Virtual Laboratory Application of Direct Current Electric Motor: An Expert-Based Evaluation

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Abstract—This research aims to validate the virtual laboratory application of a direct current motor based on expert judgment. There are two aspects of the assessment. The first is the electrical machine content aspect, and the second is the computer-based media content aspect. The instrument was developed based on scientific studies related to multimedia quality criteria. The instrument was declared valid through a content validity test and evaluation by an evaluation expert. Evaluating the virtual laboratory application media was conducted by two groups of experts: the material content expert in electrical machinery and the computer-based media content expert. The assessment results showed that the virtual laboratory application media was declared Very Appropriate for all dimensions of the assessment of material and media content.

Keywords—virtual laboratory, direct current motor, expert-based evaluation, learning, education

1 Introduction

Technological advances are rapid in the digital era [1]. Digital transformation in various fields forces us to adopt changes and transform. Virtual reality offers many potential advantages for education, especially for language teaching and learning [2]–[5]. The transformation in the field of education was felt when the COVID-19 pandemic hit the world. All levels of education simultaneously use technology for learning. VR provides students with immersive learning experiences and thereby enhancing learning and increasing students' motivation and engagement. Despite these strengths, VR is relatively unexplored in foreign language education studies [4]–[7]. The concept of learning using digital technology has long been designed for the possibility that face-to-face meetings in class cannot be carried out. Distance learning using various digital platforms is also growing [8]. Flexibility, not limited by space and time, one can take lessons at the same time even from different places and even from other parts of the world.

Vocational education is education that prioritizes practical skills. Supported by academic skills and employability skills, vocational education graduates are expected to compete in the job market in today's digital era [9], [10]. Distance learning in vocational education is very challenging during the Covid-19 pandemic. Vocational education learning requires real training in laboratories, workshops, and related industries. Theoretical learning may be implemented, but practical learning, which requires real equipment and machines, is very less effective [4], [5]. However, vocational education learning still has to be implemented. The application of distance learning is considered to be still young, so the maturity of digital pedagogy competencies from teachers is still dynamic following technological developments. The level of information technology literacy, which is still low among teachers and students, makes distance learning encounter many obstacles. Integrating theoretical and practical skills into digital learning platforms is a challenge [11] and a daunting task in the e-learning environment.

Using digital media relevant to the characteristics of practical courses is being developed rapidly in the current digital era. Flexible use and inexpensive maintenance do not require a large space such as a physical laboratory, and with graphics and animation technology can visualize a dynamic process [12]–[14]. Abstract knowledge concepts that cannot be observed with the naked eye, can be presented using digital media, so a virtual experiment can be realized to prove abstract concepts [15], [16].

Practical learning of electric machines is carried out to prove the phenomenon of converting electrical energy into kinetic energy in rotary motion. The abstract, invisible nature of electric machines can be proven only through empirical tests to construct knowledge about the phenomenon of energy conversion in electric machines [17]. With animation graphics technology, electric machine props and their accessories can be created in a virtual environment [18]–[20]. Digital replicas make the real form of teaching aids in a two-dimensional display on a computer screen. The user interface is shaped like the appearance of an electric machine trainer in a physical laboratory [12], [21]. This study focuses on evaluating the virtual electric motor laboratory application to experts. This is done to determine the feasibility of the application made for practical learning of electrical machines in vocational education. Expert validation is divided into two aspects: evaluating the content aspect of the material and validating the media aspect [22], [23].

2 Virtual laboratory application of direct current motor

In this study, the virtual laboratory application of a direct current motor was developed based on needs analysis [24] and the basis for using the Simulink model [25] as the main engine for the simulation process. Virtual laboratory application of direct current motor is used as the object of expert-based evaluation. Virtual laboratory application of the direct current motor is a substitute for the physical laboratory of electric machines. Electrical machines courses are compulsory electrical engineering courses in vocational education in Indonesia.

The virtual laboratory application of the direct current (DC) motor is used to support the practice of electric machines, especially in the learning achievement of testing

DC motors for various kinds of connections with the correct procedure. The DC motors tested included separately exited DC motors, shunt DC motors, series DC motors, short compound DC motors, and long compound DC motors. The test results are used to determine the characteristic curve of the DC motor, including electrical characteristics and mechanical characteristics. The electrical characteristics include the armature torque characteristic curve to the armature current and the motor shaft rotation characteristic curve to the armature current. The mechanical characteristics are the characteristic curve of the motor shaft rotation to the armature torque.

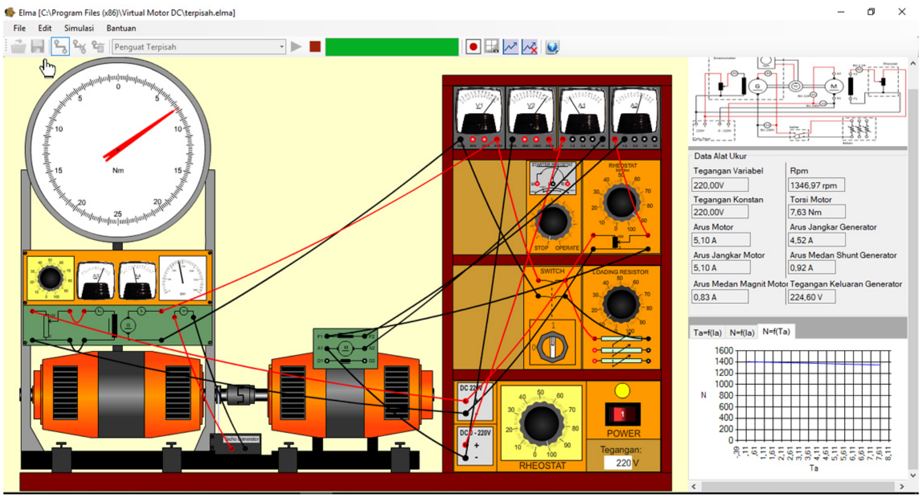

Fig. 1. The user interface of the direct current motor virtual laboratory application

Figure 1 shows a screenshot of the user interface of the direct current motor virtual laboratory application. The DC motor testing concept applies to two DC machines connected in one shaft. One of the DC machines functions as a DC motor whose characteristic parameters will be observed, while the other DC machine functions as a DC generator as the load of the observed DC motor. On the side of the DC generator is analog measuring instruments such as speed and torque. On the right side of the unit, there are various measuring equipment and instruments, such as a DC power supply of variable voltage sources 0–220V and fixed voltage sources 220V, load resistors, magnetic field rheostats, starting motors, analog ammeters, and analog voltmeters. Each piece of equipment is equipped with a banana plug connection terminal like real equipment in a physical laboratory. Students must assemble the strands according to the wiring diagram of the selected motor type. On the right side of the user interface is a facility to assist in the DC motor testing process. The top side has a wiring diagram, the middle side has measuring instrument data in digital form, and the bottom side has a graph of the DC motor test results. The characteristic graph is built based on test data, including speed, torque, and DC motor armature current.

At the top side of the user interface, there is a standard menu bar including File, Edit, Simulation, and Help. Under the menu bar, shortcut buttons are often used, such as the button to make a connection, the button to delete the connection, the button for running simulations, the button for stopping simulation, and the progress bar simulation status. The simulation process can be run when the connection is made according to the DC motor test wiring. The DC motor starting procedure must be applied until the motor runs at an empty load with a rotation of 1400 rpm and the source terminal voltage is 220V. According to the test table, the loading process is carried out by adjusting the magnetic field on the DC generator side to obtain an increase in the motor armature current. DC motor test data, including armature current, torque, and speed, can be recorded or written manually in student workbooks. If the data record feature is used, a graph of the characteristics of the relationship between armature current and torque is formed, armature current is with speed, and armature torque is with speed. When the testing process is complete, the procedure for stopping the DC motor is applied, so safety in starting and stopping the DC motor is considered like testing on real teaching aids in an electrical machine laboratory.

The simulation process behind the scenes uses the Simulink model [13], [25], so input parameters such as armature voltage, magnetic field voltage, and other variables are included in the Simulink model. The output of the Simulink model is read and then displayed through a visual interface such as speed, armature current, torque, and other variables. Every change in input parameters, such as armature voltage and the variable load resistor, then output parameters such as speed, torque, and armature current also adjust based on the motor being tested. The results of testing various types of electric motors can be represented using this virtual DC motor laboratory.

The virtual laboratory application of the direct current motor in this study is very interactive for use in practical learning, especially for testing the characteristics of direct current electric motors. The user interface was made based on the 2-D view adopted from the teaching aids in a physical laboratory. A similar electric machine virtual laboratory application has also been developed for testing asynchronous motors [26], [27], synchronous machines [28]–[30], and conventional electric machines [14], [31]. Some positive differences of this virtual laboratory application compared to previously developed applications are that the user interface is developed in more real referring to the existing equipment in the physical laboratory. Regarding the testing procedure, it is also applied as it is in a physical laboratory. It is also equipped with measuring instruments such as an analog ammeter, analog voltmeters, analog torque meters, and analog tachometer. Failure to operate a direct current electric motor can be detected at the outset in the form of a connection error through a display error pop-up window. Data of armature current, armature torque, and armature speed can be generated in characteristic graphs, namely characteristics between armature current and armature speed, characteristics between armature current and armature torque, and characteristics between armature torque and armature speed. The future work will be focused on the development of virtual reality-based electrical machine laboratories including direct current machines, alternating machines, and transformers. Virtual reality-based electrical machine laboratories have also been developed, but are focused on testing transformers [18].

3 Research method

This study aims to validate a virtual laboratory application of a DC motor. Validation is carried out to ensure that the multimedia-based instructional development meets the criteria from the material content aspect and the media aspect. Assessment based on the content aspect of the material is related to the structure and content on the practice topic, whether the learning content follows the program learning outcomes or not. Assessment of material content aspects involves several experts in electrical machines. Assessment based on media aspects refers to the appearance of the user interface regarding computer-based multimedia components, such as color composition, text display, image quality, and sound quality. The assessment process begins with developing an assessment instrument for content experts in electrical machinery and computer-based media experts. The instrument grid is prepared based on theoretical studies related to the content of electric machines, especially DC motor testing, and theoretical studies related to computer-based multimedia quality criteria. The items of the instrument were developed based on the grid and indicators to form an assessment questionnaire with a 4-point Likert scale. The developed instrument is then carried out with construct validation by an evaluation expert in education, referring to the grid and indicators of instrument development.

3.1 Developing the instruments for evaluation

The instrument was used in the form of a 4-point Likert scale questionnaire. The evaluation is to obtain quantitative data and qualitative data. Quantitative data is used to determine the level of feasibility of virtual laboratory applications, while qualitative data are suggestions, input, and comments from experts on virtual laboratory applications. The eligibility criteria for multimedia virtual laboratory applications submitted by Merrill et al. [32], Tan & Wong [33], Newby et al. [34], Mishra & Sharma [35], and Djouab & Bari [36] have been analyzed. As a result, the feasibility assessment of the virtual laboratory application is assessed based on two sides, namely the material content side and the media content side.

The material content evaluation instrument consists of two aspects, namely feasibility and functionality. The feasibility aspect consists of material content and learning dimensions, while the functional aspect assesses the efficiency dimension. The dimensions of the material content have four indicators, including learning achievement, learning material, material depth, and currency. There are three indicators, including learning strategies, learning motivation, and learning opportunities for dimensions of learning. Meanwhile, the dimension of efficiency has two indicators, including time and resources. Table 1 shows the outline of the material expert's instrument.

Table 1. The material expert's instrument grids and indicators

Aspects	Dimensions	Indicators	Descriptors	Number of Items
Feasibility	Contents	Learning achievement	The suitability of the application program with learning outcomes in terms of strand planning, test procedures, and applying Occupational Safety and Health in testing direct current electric motors with various connections.	3
		Learning material	The suitability of the application program for testing direct current electric motors for the connection of separately exited, shunt exited, series exited, short compound, and long compound.	7
		Material depth	Sufficient material for testing direct current electric motors for the connection of separately exited, shunt exited, series exited, short compound, and long compound.	7
		Currency	Following technological developments and based on virtual laboratories.	2
	Learning	Learning strategies	Application programs can be used to support practical and theoretical learning.	2
		Motivation to learn	The application program can be used to motivate Lecturers and Students.	2
		Opportunity to learn	Application programs can be used as learning resources and can be used anywhere without being limited by space and time.	2
Functionality	Efficiency	Time	Effective and efficient and even distribution of material.	2
		Resource	Application program resources are reviewed under the supervision of instructors and laboratory technicians.	2

The media content evaluation instrument consists of two aspects: feasibility and functionality. The feasibility aspect consists of two dimensions, namely visual and software, while the functional aspect also consists of two dimensions, namely usability and portability. The visual dimension has three indicators: display design, color composition, and legibility. The software dimension consists of three indicators: application programs, documentation, and interactive. The usability dimension consists of three indicators: operation, usability, and attractiveness. Meanwhile the dimension of portability has two indicators, including installation and adaptation. Table 2 shows the outline of the media expert's instrument.

Table 2. The media expert's instrument grid and indicators

Aspects	Dimensions	Indicators	Descriptors	Number of Items
Feasibility	Visual	Display design	The image display in the application program is proportional in terms of the monitor screen, motor-generator image design, menu, and navigation layout, measuring instrument images, and characteristic graphic images.	5
		Color composition	The display color in the application program is proportional in terms of writing color and background color selection, image color selection, graphic color selection, and cable color selection.	4
		Legibility	The arrangement of words or sentences in the application program is correct in terms of word selection, sentence structure, and clarity of sentence meaning.	3
	Software	Application program	The application program is small and easy to distribute.	2
		Documentation	Direct current electric motor testing can be documented to record characteristic data and store motor testing strand files.	2
		Interactive	The interactive application program is viewed from the interaction using a computer mouse, and an error message is if the string is not correct.	2
Functionality	Usability	Operation	Ease of application program in terms of ease of opening, operation, and documentation.	3
		Utility	The usefulness of the application program is viewed as a learning resource and virtual practicum teaching aid.	2
		Attractiveness	The attractiveness of the application program is viewed from the appearance of the application program and student interest in using the application program.	2
	Portability	Installation	Installation of application programs is reviewed on the ease of installation and flexibility.	2
		Adaptation	Adaptation of application programs in terms of operating system version adjustments and screen resolution adjustments.	2

3.2 The validity of the instruments

Instrument validity applies to content validity. The instrument's content validity is the representativeness of the question in measuring the object being measured [37]. An evaluation expert reviewed the instrument before being used based on the contents of the instrument items [38]. The evaluation expert validates the instrument to ensure that the instrument measures the capabilities defined in the instrument grid.

Two scientific experts from an educational evaluation background were involved in the study of the validity of this instrument. According to comments and suggestions from experts, some statements on the questionnaire need improvement related to standard words, sentence effectiveness, ambiguous sentences, and reduction of instrument items. The experts agreed to reduce some unnecessary instrument items because other instrument items already represented them. Comments and suggestions from evaluation experts are the basis for instrument improvement, so the final and valid version of the instrument can be used to evaluate virtual laboratory applications.

3.3 The evaluation procedure

There are two evaluation instruments: one instrument to assess the content material of the virtual laboratory application that will be assessed by the material experts, and another instrument to evaluate the virtual application in the context of media that will be evaluated by the media experts.

The material content experts consist of two electrical engineering vocational education lecturers who teach electrical machinery courses. The selection of lecturers in electrical machinery as material content experts is based on the intended course so that the objectivity of the assessment can be met, and comments and suggestions can be obtained from lecturers experienced in teaching electric machines. The first material content expert has more than 30 years of experience as an educator in the electrical engineering education department at a public university in Indonesia. He was involved as an electrical contractor for many small and medium projects. He is also an assessor of the Professional Certification Agency in the electrical field since 2010. In the meantime, the second expert is an educator in the subject of electrical machinery for more than 30 years. He also actively joins the Association of Indonesian Vocational Educators (AIVE) in Indonesia. He was the head of the electrical engineering study program.

The media content experts consist of two computer-based learning technology experts. The selection of computer-based learning technology expert lecturers as media content experts is based on the objectivity of computer-based media assessment, so comments and suggestions can be obtained from lecturers experienced in computer-based learning technology. The first media expert has experience in teaching educational technology since 1986. He has extensive research on the topic of multimedia for education. He is often selected as a validator to evaluate the learning media product of the student's final project. In the meantime, the second expert on media-based validation is an educator at the university for around 20 years. He has also been involved in many learning media development projects, both at the local and national levels.

The evaluation started by delivering firstly a brief demonstration regarding the DC motor laboratory virtual application. The features and usage procedures for testing a wide variety of DC motors are explained to all experts. The opportunity to use and explore independently by experts is welcome. Question and answer discussions and confirmation from experts regarding less detailed parts are carried out. An evaluation questionnaire under the assessment aspect was given to obtain quantitative data. The experts involved in this study should be agreed to ethical standards in order to prevent potential conflicts of interest. Ethical conduct applied in this study includes honesty, fairness, objectivity, confidentiality, and independence. Just after the experts filled out the instrument provided, quantitative data is then collected and analyzed to determine the feasibility of the application. Experts may also give comments, suggestions, or positive feedback as qualitative data input for this study's improvement.

3.4 Eligibility criteria

The data obtained from the questionnaire are quantitative data on a 4-point Likert scale. Quantitative data was analyzed to determine the level of feasibility. The eligibility level is determined based on the assessment score. The eligibility category is obtained based on the number of questionnaire items, the lowest score, the highest score, the average, and the standard deviation [39], [40]. Table 3 shows the categories of eligibility level criteria using normal distribution intervals.

Table 3. Criteria for evaluating virtual application media [39]

Score Interval	Category
(Mn + 1.5 SBn) – (Mn + 3.0 SBn)	Very Good
(Mn) – (Mn + 1.5 SBn)	Good
(Mn – 1.5 SBn) – (Mn)	Good Enough
(Mn – 3.0 SBn) – (Mn – 1.5 SBn)	Not Good

*Notes: Mn: nominal mean value [1/2 * (highest ideal score + lowest ideal score)]. SBn: nominal standard deviation [1/6 * (highest ideal score – lowest ideal score)].*

4 Result and discussion

The research results are presented in this part. The analysis and discussion are also presented. As previously conducted by [41], the feasibility evaluation in this virtual application media will be assessed by learning material experts and computer-based media experts.

4.1 Learning material assessment

Table 4 shows the assessment of material experts on three dimensions. The dimensions of the material's content, learning, and efficiency obtained an average score of 54, 24, and 32, respectively. Those scores in three dimensions are categorized in a "very good" category based on the eligibility criteria of Table 3. It means that the virtual laboratory application of the direct current motor is feasible to be used for the practical learning of electric machines on DC motor testing in terms of a learning material aspect.

Table 4. Analysis of the results of the material expert's assessment

Evaluators	Dimensions		
	Contents	Learning	Efficiency
Expert 1	55	24	32
Expert 2	53	24	32
Average	54	24	32
Criteria	Very Good	Very Good	Very Good

Table 5 shows qualitative data from material content experts. Besides providing assessments in the form of scores, material experts also provide comments, suggestions, and input for improving the virtual laboratory application media.

Table 5. Comments and suggestions from material content experts

Evaluators	Suggestions and Feedback
Material Expert 1	• The media is already representative. • Need to add variable input from the keyboard. • There needs to be zoning for errors in stringing. • Need a video demo on how to assemble, read experimental results, and read curves and diagrams. • Need practice questions stringing with the key results.
Material Expert 2	• Need additional material for permanent magnet direct current motor. • The voltage equation in a direct current motor needs to be added to the brush ΔV, or there is an indication that ΔV is ignored. • Correction for the formula $n = E_a/Ø$, it should be $n = E_a/(c1 * Ø)$. • On the Torque characteristics of the Ia $Ta = Ia$ function, please check again, because the correct one is $Ta \approx Ia$ (directly proportional) to the adjustment of the type of direct current motor.

Based on the comments and suggestions from material content experts in Table 5, several improvements can be made and cannot be made due to development limitations. Improvements made based on aspects of material content, include adding a variable voltage input from the keyboard, stringing fault zoning, demonstration video, practice questions, and evaluations are available in the help window, the addition of information to the voltage equation, speed equation fix, improvement of writing characteristic function equations armature torque and armature current on separately excited and shunt motors.

The previous input variable voltage feature can be done only through the knob, so the magnitude of the voltage value depends on the rotation angle of the knob. The variable voltage input from the keyboard makes it easy to determine the voltage value in integers, so by entering a number through the textbox, the knob immediately rotates to adjust. Figure 2 is part of the power supply before and after the revision.

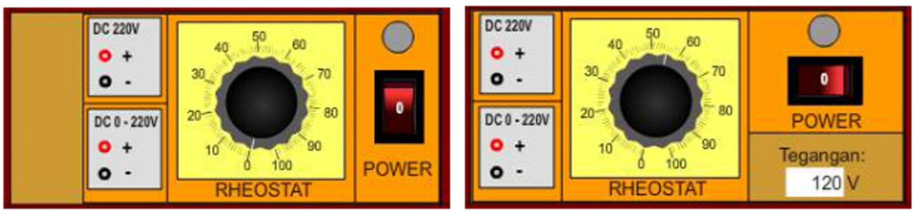

Fig. 2. Left side before revision, right side after revision by adding input textbox for voltage variable

Warnings or error messages in stringing have been facilitated through a pop-up window. The warning message must be clicked OK. Then, a blinking sign will appear on the banana plug terminal that is wrong in connection. This will make troubleshooting easier. Figure 3 shows the error warning pop-up window display.

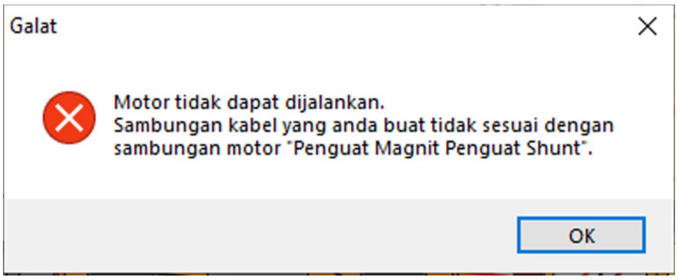

Fig. 3. Error warning pop-up window display when the connection made was incorrect

A video demonstration of the virtual laboratory application media has been created. To facilitate the dissemination of videos that have been uploaded to the internet, Figure 4 is a screenshot of a video demonstration of a virtual laboratory application. Self-paced practice guides are available in the help menu. In the help menu are theoretical studies related to DC motors, instructions for using applications, a DC motor practice Lab sheet, and independent assignments on the analysis of DC motor test results. Figure 5 is a screenshot of the help window of the virtual laboratory application.

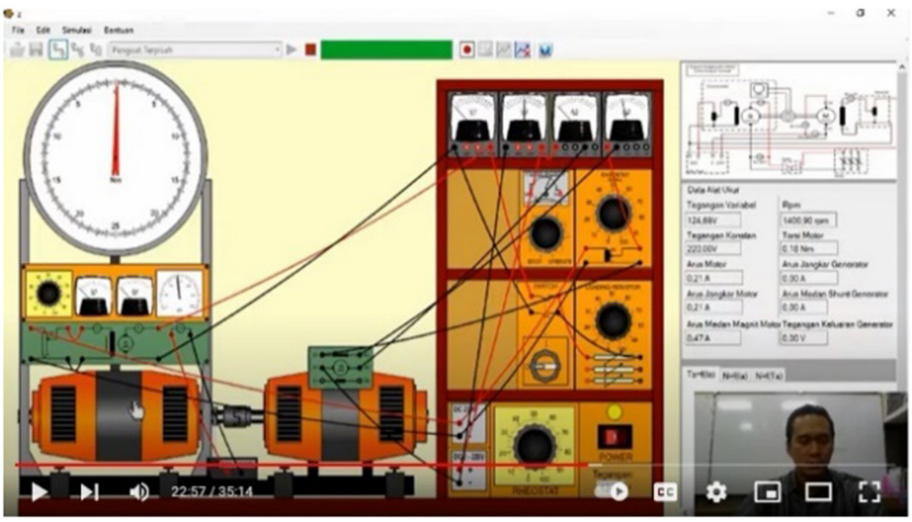

Fig. 4. Video screenshot of demonstrating using the virtual laboratory application

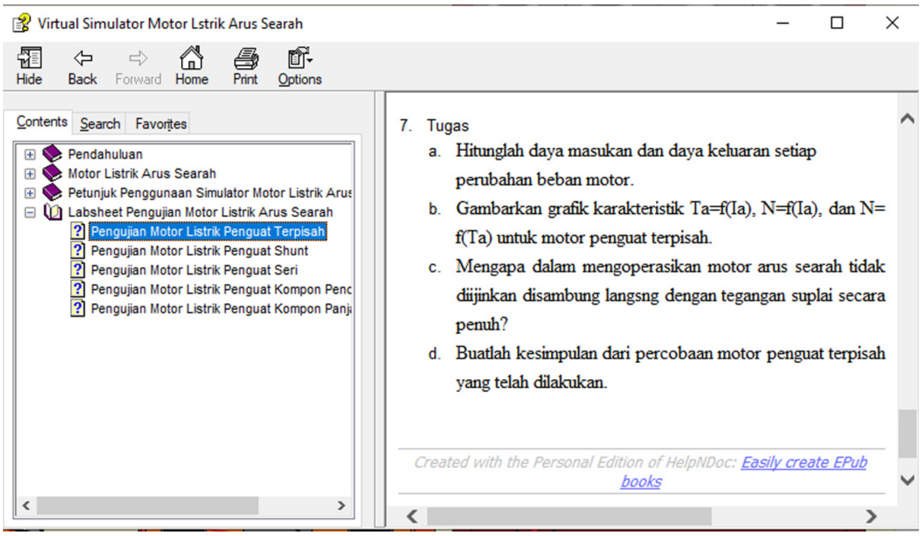

Fig. 5. Help window screenshot for self-practice guide

The voltage equation is improved on all types of DC motor connections. According to material experts, there is a voltage loss on the brush (ΔV), so it is necessary to provide information if the loss on the brush is ignored. Improvements have been made, namely by adding information on the printed lab sheet and the lab sheet on the help menu so that the stress loss on the brush is ignored.

The rotation equation is improved by adding a constant ($c1$). The previous rotation equation was $n = E_a/Ø$. Improvements have been made to the printed lab sheet and the lab sheet in the help menu so that the rotation equation becomes $n = E_a/(c1 * Ø)$. The constant $c1$ is a fixed price that does not change. The complete equation is.

$$E_a = \frac{P * n * \varnothing * Z}{A * 60} \tag{1}$$

$$c1 = \frac{P * 1 * Z}{A * 60} \tag{2}$$

$$E_a = c1 * n * \varnothing \tag{3}$$

$$n = \frac{E_a}{c1 * \varnothing} \tag{4}$$

In the last revision for material content, improvements were made in writing the equation for the relationship between the armature torque and the armature current. $Ta = Ø * Ia$, the magnetic flux in separately excited and shunt motors is constant, so the armature torque increases as the armature current increases. The previous characteristic equation is $Ta = Ia$; the equal sign (=) becomes almost equal sign (≈), so the characteristic equation becomes $Ta \approx Ia$.

4.2 Media aspect assessment

Table 6 shows the assessment of media experts on four dimensions. The dimensions of visual, software, usability and portability scored an average of 43.5, 21, 26, and 14, respectively. All scores in media assessment dimensions are categorized in a "very good" category based on the criteria of Table 3. This means that the virtual laboratory application of the direct current motor is feasible to be applied for the practical learning of electric machines on DC motor testing in terms of the media design aspect.

Table 6. Analysis of media expert assessment results

Evaluators	Dimensions			
	Visual	Software	Usability	Portability
Expert 1	48	24	28	16
Expert 2	39	18	24	12
Average	43.5	21	26	14
Criteria	Very Good	Very Good	Very Good	Very Good

Table 7 shows qualitative data from media content experts. Experts, in addition to providing an assessment in the form of scores, also provide comments, suggestions, and input for improving the virtual laboratory application media.

Table 7. Comments and suggestions from media content experts

Evaluators	Suggestions and Feedback
Media Expert 1	• Worth using without revision • The multimedia simulator model is very good and visually is following the actual electric machine model.
Media Expert 2	• The composition of the background color with tools to make it clearer. • Recording of characteristic data can be saved in jpg, excel, or word format. • In the future, to make it easier to increase user competence, there are series of error messages and there is a maximum error limit, so users are expected to be more competent in using or practicing the software.

Based on the comments, suggestions, and input from media content experts in Table 7, overall, they gave positive comments and input that was not too urgent. However, several improvements have been made based on aspects of media content, including color contrast fixes and added test data storage features.

The contrast of the unit color and the background color before the repair was considered the same as bright and the color of the family or the same bright, so it is not clear to distinguish the boundaries of the color on the unit and the color on the background. Improvements have been made by sharpening the unit's color darker, so the boundaries of the unit parts are visible. Improvements were made thoroughly to all elements with bright colors on the overlapping parts. Figure 6 is an example of the color contrast correction section.

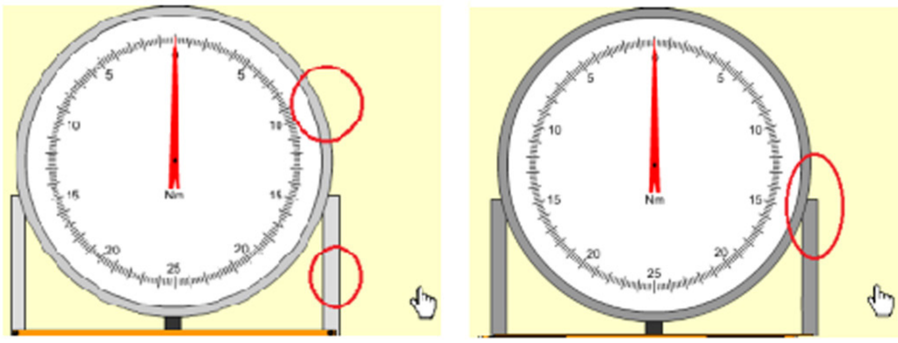

Fig. 6. Left side before repair, right side after repair on unit color contrast with background color

After the validation process, the feature to save test data is an additional feature. The previous storage feature was limited to the motor connection strand. The new storage feature adds tools or finds navigation to perform characteristic data save commands. Characteristic data recorded can be saved in the form of a file with *.csv (comma separate value) format (see Figure 7).

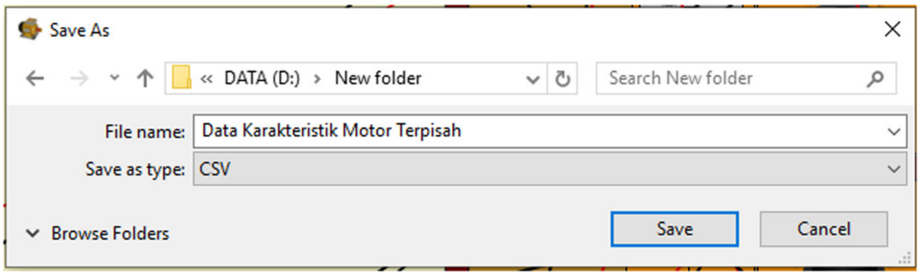

Fig. 7. Screenshot of the save as characteristic data window in *.csv format

5 Conclusion

The development of technology in the digital era has disrupted all fields of work, and the field of education has also not escaped this change. Distance learning based on computer technology is a hallmark of learning in the digital era. Vocational education prepares students to work according to their field of expertise. Mastering hands-on skills in practical learning are difficult when distance learning is applied. This study proposes a computer-based tool or media as a virtual laboratory application for the practice of electrical machines.

The focus of this study is an evaluation based on expert judgment referring to two aspects. The first aspect assesses the application of virtual laboratories related to the content of learning materials, while the second aspect assesses media content. Experts are selected according to the expertise of the assessment aspect. Material content experts are selected from lecturers who teach electrical machinery courses, while media content experts are selected from lecturers with expertise in multimedia-based learning technology. The collected data is then analyzed using the normal distribution assessment category [39]. The results showed that the assessment of the experts was "very good" for all dimensions of the assessment. The assessment of the media content aspect is also "very good" for all assessment dimensions.

Research limitations. The limitation of this study is that the assessment is still in the context of the content of the electrical machine learning material and the multimedia display point of view, so it needs the perception of end-users, namely students and lecturers from various vocational education institutions.

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