Investigating the Higher Education Students' Perception of an Interactive DC Motor Simulator

Didik Hariyanto [1], Rohjai Badarudin [1,2], Miladiah Setio Wati [1,2],
Amelia Fauziah Husna [1], Gulzhaina K. Kassymova [3], Yanning Lu [4]

[1] *Department of Electrical Engineering Education, Faculty of Engineering,
Universitas Negeri Yogyakarta, Yogyakarta, Indonesia*
[2] *Study Program of Technology and Vocational Education, Graduate School,
Universitas Negeri Yogyakarta, Yogyakarta, Indonesia*
[3] *Institute of Metallurgy and Ore Beneficiation, Satbayev University, Almaty, Kazakhstan*
[4] *Teachers College for Vocational and Technical Education, Guangxi Normal University, Guilin, China*

Abstract – **This study investigates the perceptions of higher education students regarding an interactive DC (Direct Current) motor simulator, shedding light on the evolving landscape of virtual education. By utilizing five aspects of learning dimension, visual elements, software functionality, usability, and portability of a four-point Likert scale questionnaire, the research uncovers a generally positive reception of the simulator among students, who view it as a valuable complement to traditional hands-on laboratories, enabling self-paced learning and offering repeatable experiments in a safe environment. Nevertheless, our research highlights notable concerns, such as challenges related to user interface design and pre-installation software. These findings offer crucial insights into the strengths and limitations of a DC motor simulator in higher education, providing guidance for educators and instructional designers striving to optimize digital learning experiences.**

Keywords – **Students' perception, virtual education, higher education, DC motor simulator.**

1. Introduction

In recent years, the field of education has undergone significant transformations, primarily driven by technological advancements that have reshaped the dynamics of teaching and learning [1], [2]. The use of digital tools and virtual environments in education has changed how we share and gain knowledge [3], [4]. One interesting tool is the virtual simulator, which is like a computer program that helps students to learn in a more interactive way. This research is about finding out what students in higher education think about using a simulator for a DC motor (a type of motor used in electrical engineering).

Simulators are getting a lot of attention in education because they can help connect what students learn in theory to real-life applications. Using simulators lets students explore complex ideas in a virtual space, which helps them learn actively, solve problems, and think critically [5].

The DC motor is important in electrical engineering, so it is a good topic for students to learn about. With a simulator, students can understand things like electromagnetism, torque, speed control, and designing circuits by simulating how DC motors behave. But for any new educational tool, like a simulator, it is crucial to know what students think about it.

This study aims to discover what higher education student perception is and how they feel when using a virtual DC motor simulator [6]. By understanding their thoughts, the research hopes to find out how the simulator might help students learn better, be more engaged, and have a better overall educational experience. The study also wants to discover any problems students might face while using this new technology.

2. A Virtual DC Motor Application

The Virtual DC Motor Simulator employed in this study is grounded in a system that was previously conceived and developed through our prior research efforts [7], [8]. In the current investigation, the virtual DC motor application was meticulously crafted using the Simulink model [9], [10] as its central framework for conducting the simulation processes.

Several virtual laboratory applications for electric machines have been created by various researchers. Notable examples include virtual laboratories for understanding asynchronous motors [11], [12], virtual laboratories for exploring synchronous machine applications [13], [14], and virtual laboratories for investigating conventional electric machines [15], [16]. However, the virtual electric machine laboratory developed by the authors and employed in this study distinguishes itself in one crucial aspect: its user interface closely mirrors the physical equipment found in a traditional laboratory setting, providing a more realistic and immersive experience for users.

As depicted in Figure 1, a snapshot of the user interface of this virtual DC motor application is presented offering a visual representation of the tool under examination. Basically, the system is divided into three important areas. The first, which is located in the main area, contains the main parts of DC motor equipment and instruments. This area involves the utilization of two interconnected DC machines on a single shaft. One of these DC machines operates as a DC motor, and its characteristic parameters are subjected to observation. Meanwhile, the second DC machine functions as a DC generator and serves as the load for the aforementioned DC motor. Analog measuring instruments, including devices for monitoring speed and torque, are positioned on the DC generator side. A comprehensive array of measuring equipment and instruments is also available. This includes a variable voltage DC power supply spanning from 0 to 220V, fixed voltage sources at 220V, load resistors, magnetic field rheostats, starting motors, analog ammeters, and analog voltmeters. Each of these instruments is equipped with banana plug connection terminals to mimic real-world laboratory equipment. Students are required to assemble the connections as per the wiring diagram corresponding to the selected motor type.
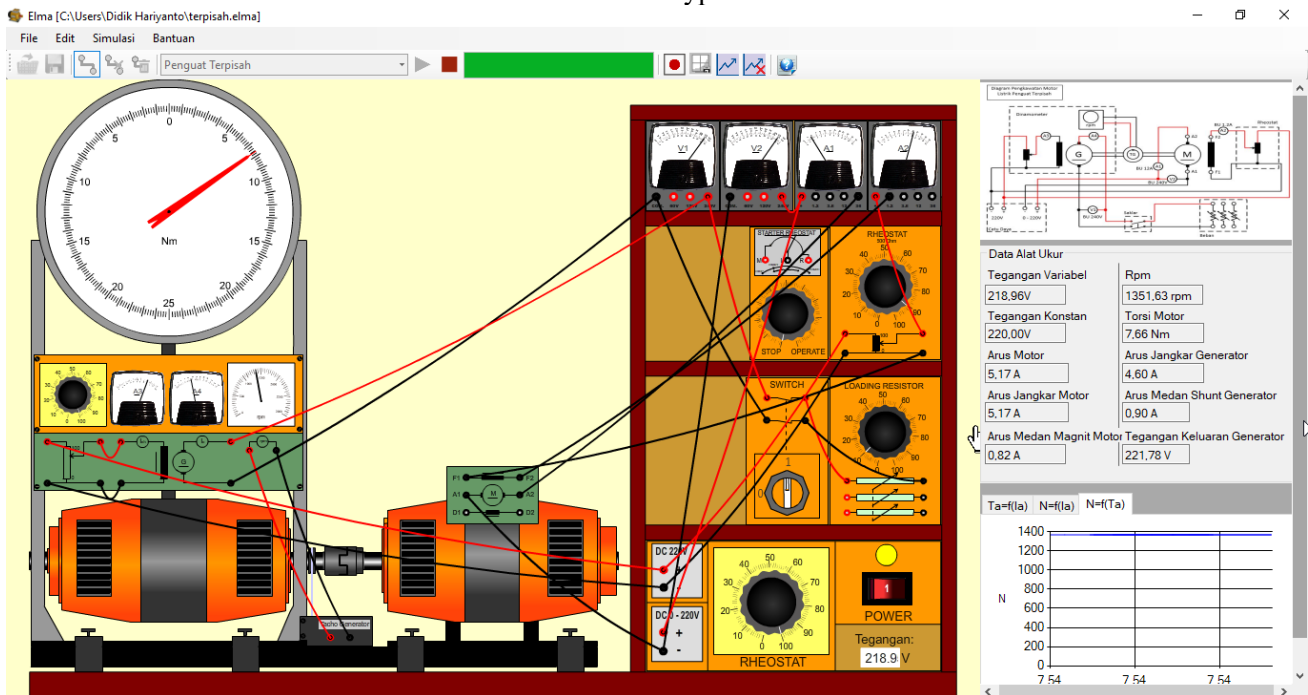

Figure 1. The user interface of the virtual DC motor application

The second area located on the right-hand side of the user interface is a toolset to facilitate the DC motor testing procedure. This toolset comprises a top section housing a wiring diagram, a middle section displaying digital data from measuring instruments, and a bottom section presenting graphical representations of the DC motor test results.

The characteristic graph is constructed based on test data encompassing parameters such as speed, torque, and DC motor armature current.

The last area which is located in the top section features a standard menu bar containing options for file, edit, simulation, and help. Below the menu bar, convenient shortcut buttons are readily available.

These buttons include those for establishing connections, deleting connections, initiating simulations, halting simulations, and a progress bar indicating the status of the ongoing simulation. The simulation process is executable when the connections adhere to the wiring configuration specified for the DC motor test.

3. Research Design and Procedure

In the pursuit of comprehensive feedback regarding the virtual DC motor simulator, an empirical investigation was undertaken through the administration of a structured questionnaire. The questionnaire used in this study encompassed five distinct facets, namely learning [17], [18], visual elements [18], [19], software functionality [21], [22], usability considerations [21], [22], and portability attributes [21], [22]. Within the questionnaire instrument, a total of 33 statement items were incorporated, partitioned as follows: four items pertaining to learning aspects, 12 items concerning visual attributes, six items addressing software functionality, five items evaluating usability dimensions, and four items appraising portability features. The following table (Table 1) shows the outline of the questionnaire used in this study to assess the students' perception.

Table 1. The outline of the questionnaire

Aspect	Dimension	Indicator	Item Number
Feasibility	Learning	Learning motivation	1, 2
		Opportunity for learning	3, 4
	Visual	Design of interface	5, 6, 7, 8, 9
		Color composition	10, 11, 12, 13
		Readability	14, 15, 16
	Software	Application programs	17, 18
		Documentation	19, 20
		Interactive	21, 22
Functionality	Usability	Operation	23, 24
		Utility	25, 26, 27
		Attractiveness	28, 29
	Portability	Installation	30, 31
		Adaptation	32, 33

The experiment study spanned approximately four hours and took place within the Electrical Machines Laboratory of the Department of Electrical Engineering Education at Universitas Negeri Yogyakarta. A total of 13 students participated in this study.

In the initial session, students were briefed on the primary study objectives, the DC motor simulator application, its features, and operational instructions.

A simple example was demonstrated to illustrate concepts, and a question-and-answer session was open for discussion during this period.

In the subsequent session, students were tasked with using the DC Motor Simulator application, guided by a provided job sheet. They were encouraged to explore various features offered by the application and could seek assistance from the instructor if any problems or shortcomings arose during their practice. At the end of the session, paper-based questionnaires were distributed to the students. Clear instructions were given on how to complete the 4-point Likert scale questionnaire.

This research also gathered thoughts from participants through open comments and suggestions. They were asked to share their experiences with the DC Motor Simulator application, explaining their thoughts and feelings while using it. This qualitative research goes deeper into understanding the user experience, providing a richer insight into the various aspects contributing to the effectiveness and usability of the DC Motor Simulator application.

Regarding ethical concerns, this research took careful steps, including obtaining informed consent from all participants, ensuring that any received information remains private and anonymous, and strictly adhering to the principles and standards of academic integrity [23], [24], [25], [26], [27], [28]. These ethical practices are in place to protect the rights of participants and ensure the trustworthiness of the research results.

4. Results and Discussion

This section will discuss the results of the respondent's assessment after they used the DC motor simulator application. The results of the respondent's assessment are in the form of a Likert score for five aspects of the assessment. In addition, it also discussed comments or suggestions from respondents which they filled in through open-ended questions. The results of both quantitative and qualitative data are then discussed to get an overview of user responses to the virtual applications.

4.1. The Quantitative Data Collection

The quantitative data collected in this study are grounded in five distinct aspects, which are presented in Table 2. The information in each aspect comprises the total scores obtained from a set of questionnaire items related to that specific aspect. Additionally, the average scores resulting from the assessments of all 13 respondents for each aspect are displayed at the bottom of the table.

Table 2. The quantitative data collected from respondents

Respondent	Aspects' Score				
	Learning	Visual	Software	Usability	Portability
Student 1	16	48	20	23	14
Student 2	16	47	22	27	16
Student 3	12	42	17	23	12
Student 4	16	41	23	26	14
Student 5	14	38	21	22	13
Student 6	16	38	21	25	15
Student 7	15	36	24	25	16
Student 8	16	40	21	26	14
Student 9	16	41	24	27	15
Student 10	13	40	22	26	12
Student 11	16	48	24	28	16
Student 12	16	40	23	25	12
Student 13	15	43	24	27	16
Average	15.2	41.7	22.0	25.4	14.2

4.2. Data Categorization

In this research, the data categorization is an essential part to organize and classify the quantitative information collected from a survey into distinct groups or categories. To appropriately categorize and interpret these responses, our study adopted an established method from prior research [29], [20]. This method involved organizing and classifying the questionnaire responses based on the total Likert scale scores. As seen in Table 3, the feedback provided by respondents was categorized into four distinct levels, spanning from "very poor/very unfeasible" to "very good/very feasible" This classification allowed for a more comprehensive understanding of the participants' responses and their overall evaluation.

Table 3. Classification of respondent's response

Score Range	Criteria
M + 1.5 SD $< X \leq$ M + 3 SD	Very Good/Very Feasible
M + 0.5 SD $< X \leq$ M + 1.5 SD	Good/Feasible
M − 0.5 SD $< X \leq$ M + 0.5 SD	Poor/Unfeasible
M − 1.5 SD $< X \leq$ M − 0.5 SD	Very Poor/Very Unfeasible

where:
X   = respondent response
M   = ideal mean score
*   = 1/2 x (ideal maximum score + ideal minimum score)*
SD = ideal standard deviation
*   = 1/6 x (ideal maximum score - ideal minimum score)*

4.3. Data Analysis

In this research, the collected data was then analysed quantitatively and interpreted according to Table 3 category.

Regarding the learning aspect, the average assessment score from 13 respondents was 15.2. This score was then compared with Table 3 to determine its qualitative interpretation, placing the learning aspect in the "very feasible" category. Similarly, in the visual aspect, an average score of 41.7 was achieved, categorizing it as "very feasible based on Table 3.

Applying the same method to the software aspect, the average score from respondents was 22, leading to its classification as "very feasible" according to Table 3. The assessment results for usability and portability were 25.4 and 14.2, respectively. These two outcomes were categorized using the guidelines outlined in Table 3. Upon examination, it was ascertained that both aspects, usability and portability, were categorized as "very feasible."

4.4. Showing Data in Percentage

Converting Likert scale scores to percentages serves the purpose of providing a more easily interpretable representation of the data. This transformation allows for a clearer understanding of the distribution of responses across different categories within the Likert scale. By calculating the percentage distribution of responses for each option, researchers can gain insights into the overall sentiment or agreement level of participants with respect to the evaluated aspects. Table 4 shows the Likert score results converted into percentage and its category.

Table 4. Respondent's response in percent and its category

Respon-dent	Aspect									
	Learning		Visual		Software		Usability		Portability	
	(%)	Cat.	(%)	Cat.	(%)	Cat.	(%)	Cat.	(%)	Cat.
Student 1	100	VF	100	VF	83.33	VF	82.14	VF	87.5	VF
Student 2	100	VF	97.92	VF	91.67	VF	96.43	VF	100	VF
Student 3	75	VF	87.5	VF	70.83	VF	82.14	VF	75	VF
Student 4	100	VF	85.42	VF	95.83	VF	92.86	VF	87.5	VF
Student 5	87.5	VF	79.17	VF	87.5	VF	78.57	VF	81.25	VF
Student 6	100	VF	79.17	VF	87.5	VF	89.29	VF	93.75	VF
Student 7	93.75	VF	75	VF	100	VF	89.29	VF	100	VF
Student 8	100	VF	83.33	VF	87.5	VF	92.86	VF	87.5	VF
Student 9	100	VF	85.42	VF	100	VF	96.43	VF	93.75	VF
Student 10	81.25	VF	83.33	VF	91.67	VF	92.86	VF	75	VF
Student 11	100	VF	100	VF	100	VF	100	VF	100	VF
Student 12	100	VF	83.33	VF	95.83	VF	89.29	VF	75	VF
Student 13	93.75	VF	89.58	VF	100	VF	96.43	VF	100	VF
Average	94.71	VF	86.86	VF	91.67	VF	90.66	VF	88.94	VF

Remarks:
Cat. = Category
VF   = Very Feasible

5.   Discussion

Based on user evaluations, the learning aspect achieved an average score of 15.2, with a feasibility percentage of 94.71%, categorizing it as "very feasible." The visual aspect obtained an average score of 41.7, with a feasibility percentage of 86.86%, falling into the "very feasible" category. Regarding the software aspect, it garnered an average score of 22, with a feasibility percentage of 91.67%, also qualifying as "very feasible". The usability aspect achieved an average score of 25.4, with a feasibility percentage of 90.66%, categorizing it as "very feasible." Lastly, the portability aspect obtained an average score of 14.2, with a feasibility percentage of 88.94%, similarly classified as "very feasible." Based on these user assessments, as seen on Figure 2, the overall consensus suggests that the application program has been well-received by users for conducting practice of DC motor on various connections, adhering to proper procedures.
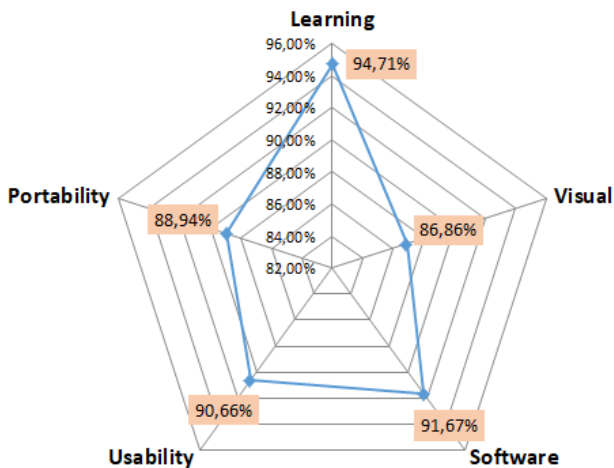

Figure 2. The spider diagram of all aspects of evaluation

5.1. User Open-Ended Feedback

User feedback, conveyed through comments and suggestions, was an integral part of our data collection process. Participants had the opportunity to share their experiences and thoughts on using the DC motor simulator application through open-ended feedback. In our study, which involved 13 students, only one student chose not to provide feedback, while the remaining 12 students contributed a variety of comments. Among these comments, we observed several recurring positive remarks, which are highlighted below:

- *"The application is effective in supporting students' understanding of electrical machinery principles."*
- *"It serves as a valuable tool for students to simulate real electrical machinery practices before practical experiments."*
- *"The application is user-friendly, easy to install,*

and provides detailed design components for a comprehensive understanding.*"*
- *"It is visually appealing interface adapts well to different screen resolutions, enhancing the user experience."*

While the majority of comments indicated students' positive reception of the DC motor simulator implementation, certain limitations were identified. Specifically, a few students highlighted the existence of a bug where, even after powering off the circuit, the machine continued to run. Additional feedback included suggestions to enhance the application by incorporating features such as undo and redo functions, as well as simplifying zoom-in and zoom-out functions through mouse scroll functionality. Furthermore, some students noted that the installation process still presented challenges, particularly in terms of installing supplementary software components, suggesting the need for a more streamlined installation procedure.

6.   Conclusion

This research represents a continuation of previous investigations. In the prior study, an application simulator for DC motors was successfully developed based on an assessment of user needs. Furthermore, the application created had undergone evaluation by experts, encompassing both media and substantive content aspects related to DC motors. In the current study, the primary focus was on assessing the extent of students' perceptions while utilizing the DC motor simulator application within electric machine practical instruction.

The results obtained from the distributed questionnaires revealed that all five evaluation aspects (learning, visual, software, usability, and portability) received ratings in the "very feasible" category. This suggests that students found the DC motor simulator application to be highly beneficial in their study of electric machine coursework. However, upon closer examination, the "visual" aspect received the lowest score among the five, registering at 86.86%. This observation aligns with the feedback provided by several students in the open-ended feedback section, where some suggested that the application could benefit from an easier zoom-in and zoom-out feature, possibly implemented using mouse scroll functions. The second lowest-rated aspect was "portability", with a score of 88.94%. Within this portability aspect, there were inquiries about the application installation process, and some students noted that the installation was somewhat complex due to the requirement for additional software installations.

From these two lower-scoring aspects, valuable insights emerge for potential improvements or updates to the application, particularly in the realms

of visual and portability. Considering the highest rating assigned by students, which pertained to the "learning" aspect, signifies the success of the application in facilitating and enhancing students' comprehension of the subject matter, particularly in electric machine topics. This outcome further bolsters the perspective held by many experts that virtual laboratory applications can significantly aid students in their learning endeavors.

Acknowledgements

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