) = $\frac{value\ interval}{maximum\ score} x100\%$

Questionnaire data processing uses a Likert scale, the following scores are used (Purwanto, 2013):

Table 1 Likert Scale

Percentage	Criteria
86%-100%	Very Good
76%-85%	Well
60%-75%	Enough
55%-59%	Not Good

3 Analysis Results

The product design results in this research and development are in the form of teaching materials that contain modules and learning videos on Operations and System Stability for the Operations and System Stability course. The design of the development of this teaching material uses the ADDIE development model. The development process is divided into five steps, namely (1) *analyze,* (2) *design*, (3) *develop*, (4) *implement*, and (5) *evaluate*.

The design of the Operations and System Stability module according to the Daryanto format (2014: 193) which has been adapted according to needs consists of (1) cover, (2) introduction, (3) introduction, (4) learning materials, (5) summary, (6) formative test, (7) list of references. While the structure of the video refers to [12] which has been adapted as needed as it consists of: (1) front page, (2) learning objectives, (3) apperception, (4) learning materials. Trial data in the form of data from one-on-one trials, small group trials, and field trials. The data from the one-on-one trials were obtained from

the validation results of expert 1 and expert 2. While the data from the small group trial results were obtained from distributing questionnaires to 5 2018 TE students and 2 2017 TE students. Field trials were obtained by distributing questionnaires to 76 TE students. 2017 and TE 2018 who are currently taking and have taken the Operations and System Stability course:

A. Flowchart Presentation and Data Analysis of One-on-One Trial Results

The data on the results of the one-on-one trial were obtained from expert 1, namely Imron Ridzki, and expert 2, namely Syarifuddin. Presentation of the data from the one-on-one trial. The explanation of the results of the one-on-one test assessment by expert 1 and expert 2 for digital modules and learning videos is as follows: :

a. Module

Details of quantitative data from the results of the one-on-one trial assessment for the module by expert 1 and expert 2 are shown in Table 2.

Table 2 Presentation of Expert Test Result Data Module

No		∑Tse	∑Tsh	V-ah (%)	Keterangan
Expert 1					
1	Content Eligibility	40	40	100	Sangat baik
2	Language Eligibility	23	24	96	Sangat Baik
3	Serving Eligibility	32	32	100	Sangat baik
4	Graphic Eligibility	12	12	100	Sangat baik
Total		**95**	**108**	**99**	**Sangat baik**
Expert 2					
1	Content Eligibility	35	40	88	Sangat baik
2	Language Eligibility	21	24	88	Sangat baik
3	Serving Eligibility	27	32	84	Sangat baik
4	Graphic Eligibility	12	12	100	Sangat baik
Total		**101**	**108**	**90.00**	**Sangat baik**
Average				**94.50**	**Sangat baik**

Description:
V-ah (%) = Expert validation.
Tse = Total empirical score achieved.
Tsh = Total maximum expected score.

Based on the module validation analysis by expert 1 and expert 2, the average per aspect is 94.50%, which is included in the very valid criteria. This is following the criteria that there is a percentage of 86%-100% included in the very good criteria.

b. Tutorial Video

Details of quantitative data from the results of the one-on-one trial assessment for videos by expert 1 and expert 2 are shown in Table 3.

Table 3 Presentation of One-on-One Test Result Data for Video

No	Value Aspect	∑Tse	∑Tsh	V-ah (%)	Keterangan
Expert1					
1	Learning Design	28	32	88	Very Good
2	Visual Communication	35	40	100	Very Good
Total		**85**	**96**	**94**	**Very Good**
Expert 2					
1	Learning Design	27	32	84	Very Good
2	Visual Communication	32	32	100	Very Good
Total		**94**	**96**	**97.91**	**Very Good**
Average				**92**	**Very Good**

Based on the analysis of the video validation results by expert 1 and expert 2, the average per aspect is 92%, which is included in the very valid criteria. This is following the existing criteria that the percentage of 86%-100% is included in the very good criteria.

B. Presentation and Data Analysis of Small Group Trial Results

The data from the small group trial results were obtained from students who are currently taking or have taken the Operations and System Stability course with details of 5 2018 TE students and 2 2017 TE students. The following is an analysis of module data and learning videos.

a. Module

Quantitative data were obtained from three aspects, namely aspects of appearance, presentation, and benefits which are translated into 20 items. The presentation of the data from the small group trial results for the module is shown in Table 4.

Table 4 Presentation of Small Group Trial Results Data for Modules

No	Aspect	Tse	Tsh	V-au (%)	Description
1	Display Aspect	191	196	97	Very Good
2	Presentation Aspect	233	252	92	Very Good
3	Benefit Aspect	104	112	93	Very Good
Total		**528**	**560**	**282**	Very Good
Average				**94**	Very Good

Description:
V-au = Audience validation.
Tse = Total empirical score achieved.

Tsh = Total maximum expected score.

Based on the analysis of the results of the small group trial, it was found that the average percentage per aspect was 93.25% which was included in the very valid criteria. This is following the criteria contained in Table 2 that the percentage of 86%-100% is included in the very good criteria.

b. Tutorial Video

Quantitative data were obtained from three aspects, namely aspects of software engineering, learning design, and visual communication which were translated into 20 items. The presentation of data from small group trials for video is shown in Table 5. and more fully is presented in Appendix 10.

Table 5 Presentation of Small Group Trial Result Data for Video

No	Aspect	Tse	Tsh	V-au (%)	Descriptiom
1	Aspects of Learning Design	222	224	99	Very Good
2	Visual Communication Aspect	201	224	90	Very Good
Total		**423**	**448**	**189**	Very Good
Average				**94.5**	Very Good

Based on the analysis of the results of the small group trial, the average percentage per aspect was 94.5% which was included in the very valid criteria. This is following the existing criteria that the percentage of 86%-100% is included in the very good criteria.

Presentation and Analysis of Field Trial Results

The data from the field trials were obtained from 76 students who are currently taking or have taken the Operations and System Stability course. The following is an analysis of the module data and learning videos.

c. Module

Quantitative data is taken from three aspects, namely aspects of appearance, presentation, and benefits which are translated into 20 items. The presentation of the data from the field trial results is shown in Table 6.

Table 6 Presentation of Field Trial Result Data for Module

No	Aspect	Tse	Tsh	V-au (%)	Description	Keterangan
1	Display Aspect	1987	2128	93	Very Good	Sangat baik
2	Presentation Aspect	2468	2736	90	Very Good	Sangat baik
3	Benefit Aspect	1092	1216	90	Very Good	Sangat baik
Total			**6080**	**273.**	Very Good	Very Good
Average				**91**	Very Good	Very Good

Based on the analysis of the results of field trials, the average percentage per an aspect of the whole is 91%, which is included in the very valid criteria. This is following the criteria contained in Table 2 that the percentage of 86%-100% is included in the very good criteria.

d. Tutorial Video

Quantitative data is taken from three aspects, namely aspects of software engineering, learning design, and visual communication which are translated into 20 items. The presentation of data from field trials for video is shown in Table 7.

Table 7 Presentation of Field Trial Result Data for Video

No	Aspect	Tse	Tsh	V-au (%)	Description
1	Aspects of Learning Design	2216	2432	88.87	Very Good
2	Visual Communication Aspect	2155	2432	88.14	Very Good
Total		**4371**	**4864**	**180**	Very Good
Average				**90**	Very Good

Based on the analysis of the results of field trials, it was found that the average percentage per aspect was 88.6% which was included in the very valid criteria. This is following the criteria contained in Table 2 that the percentage of 86%-100% is included in the very good criteria.

4 CONCLUSION

The resulting product is Operations and Stability teaching materials in the form of learning modules and videos. The materials discussed in this digital teaching material are (1) Contingency Analysis in the System, (2) Load Distribution on the System, (3) Unit Commitment and Economic Dispatch, (4) System Dynamic Modeling, (5) System Stability (6) System Control.

The module components consist of the cover page, preface, table of contents, list of pictures, concept map, introduction, learning materials, summary, formative test, list of references. The developed digital module is accompanied by formative test answer keys and assessment guidelines which are placed separately from the digital module. While the learning video consists of the front page, learning objectives, apperception, learning materials.

The teaching materials developed are suitable for students to use in learning the Operations and System Stability course based on the results of formative test data. In the one-on-one trial, the percentage of expert eligibility was 94.5% for digital modules, and 92% for learning videos. In the small group trial, the percentage of eligibility results was 94% for digital modules, and 94.5% for learning videos. Meanwhile, in the field trial, the percentage of feasibility results was 91% for digital modules and 90% for learning videos.

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