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Developing the Integrated Control Systems Media for Enhancing the Electrification Competency of Electric Railway Drive

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Abstract

This study aimed to determine the operation of the integrated control media for the traction system in electric railway drives at the Polytechnic, to assess the feasibility of the integrated control media for the traction system, and to produce an effective integrated control media for the traction system that can be used to increase the electrification competence of electric railway drives. This study was conducted using a development research approach, employing the RAD (Rapid Application Development) and ASSURE methods. The subjects of this study were 39 students from the Madiun State Polytechnic Railway. Data was collected using observation sheets, interview sheets, media questionnaires, module questionnaires, and tests. Validation of the questionnaire instrument was carried out using Aiken's-V formula and Pearson Product-Moment correlation, while the reliability test of the test instrument used Cronbach's Alpha. The validity coefficient of the material and media questionnaire instrument falls into the category of "Feasible". The data was analyzed in combination, where the qualitative data were carried out using Huberman's steps, and the quantitative data were descriptive, the Wilcoxon test, and the Gain Score value. The results of this study can be stated that the operation of the integrated control media for the traction system in electric train (EMU) drivers at the Polytechnic is "Very Feasible", the feasibility of the integrated control media for the traction system is "Very Feasible" with a significance of 0.00. The final results are applications and teaching modules for traction systems used as learning support during the railway electrical engine practicum at the Madiun State Polytechnic Railway.

INTRODUCTION

Traffic jams are often experienced in big cities such as DKI Jakarta. BPS records (2022) show that Jakarta has a motor vehicle density of 26,370,535 units. The impact of congestion can be felt by reducing air quality and increasing travel time. The solution that can be taken to overcome this is the use of public transportation modes based on green technology, green economy, and more energy efficiency. The implementation and development of environmentally friendly transportation have been carried out in various countries. Environmentally friendly transportation is expected to be able to overcome the problems of globalization. Multiple solutions have been designed to encourage the development of environmentally friendly transportation, such as efficient transportation costs, reducing the level of environmental damage, and reducing fuel consumption and greenhouse gas emissions [1]. The development of comprehensive modes of public transportation based on environmentally friendly fuel needs to be carried out quickly and precisely [2]. The transportation impact assessment process also includes the development of public transportation to address traffic issues [3]. Trains are one of the modes of public transportation that have the lowest emissions, considered a sustainable transportation transition [4]. Environmentally friendly transportation can be categorized as clean technology vehicles, such as EMU (Electric Multiple Unit). EMU (Electric Multiple Unit) is a type of electric-powered multi-car train supported by a traction motor, train control network system, and braking [5]. Electric trains are a mode of public transportation that meets these criteria. Apart from that, EMU (Electric Multiple Unit) has several advantages, including large passenger capacity, station location in the middle of a big city, and more efficient use compared to buses. The operation of electric trains utilizes an electric-powered traction motor drive system. The use of environmentally friendly transportation can alleviate ecological problems to encourage the creation of a sustainable environment [6]. The EMU (Electric Multiple Unit) control can be used to save energy by optimizing train speed. In the EMU (Electric Multiple Unit), when the brake is applied, the electric motor, which normally functions as a driving motor, will change its function to become a generator, which will convert kinetic energy into electrical energy. This electrical energy is then stored in a battery or capacitor and can be reused to drive an electric motor [7].

Currently, the enthusiasm of EMU (Electric Multiple Unit) users is increasing, so a large number of units are needed. PT KCI's annual report shows that KAI commuter has 1,150 EMU (Electric Multiple Unit) units as of December 2021 (KCI Data 2022). Efforts to increase the number of fleets continue to be made by PT Kereta Commuter Indonesia to serve the needs of the community in line with the increase in the number of passengers. However, the importance of readiness to modernize electric railway facilities is often ignored by EMU (Electric Multiple Unit) managers. Most of the EMU (Electric Multiple Unit) units owned are imported from abroad. The transition to driverless technology in rail transport is impossible without the creation of automated control systems [8]. The modernization of electric rail facilities is carried out to ensure that all EMU (Electric Multiple Unit) units can operate in optimal condition. One of the retrofit or modernization steps that can be carried out domestically is changing the DC Chopper traction motor to a VVVF (Inverter Variable Voltage Variable Frequency) inverter.

Operational disorders are often experienced by trainees in Indonesia. According to PT KAI's annual report for 2021 [9], there were 68 instances of strikes in electric locomotive control and 11 recorded incidents of impairment in the locomotive traction motor. The existing problems in electric trains had to be solved so that would ensure a future return train would not happen often. The latest technology on the railway can be used to tackle the disorder of the electric train. One of the technologies that can be used as materials for the re-engineering process is regenerative braking as a traction system constructor [10]. A re-engineering process is necessary to maintain and repair electric train components, as not all parts can be produced in Indonesia. Another problem found is the electric railway train belonging to the technology KCI developed, according to Japanese manufacturers, which impacts the availability of electrical and electronic parts. According to [11], Treatment management on the EMU (Electric Multiple Unit) requires parts available at all times. The condition of these parts demands that the domestic railway industry attempt re-engineering, updated EMU (Electric Multiple Unit) technology, without having to order imported parts. So, re-engineering is considered an effective act to ensure the survival of the EMU (Electric Multiple Unit) operation in Indonesia. This reengineering process can be carried out by the nation's children, of course, with good railway engineering competence. Competent human resources in the railway sector must be prepared with vocational education that is relevant to industry trends.

The relevance of vocational education in Indonesia has not yet been adapted to industry demands. In other developing countries, a gap is also found between the skills possessed by graduates and industry needs [12]. Vocational education aims to increase the relevance of vocational education and guidance to the needs of the industrial world [13]. The assessment of the relevance of vocational education can be seen from the skills mastered by vocational education graduates and their mastery of the latest industrial technology. The skills needed by vocational education graduates include adaptability, accountability, and critical and innovative thinking patterns [14]. In other countries such as the United States, Russia, and China, the number of railway education programs has decreased. Some existing railway education still uses the old curriculum and does not follow railway technology trends [15]. The application of the latest technology in education is very important to improve the quality of education graduates [16]. Apart from that, the use of IoT (Internet of Things) in learning can also overcome audience-oriented learning problems [17]. Educational institutions should prepare vocational school graduates who are ready to use, but in reality, the readiness of graduates to adapt to the latest technology is still lacking. The steps needed to ensure graduates are in line with current industry needs include efforts to increase the relevance of competencies according to industry qualifications.

Another problem found was the limited vocational education program for railways in Indonesia. According to PDDikti data, in Indonesia, 4 universities open railway study programs: Land Transportation High School, Indonesian Railway Academy, Madiun State Polytechnic, and Sumatra Institute of Technology. However, of the four universities, only 3 universities have study programs that focus on railway engineering. The limited number of universities that teach railway science in Indonesia has resulted in a decline in human resources with railway competence. Railway human resources consist of regulatory human resources and operator human resources. Human resource regulators are human resources who function as facility examiners, police officers, safety auditors, and railway builders [9]. Based on the performance report of the Directorate General of Railways in 2023, human resources in all work units of the Directorate General of Railways 2023 totaled 1,588 people. This number is stated to not meet the needs for human resources in the railway sector, both in terms of quantity and quality. The human resource needs of railway regulators in 2030 are estimated to require as many as 2,330 people and 101,440 people as operators. Apart from that, it is necessary to master and increase the competence of human resources regarding the latest railway technology (Directorate General of Railways, 2023). The lack of human resources in vocational education is caused by the absence of a link and match between graduate standards and the latest industry needs. Several other obstacles cause vocational graduates not to link and match with industry, such as teacher skills, less effective methods of learning, lack of infrastructure tools, curriculum discrepancy, a lack of apprenticeship opportunities, and a lack of graduate skills [18]. All graduates of polytechnic skills are expected to have an appropriate level of qualification with achievements, KKNI arranged in learning. Standard polytechnic graduates include a definition of the graduates related to a minimum, according to KKNI skills and knowledge. Diploma 4 vocational higher education is included in the KKNI level 6 qualification or the equivalent of an applied bachelor's degree. Currently, there are only two higher education institutions with railway engineering curriculums, the Indonesian Railway Polytechnic and Madiun State Polytechnic Railway. Madiun State Polytechnic Railway became the only high school that offers education in connection with railway techniques.

Knowledge regarding the electrification of electric railway drives is still less developed in Indonesia. This was found based on the number of trains imported and plans for additional procurement. The technology transfer program is to be one of the main programs in the master railway plan of 2018. One such program is to carry out the transfer of knowledge related to operation and care that corresponds to modern technology. The development of knowledge regarding the railways' driving energy sources or electrification is also a major focus of RIPNAS in 2018. If the knowledge regarding the electrification of the train drives possessed by the sons of the nation is sufficient, EMU (Electric Multiple Unit) can be produced domestically without importing thirst. Other than that, knowledge regarding the electrification of the train can be used for the process of modernization of the EMU (Electric Multiple Unit) that PT KCI has at present. The problem of media learning is found in the Madiun State Polytechnic Railway. This train polytechnic, opened in 2018, is still considered a new media with a low process of lab work low. Vocational education requires learning media that can include academic and practical approaches in it [19]. Until now, there have been no researchers who have researched the traction system teaching media in EMU. Handoko's research [20] entitled "The Influence of EMU Driver Education and Training on Train Driver Competency Indonesian High-Speed Rail 'Whoosh" examines increasing the competency of railway crews through education and training. Other research conducted by Chymera [21] discusses the basics of train performance and an overview of the application of simulation in the design and development of railway systems.

Based on the preliminary description, research problems were found in the form of limited learning media used in the learning process in railway vocational education, which occurred because there were no facilities from the center, or minimal research was carried out regarding the material. Another cause of limited learning media can occur due to the unavailability of media procurement costs. Vocational education requires real learning media that is by the latest technology. The deficiency of media in the laboratory can be overcome by developing media with the latest technology that is relevant to railway industrial technology. The solution that can be taken is to collaborate with related industries so that they can borrow equipment as practical teaching aids. The integrated control media intended in this research is related to system learning media problems in terms of the type of software media and printed traction system modules for vocational education students at the Polytechnic. The software developed has a Centered System Design or computer-based design. The software contains menus for the electric train traction system. Meanwhile, the traction system learning module is in the form of a printed module that contains supporting material for operating the electric train traction system software. The traction system in this research is related to the problem of traction control on induction motor electric trains with VVVF (Inverter Variable Voltage Variable Frequency) control in terms of speed regulation, ISO 9126-based inverter, acceleration, IGBT switching, degree setting, and regenerative brake. The inverter on electric rail trains uses a VVVF (Inverter Variable Voltage Variable Frequency) 1500 V DC inverter type. One inverter unit has two IGBTs rated 3.3 kV-1200A, one phase capacitor, and one gate amplifier board. Regenerative braking with brake command 1 digital signal commanded by a 100V DC trainline. Increasing the electrification competence of KRL drivers is an issue related to the train electrical engine course at the Madiun State Polytechnic.

This study focuses on two main research problems. First, how the functionality and feasibility of an integrated traction system control media can support the improvement of students' competency in electric traction systems for Electric Multiple Units (EMU) within a Polytechnic environment. Second, whether the use of this integrated traction system control media is effective in enhancing the learning process and mastery of competencies related to electric traction systems among Polytechnic students. The objective of this research is to examine the functionality of the traction system software media and assess the feasibility of both the media and the traction system modules, with the ultimate goal of developing an integrated traction system control media that can be effectively used to enhance the electrification competence of electric train operation students at the Polytechnic level. Developing the Integrated Control Systems Media of the Traction System can be carried out as an effort to overcome the problem of a lack of learning media in Polytechnics and as a complement to media in railway laboratories. Apart from that, the development of integrated control media for traction systems can be used to increase the electrification competence of EMU (Electric Multiple Unit) drives.

The novelty of this research lies in its instructional media development approach, which integrates two models, Rapid Application Development (RAD) and ASSURE. The combined application of these two models is still rarely found in vocational education research, particularly in the field of railway technology. This approach enables a rapid yet systematic design and evaluation process while accommodating learner-centered educational needs. Furthermore, the final product of this study is a learning media on the traction system of Electric Multiple Units, specifically designed to meet the needs of railway polytechnic institutions in enhancing students' competencies aligned with the latest advancements in railway technology. Therefore, this study contributes not only methodologically but also practically, by advancing the development of technology-based instructional tools in vocational education.

METHODS

This development research was done by approximating RAD (Rapid Application Development) design to develop media electrical rail traffic systems and approach ASSURE design to develop material teaching the electrical rail traffic system. RAD (Rapid Application Development) is a software development process that focuses on fast development cycles [22]. RAD (Rapid Application Development) depends on user involvement because the product development that will be produced is tailored to user needs [23]. ASSURE is a procedural tool for planning and implementing the learning process and the supporting media that will be used. This research uses the RAD (Rapid Application Development) development model because it focuses on technology to produce software. Apart from that, RAD (Rapid Application Development) is a development model with structured stages to produce quality software in a short time. The software developed is expected to suit user needs. The selection of ASSURE is based on a learning model that focuses on the use of technology and media. Module development using the ASSURE model can be carried out in several stages so that the resulting module aligns with the goals, needs, and characteristics of students. This is done so that the quality of learning can improve.

RAD (Rapid Application Development) design research approach has three stages, which are: the requirements planning phase, user design phase, and implementation, while the ASSURE design research approach is carried out by six stages: analyze learner characteristic stated performance, select methods, media, and materials, utilize materials, utilize media and materials, requires learner participation, and evaluation and revision. The development model of media and module of the electric rail traction system is carried out with three stages i.e. (1) the planning phase consists of the requirements planning phase and analyze learner characteristics as well as stated performance on design assure; (2) The design phase consists of user design phase; select methods, media and materials; and utilize media and materials; and (3) the implementation phase of the implementation phase, requires learner participation and evaluation and revision.

This research uses an experimental design, quasi-experimental quasi-pretest-posttest, nonequivalent control group design form. The subject of this study is 39 students in the 4th-grade program of polytechnical study in the country. The selection of subjects relevant to this research is limited due to the restricted educational opportunities in railway engineering, which is offered only as a major at polytechnic institutions. The subject of the study will be divided into two groups, which are control classes and experimental classes. Control class is a class that is not given the treatment of media use and the delivery system module, while experimental classes are selected as experimental classes, research, or classrooms given the treatment of media usage and delivery systems modules. Data collection for the study will be done in May 2024 through observation, interviews, and the division of the survey. The instruments used to gather data in this study included observation sheets, interview sheets, a survey, and an assessment of student learning outcomes. Data analysis of this research was done with an approach to mixing methods with decorative designs, where qualitative data is obtained from instruments of observation instruments and interviews, while quantitative data is obtained using media feasibility instruments, module felicitation, and an inverter study assessment tests. Qualitative data analysis is carried out according to the Huberman step, and then quantitative data analysis is done through the design of a quasi-experimental study using the Wilcoxon Signed Rank Test.

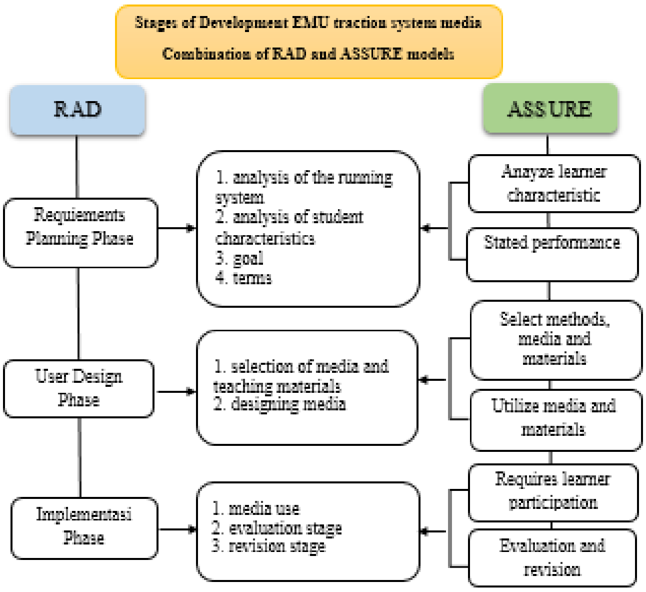

Figure 1. Combination design of RAD and ASSURE for developing EMU (Electric Multiple Unit) traction system media

RESULT AND DISCUSSION

The resulting product in this study is software and a module for learning traction systems. The developed software includes a system program for electrical traction railroads at Madiun Polytechnic, while the traction system module contains materials that support the use of the traction system application. Development of traction system learning media using a combination method (mix method), RAD (Rapid Application Development), and ASSURE model. The combination of these two development designs results in a combination procedure, namely (a) the planning phase, (b) the design phase, and (c) the implementation phase. The planning phase is carried out by observing the learning system that is running and interviewing the student of the student. This study employed qualitative methods through observation and interviews, analyzed using Huberman's model, consisting of data reduction, display, and conclusion drawing. Observations at Politeknik Negeri Madiun revealed that the current learning system relies heavily on lecture-based delivery using PowerPoint, which contributes to student disengagement, with 60% reporting boredom due to one-way communication. The results of the observation on the electric machinery learning method are presented in Figure 2.

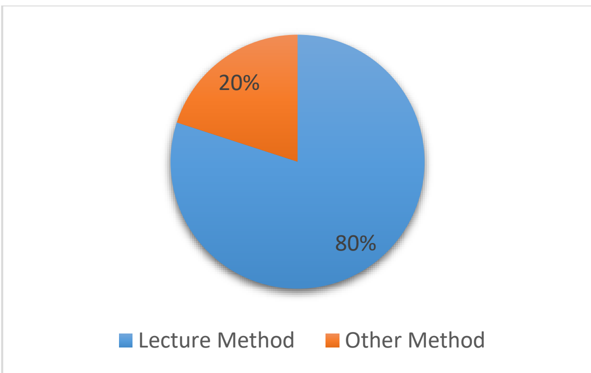

Figure 2. The results of the observation on the electric machinery learning method

Interviews further indicated that most students have a kinesthetic learning style, aligned with the vocational education model, emphasizing 70% practice and 30% theory. Despite the availability of a hybrid train set, the lack of interactive and practical learning media remains a limitation. These findings inform the proposed development of an integrated software-based learning tool and supporting module

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for electric traction systems, aimed at enhancing student engagement, practical skills, and alignment with current industry needs. The results of the interviews regarding students' learning styles are presented in Figure 3.

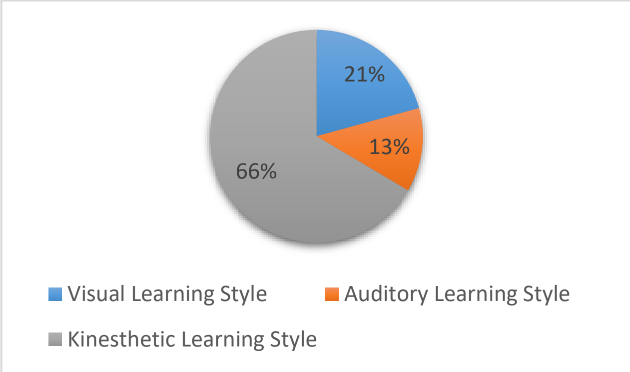


Figure 3. The results of the interviews regarding students' learning styles

The second phase is focused on designing a medium that will facilitate the media development process. The initial step in the design phase involved selecting appropriate learning media. Accordingly, this study proposes the development of an integrated traction system practicum media, consisting of a trainset-connected application accessible via laptops and a supporting teaching module, aimed at enhancing the effectiveness of learning and practicum activities at the Polytechnic.

The developed traction system application requires a computer or laptop running at least Windows 7 OS, equipped with a minimum dual-core processor, 80 GB of hard disk storage, and 1 GB of RAM. The application comprises three key modules: the traction performance module, the power electronics components module, and the VVVF (Variable Voltage Variable Frequency) control module, which together support comprehensive simulation and practical learning of electric traction systems. The design results of the traction system media are shown in Figures 4 and 5.

Figure 4. Traction System App Home View

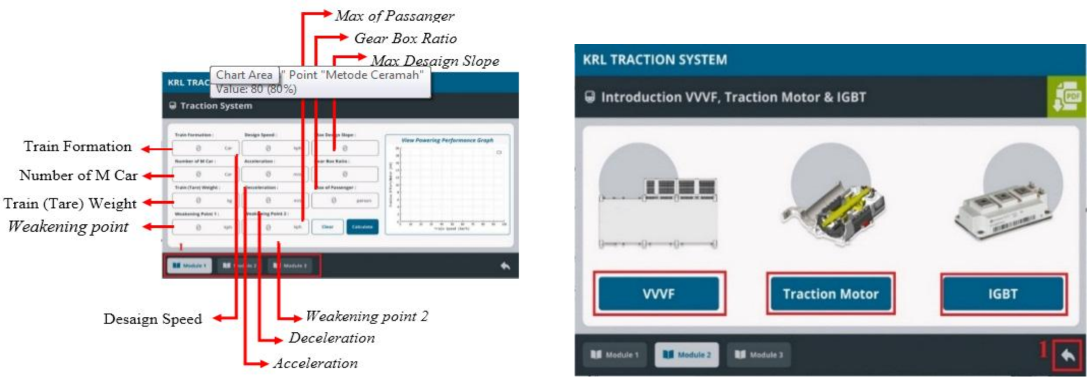


Figure 5. Module Menu Display

The development of support media is the teaching module of the traffic system that contains three major theories, including the theory of mathematical traction performance, power-electronic components theory, and VVVF (Inverter Variable Voltage Variable Frequency) theory monitoring system.

Figure 6. Cover Of The Traction System Teaching Module

Figure 7. Cover Lab Labsheet And Practical Report On Traction Systems

The final phase of the implementation phase is done by proposing media development suited to the needs of user applications and module lab work on the electric railway train traction systems. User evaluation was conducted to determine a student on the use of the application system traction in practicum. A validity test survey is carried out through expert judgment, the validity of the instrument tests is carried out using formulas Pearson's product-moment correlation, while the reliability test instruments it with alpha Cronbach. The results of the validity of the media feasibility questionnaire show that 27 statements are "Feasible", the validity of the module feasibility questionnaire is known to be 35 "Feasible" statements, the validity of the media effectiveness questionnaire is known to be 27 statements "Feasible", the validity of the test obtained a test validity coefficient between 0.32 to 0.56. The test reliability coefficients were obtained at 0.69 and 0.76. The results of the pretest reliability test obtained a coefficient of 0.69 and a posttest of 0.76.

The working sample test was carried out by observing ten students to find out the functioning of the traction system application according to the user. The test sample work using an observation sheet with a number of 27 grains consisting of three dimensions, i.e., 8 grains of portability statement, 13 grains of functionality, and 6 grains of usability. The portability aspect obtained an Aiken-V coefficient of 0.912 in the "Very Feasible" category. Respondents' assessment of the portability aspect obtained an average score of 7.3 in the "Very Appropriate" category. The functionality aspect of getting the Aiken-v coefficient by 0.99 categories is feasible. The functionality assessment by the responder, which got an average score of 12.9 categories, is very feasible. The aspect of useability acquires an Aiken-V coefficient of 0.98 categories is feasible. Approval of the useability aspect by the responder earns an average score of 5.9 categories is feasible.

Description of The Feasibility of Software System Traction

Testing requirements media consists of three aspects: portability, functionality, and usability. Testing requirements media carried out using the Aiken formula. The instrument used as a medium-proper socket contains 27 items of the statement, covering 8 grains of portability statement, 13 grains of functionality, and 6 grains of usability. Grading scores used are the size scale with a range of 1-4. The portability dimension test result obtained an Aiken-v coefficient of 0.708 decent category. The average score by media experts on the portability dimension of 25 is included in the decent category. The functionality dimension test obtains an Aiken-V coefficient of 0.846 very decent category. Functionality dimension assessment by media experts obtained an average score of 46 included in the very decent category. The Usability dimension media feasibility test obtained an Aiken-V coefficient of 0.889 in the "Very Feasible" category. The results of media expert testing on the usability dimension obtained an average assessment score of 22, including the "Very Appropriate" category.

Based on the description of the media suitability assessment by material experts above, the suitability category for each dimension can be identified. The results of the media feasibility assessment by media experts obtained an average Portability dimension score of 78.12% in the "Very Feasible" category, an average Functionality dimension score of 88.46% in the "Very Feasible" category, and an average Usability dimension score of 91.67%. With the "Very Decent" category.

Table 1. Result Testing Feasibility of Software System Traction

Respondents	Dimensions					
	Portability		Funcionality		Usability	
	(%)	Category	(%)	Category	(%)	Category
Media Expert 1	71.87	Feasible	82.69	Very Feasible	91.67	Very Feasible
Media Expert 2	84.34	Very Feasible	94.23	Very Feasible	91.67	Very Feasible
Average	78.12	Very Feasible	88.46	Very Feasible	91.67	Very Feasible

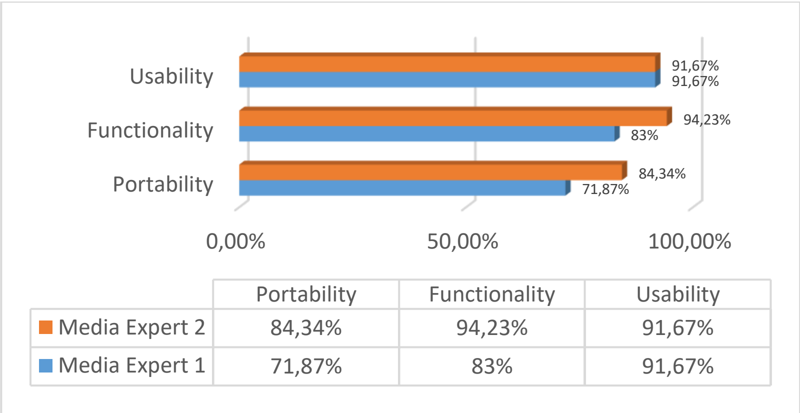


Figure 8. Testing the Feasibility of Software System Traction

The results of testing the effectiveness of the traction system learning media are in line with the results of research conducted by [24] with the title "Interactive Multimedia Learning for Power Electronics Course". Krismadinata's research results showed that multimedia-based learning media were declared valid by media experts and material experts. The results of the effectiveness test show that the learning media developed are in the "Medium" category to help improve learning outcomes and student motivation. Based on this research, it can be concluded that the research belongs to Krismadinata Strengthens the results of this research.

Description of The Feasibility of Module System Traction

Testing was performed by two feasibility material experts to find out the feasibility module system traction in terms of material. The test is performed using the modules qualification instrument, Parquet module, consisting of a dimensions assessment, which includes the quality dimension content containing 15 grains, and the module display dimension, containing 7 grains. The module application dimension contains 8 grains, and the practice assessment dimension contains 5 details of the statement. Assessment score using the Likert scale with a range of 1-4.

The results of the material feasibility assessment based on the content quality dimension obtained an Aiken-V coefficient score of 0.733 in the "Appropriate" category. The feasibility assessment on the content quality dimension obtained an average assessment score of 48, including the "Very Eligible" category. Assessment of the feasibility of the display dimension module using the Aiken formula obtained an Aiken-V coefficient score of 0.74 in the "Feasible" category. The assessment of appearance dimensions by material experts received an average score of 22.5, including the "Decent" category. The results of the Aiken formula calculation for the application dimensions of the module obtained an Aiken-V coefficient of 0.92 in the "Very Feasible" category. The worthiness assessment of matter in the application dimension earns an average score of 30, including a very decent category. Dimensions of practical assessment are done using an Aiken formula with a due coefficient Aiken-v score of 0.93 categories. The result of the material feasibility assessment in the dimension of the physics assessment by a material expert gained a score of 19, including the very decent category.

The results of the material feasibility assessment by material experts obtained an average Content Quality dimension score of 80% in the "Very Appropriate" category, an appearance dimension average score of 80.36% in the "Very Appropriate" category, and an average Implementation dimension score of 93.75% in the "Very Appropriate" category. "Very Feasible", and the average Practical Research dimension score is 95.00% in the "Very Feasible" category.

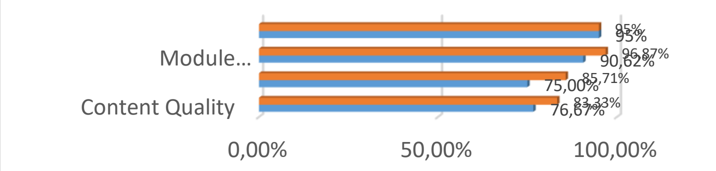
Table 2. Result: The Feasibility of Module System Traction

Respondent	Dimensi							
	Content quality		Appearance		Implementation		Practical assessment	
	(%)	category	(%)	category	(%)	category	(%)	category
Material Expert 1	76.67	VF	75	F	90.62	VF	95	VF
Material Expert 2	83.33	VF	85.71	VF	96.87	VF	95	VF
Average	80	VF	80.36	VF	93.75	VF	95	VF

Category:

VF = Very Feasible

F = Feasible



	Content Quality	Module Appearance	Module Implementation	Practical Assessment
Material Expert 2	83,33%	85,71%	96,87%	95%
Material Expert 1	76,67%	75,00%	90,62%	95%

Figure 9. The Feasibility of Module System Traction

Characteristics that need to be considered in preparing learning modules include (a) self-instructional, students learn independently; (b) self-contained, learning material is arranged in one module; (c) stand alone, the module can be used alone and is not tied to other modules; (d) adaptive,

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by developments in knowledge; (e) user-friendly, easy for users to understand; (f) consistency, accuracy in writing and display [25]. Another thing that needs to be considered in developing a module is the format used in preparing the module, namely (a) the module begins with an introduction to the main material, (b) the middle part of the module is filled with an explanation of the material, (c) it is supported by illustrations or pictures explaining the material, (d) don't forget to add exercises or evaluations for users, (e) the end of the module is filled with a summary of the material [26].

Average Test Description of The Learning System's Traffic

The average test of the learning of the traffic system is done by comparing pretest and posttest assessment results. Average study data was obtained from pretest sheet values and posttest sheets on each group. The subject of the pretest assessment is divided into two parts: the electrical system consists of 11 questions and 11 items of questions. While the posttest assessment material is divided into two, the electrical system consists of 12 questions and 8 questions for the material subjects of the electrical rail traffic system. This means the test was performed as an early pre-experiment requirement test with nonparametric analysis. The first conditional test is conducted by comparing the pretest values of the control class with the pretest statistics of the experimental class, which should be the same. The second conditional test is done by comparing the post-test value of experimental classes must be greater the post-test class control values statistically.

The distribution of pretest scores obtained by the control class was as follows: 5 students, or 23.8% of control class students, got a "Good" score, 11 students, or 52.38% of control class students, got a "Pretty Good" score, 5 students, or 23.8% received a grade of "Poor". The distribution of pretest scores obtained by the experimental class was as follows: 6 students or 33.33% of experimental class students, got "Not Good", 7 students, or 38.89% of experimental class students, got "Quite Good", and 5 students, or 27.78 % of experimental class students obtained a "Good" score. The result of the calculation of the average value of the pretest on both classes using the SPSS program obtains a sig value of 0.913 or a sig > value; the coefficient value of sig (0.05). This shows that there is no increase in the average value of pretest in both classes.

Table 3. Average value of pretest

Class	Number of students	Average value
Control Group (O3)	21	38.7
Experiment Group (O1)	18	39.4

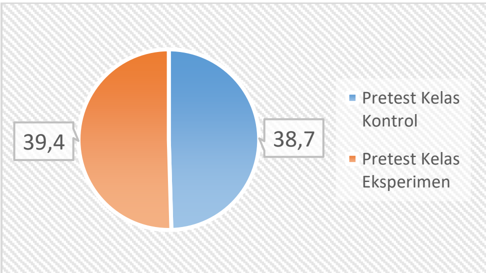

Figure 10. Average value of pretest

The distribution of posttest scores in the control class is as follows: 5 students or 23.8% got a "Not Good" score, 13 students, or 61.9% got a "Quite Good" score, 2 students, or 9.5% got a "Good" score and 1 student or 4.7% received a score of "Very Good". The distribution of posttest scores for the experimental class is as follows: 5 students, or 27.77% of experimental class students, got a "Pretty Good" score, 12 students, or 66.67% got a "Good" score, and 1 student, or 5.5% of experimental class students, got a "Very Good" rating. The second test results average posttests in both groups using an SPSS program, getting a sig value of 0.00 < sig coefficient value (0.05). That shows that there's an increase in the average post-test value in both groups. Based on the results of research conducted by

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Mubarak, it was explained that the results of trials using the module resulted in an increase in pretest and posttest scores for students [27].

Table 4. Average value of posttest

Class	Number of students	Average value
Control Group (O4)	21	39.05
Experiment Group (O2)	18	70.83

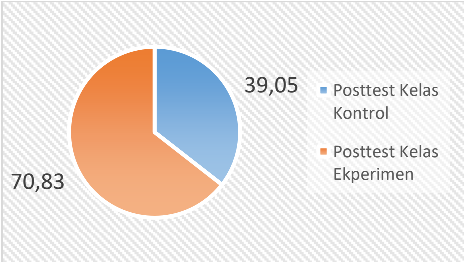

Figure 11. Average value of posttest

Test increase competence in electrification movements EMU

Testing the competence electrification drive train was held to find out whether there has been an increasing competence in electrification drive after respondents were given the media treatment of learning system traction. Based on the results of the research requirement obtained the posttest class experiment is greater than the class experiment, then the hypothesis was tested using the Wilcoxon signed rank test. The Wilcoxon signed-rank test is used to compare and see the difference between pretest and posttest respondent data. When the asymptotic value Sig < the coefficient value sig.0.05, Then it is accepted, meaning a difference in student assessment test value on electric railway inverter material.

The Wilcoxon signed ranks on class control indicate results show 11 students have posttest < pretest values, 9 students who have posttest > pretest, and as many as 1 student has posttest value = pretest value. Student assessment on the control class or class shows that z counts as -3,437 and sig as 0.97. This shows that sig 0.97 is more than the error rate of 5% (0.05). Then it can be concluded that there is no difference in the student assessment results in the control class. Wilcoxon signed-rank test results on experiment classes show that as many as 18 students have posttest > pretest grades. Student assessments in experimental classes show that z counts by -3,728 and sig by 0,000. This shows that the sig 0.000 is less than the level of error 5 % (0.05). Then it's concluded that there is a difference between student assessments in the experimental class before and after treatment.

Gain Score Test

The gain test was performed to find out the category of increased student competence. The effective use of media learning traffic systems can be known from the value obtained from pretest and posttest in control classes and experimental classes. The gain score on the control class got a gain score of 0.002, including the low category. Gain score in experimental class scores 0.51, including medium categories.

Education shapes the future generations of our nation. The quality of education plays a crucial role in producing high-quality graduates. Quality education can be assessed through several aspects, including high student learning achievements and teaching-learning outcomes that are relevant to the demands of the workforce. [28]. To achieve quality education, several references for the learning process are necessary, including: (a) preparing graduates for the workforce, (b) meeting the needs of the workforce's human resources, (c) focusing on skills, attitudes, and values required by the workforce, (d) assessing graduates' success based on their quality of work, (e) keeping up with technological advancements, (f) based on "learning by doing," (g) utilizing high-quality practical media, and (h) requiring significant operational costs [28].

Learning in vocational education is a stage in forming the character of vocational students through the scope of their work. Apart from producing graduates who are competent and have abilities according to industry needs in the world of work, other goals of vocational education are: (1) meeting the need for quality human resources in the world of work; (2) increasing student motivation with a wide choice of majors or fields of science; and (3) encourage students' enthusiasm for learning. Apart from that, vocational education was established to increase the relevance of vocational education and guidance to the needs of the industrial world [29]. Labor needs in industry will change and develop over times. Vocational education graduates need to prepare themselves to be competent. There are four main aspects of workforce competency, including graduates having a good level of ability, moral skills, knowledge skills, and work attitudes [30]. Competency is the ability that a person has in the form of knowledge, skills, and behavior that must be mastered to carry out tasks according to their profession [20]. The appropriate system to use in vocational education is a vocational school-based system coupled with industrial training [31]. According to the ILO (International Labor Organization), vocational graduates not only need to develop vocational skills but also need soft skills workshops, so that there is no gap between the competencies of vocational graduates and industry needs [30]. Learning media is used to support the learning process, which is considered to help increase student learning motivation with busy polytechnic lecture hours [32].

Software is an application that meets computer needs, and a translator of a program in the computer. Software or software can be used as a media study on Vocational education. The successful use of learning media is determined by instructional design and user interface factors [33]. The media of good learning can be rated using 6 assessments according to ISO 9126, including functionality, reliability, efficiency, maintenance, usability, and portability [34]. A traction system application developed to support the learning process, so that the application can be installed on the laptop device or computer of each student. Other than that, traction system applications can be reinstalled from the distribution file on other devices. The research results show that the feasibility of traction system application in the portability dimension is included in the "Feasible" category.

Other research states that the indicators for assessing software suitability are suitability, interoperability, accuracy, functional compliance, and safety of use [35]. Assessment of the functionality of the traction system application is carried out by assessing the function of each button available in the application, such as the menu button, back button, and next button. The accuracy indicator in the functionality dimension aims to ensure that calculations in the application produce accurate results (traction performance calculations). Usability criteria are the ability of the software to be easy to understand, use, learn, and attract user interest. The traction system application developed can be used during learning or outside the learning process. In addition, the traction system application has been equipped with traction calculations that are integrated with the Madiun State Polytechnic Railway hybrid train series. The results of the [36] Research shows that the level of feasibility of programmed logic controller learning materials received an average score of 4.13, which is in the good category. The test results received a score equivalent to 4.11, including the good category, and the test results from student assessments obtained an equivalent score of 4.08, including the good category.

Modules are supportive tools in the learning process that contain focused content to facilitate students' understanding of the learning material. According to [37], modules are instructional materials consisting of systematically organized learning collections to aid students in comprehending the material easily. The assessment criteria for modules in terms of content quality dimensions can be determined based on Dr. E. Kosasih [38]. Kosasih explains that module testing needs to consider the following aspects: the content aspect, language usage aspect, and the usage of learning materials [38]. According to BSNP, assessing the suitability of learning modules needs to pay attention to several components, namely aspects of content suitability, language, image aspects, presentation, and graphic aspects [39]. The development of modules should adhere to proper formatting guidelines to ensure they are systematically and neatly organized. The format used in module development includes starting with the main material, followed by explanatory content in the middle section, accompanied by illustrations or images, including exercises or evaluations, and concluding with a summary of the material [26]. Mufidah [40] mentions that the assessment of module development can be evaluated based on three aspects: material aspect, presentation aspect, and language aspect [40]. The presentation aspect relates to the use of formal language and language that is easily understood by users. The quality of the content and display on the traction system module has been evaluated by content experts and rated "Very Satisfactory". The module assessment criteria are then reviewed from the following characteristics: (a) instructional, (b) independent, (c) stand-alone, (d) adaptive, (e) easy to use, and (f) consistent [25]. The traction system module has been evaluated based on indicators such as ease of use, self-instructional capability, and adaptability, with the achievement of the category "Very suitable".

The Wilcoxon test results in this study showed that there was no significant difference between the pre-test and post-test scores of the control group. Meanwhile, the experimental group showed a significant difference between the pre-test score (before using learning media) and the post-test score (after using the traction system learning media), with a score in the "Medium" category.

In general, vocational education students exhibit high enthusiasm for learning through "learning by doing" or practical learning methods. The quality of practical learning, such as in laboratory sessions, can be enhanced with appropriate learning media developed in line with the latest technology. According to Sangsawang [19], Vocational education requires learning media that incorporate both academic and practical approaches. The benefits of using learning media include increasing learning motivation due to more engaging lessons, aiding students in understanding the material easily, alleviating student boredom with varied teaching methods, and encouraging active learning processes among students [41]. System learning media has benefited 4th-semester students at Madiun State Polytechnic Railway. Students find it easier to grasp traction system materials with the aid of developed media and traction system modules. Test results indicate that the average post-test scores of the experimental group were higher compared to the average post-test scores of the control group, which did not receive the traction system learning media treatment.

CONCLUSION

The traction system learning media have been developed to enhance competencies in electrifying electric train drives. The developed learning media consists of a traction system application and module. The traction system application serves as a supporting tool in the laboratory sessions of the electric machinery course. Performance testing to evaluate the functionality of the traction system application resulted in it being categorized as "Very Suitable," with an average percentage score of 96.25%. The suitability of the traction system media was assessed based on evaluations conducted by media and content experts using Aiken-V analysis. The aspects of portability, functionality, and usability each received a "Very Suitable" rating in the media testing. The suitability of the traction system learning material, evaluated by content experts, also received a "Very Suitable" rating. Additionally, student evaluations of the effectiveness of the media also categorized it as "Very Suitable." Overall, the traction system learning media, including the application and module, has been well-received and deemed highly effective based on assessments by experts and student feedback.

The use of traction system media has been found to have a significant impact on improving student learning outcomes in the experimental class. The improvement in student learning outcomes was assessed based on the pretest and posttest scores. Wilcoxon test results indicate that in the control class that did not receive the traction system learning media treatment, there was a significance value of 0.001 with a "Low" gain score category. On the other hand, the experimental class, which received the traction system learning media treatment, achieved a significance value of less than 0.00005, which is smaller than the significance level of 0.05, with a "Moderate" gain score category. Overall, these results indicate a greater improvement in learning outcomes in the experimental class compared to the control class. The traction system learning media is considered effective in enhancing competencies in electrifying electric train drives at the Polytechnic.

Traction system learning media in the form of applications and teaching modules can be used to increase students' understanding and competence regarding train traction system material. This research shows that the development of media and teaching modules for KRL traction systems has significant implications for railway vocational education in Indonesia. Research findings show that with media that is integrated with EMU units and is technology-based, the learning process becomes more interactive and effective, preparing students to face the challenges of the railway industry. The implications of this research also include the need for collaboration between educational institutions and the railway industry to ensure that the curriculum taught is relevant to the needs of the job market. By integrating innovative media and teaching modules, it is hoped that students' technical skills will improve, resulting in a competent and prepared workforce. Therefore, it is recommended that related parties, such as the government and educational institutions, consider these recommendations to formulate policies that are more adaptive and responsive to the dynamics of technological and industrial development.

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