Jurnal Pendidikan Vokasi
Volume 9, No 3, November (307-317)
Online: http://journal.uny.ac.id/index.php/jpv

THE DUAL-DESIGN-BASED PNEUMATIC SIMULATOR AS SUPPORTING MEDIA FOR ELECTRO-PNEUMATIC PRACTICUM IN VOCATIONAL HIGHER EDUCATION

Sulaeman Deni Ramdani
Universitas Sultan Ageng Tirtayasa

Angga Pangestu
Universitas Sultan Ageng Tirtayasa

Haris Abizar
Universitas Sultan Ageng Tirtayasa

Abstract

This study aims to: (1) determine the process of developing a learning media simulator for electro-pneumatic systems based on dual design, (2) knowing the effectiveness of learning media in the form of electro-pneumatic system simulators based on dual design. This research is a research and development adapted from the 4D development model, namely, Define, Design, Develop, and Disseminate. The subjects of this study were students of Mechanical Engineering Education in Semester IV and V, with 30 students taking pneumatic hydraulic courses. Data collection techniques in this study used questionnaires and interviews with research instruments in the form of interview guidelines and questionnaires. The data obtained were analyzed with a descriptive quantitative method. The results show that (1) the results of the development of learning media for electro-pneumatic system simulators based on Dual Design as supporting media for electro-pneumatic practices produce three main components, namely the working system in the pneumatic electro system, wiring diagrams, and electrical circuits, (2) the feasibility results of expert validation media is 84% (Very Good), expert material validation is 92% (Very Good), and user validation is 86% (Very Good). Therefore, the learning media for electro-pneumatic system simulator is feasible as a learning media in pneumatic hydraulic courses.

Keywords*: simulator, electro pneumatic, dual design*

Permalink: *http://dx.doi.org/10.21831/jpv.v9i3.27345*

Contact Sulaeman Deni Ramdani
s.deni.ramdani@untirta.ac.id
Department of Mechanical Engineering Education,
Faculty of Teacher Training and Education,
Universitas Sultan Ageng Tirtayasa
Jl. Ciwaru Raya No. 25, Cipocok Jaya, Kota Serang, Banten 42117, Indonesia

INTRODUCTION

Education is an activity carried out to gain knowledge or insight. Education is a conscious and planned effort to create an atmosphere of learning so that students actively develop their potential to have spiritual strength, self-control, personality, noble moral intelligence, and skills. Education should provide supportive learning to help students become competent and well-adjusted individuals (Taylor & MacKenney, 2008). The development of individual potential can be obtained through formal education in higher education.

Higher education is divided into several types, one of which is vocational education. Vocational education is an education program that prepares students to become professional workforce and continue their education to a higher level (Djohar, 2007). Many factors affect students' understanding in learning, one of which is learning media.

Learning media are aids in the teaching process. Everything that can be used to stimulate students' thoughts, feelings, concerns, and abilities or skills is a learning medium (Ali, 1998). It aims to encourage an effective learning process. Thus, learning media must pay attention to the suitability of the subject matter, the accuracy of the contents of the media with the content of the subject matter, and the quality of the learning media. Learning media must be able to provide information to students to learn easily (Syaefrudin, 2016). In addition, instructional media must be able to facilitate communication between learners, teachers and other learning resources (Tafakur & Solikin, 2018). Based on its development, learning media can be classified into two groups, namely traditional media and modern technology media. Traditional media is media that is still conventional, whereas modern technology media utilizes technological developments.

One form of modern learning media is simulator. Simulation is the application process of building a model of a real system or a proposed system, conducting experiments with the model to explain the behavior of the system, study the performance of the system, or to build a new system in accordance with the desired performance (Khoshnevis, 1994). Simulators are shown to support student learning in applying the knowledge or concepts acquired to real objects. The main purpose of the simulator media is to facilitate practice in terms of understanding and operation, as well as educating students to understand the electronic circuit scheme because basically, the simulator is a hardware scheme. Simulation is a model of the results of the simplification of reality. The simulator must reflect the real situation and be operational. Simulators describe ongoing processes that are physical, verbal, or mathematical (Sadiman et al., 2010). Therefore, simulators have a very important role in learning because original tools have high prices and low levels of efficiency.

Anderson (1987, p. 181) argues that the influence of physical objects or tangible objects used in education will provide a very important stimulus for students in learning tasks involving psychomotor skills. In addition, Ahmadi (2005, p. 23) states that simulation means an imitation or an act that is only mock. Vocational education must be able to organize learning according to real conditions, and it has not been able to be done well. It has an impact on the low competency of students. Vocational schools have not optimally prepared students' skills to master technology in the workforce (Jamaludin & Khairudin, 2017). Thus, learning requires a simulator to bring situations that are similar to the real thing in class. In the application of media simulators, a problem-solving learning strategy is needed in solving problems related to the pneumatic electro system to improve students' skills and competence in understanding components and understanding the pneumatic system circuit to the maximum, so we need appropriate learning media to overcome the limitations of practical learning.

The conclusion from several related studies about the importance of learning media in the form of simulators shows that the media helps the learning process. However, the media simulator also still does not give a real picture of the material being studied. Simulator learning media by combining two types of learning media characters in the form of dual design is expected to be able to attract the attention of students and can increase knowledge significantly. This study chooses dual design because simulators in the form of dual design have not yet been developed specifically. Dual design simulators are also able to provide clear images to students to better understand the material being taught.

Pneumatic systems are used for the purpose of, among others, gripping workpieces, shifting the workpiece, positioning the workpiece, and directing the flow of goods to different directions. Moving machines are absolutely necessary in the industry (Raharjo, 2013). Automatic equipment is needed by the industry today to improve work efficiency and productivity (Kurniawan, 2008). Pneumatic systems have the advantage of high power-to-weigth ratio, high stiffness, high instant expansibility, and high speed (Li et al., 2013). Besides, pneumatic system is very interesting because it has softness of movement, high power volume rate, and strength (Rubio et al., 2009). In addition, pneumatic systems have easy maintenance, clean, low manufacturing costs, availability, and low energy consumption (Oladapo et al., 2016). It makes the pneumatic system very useful for production in the automation systems using compressed air in the industry.

The application of pneumatic systems used in mobile industries is still not widely used (Bahar, 2017). It is different from the use of hydraulic systems in the automotive industry, especially in transmission systems (Balau et al., 2011), but the electro pneumatic system is one option that can be expected to be a solution for manufacturing automated equipment (Hudallah, 2010).

Obstacles are faced by students from observations in the Department of Mechanical Engineering Education Untirta, namely: (1) learning that is difficult to understand because learning is theoretical. When the theory has been understood, students do not necessarily understand with practical learning. (2) The method used is quite good, but the application is still not optimal, (3) The media used is only an application that cannot yet explain the components and mechanism of action directly, so by using an application, students lack understanding of it. Many of them are less skilled in practice, and there are even students who have never done practical learning. Whereas, vocational education must be able to improve the skills of students (Clarke & Winch, 2007). This problem must be resolved immediately because it will affect students' skills to become weak. Finally, many students still do not understand the learning provided.

Based on those problems, an incomplete learning system occurs, especially in the students' skills. Electro pneumatic system material is one of the topics that is considered difficult (Najjari et al., 2014). It is because the electro pneumatic system uses more complicated components and circuits. In addition, the automation system with electro pneumatic technology with three main components namely, actuators, sensors or buttons, and control devices requires students to understand more deeply (Najjari et al., 2012). Thus, pneumatic system material requires the development of a comprehensive learning media (Setiadi et al., 2018).

Students' skills are influenced by the methods and media used in the learning process. The use of appropriate methods and media is reflected in the practical skills of students in learning (Fatkhurrokhman et al., 2018). Learning methods must be in accordance with the characteristics of each student, while the learning media must be able to facilitate students in understanding learning material. It is because teachers and students must have knowledge and skills both theoretically and practically (Wiyanto et al., 2017). Therefore, developing pneumatic system simulators to support electro pneumatic practicum becomes very important.

RESEARCH METHOD

This research was conducted at the Department of Mechanical Engineering Education Study Program to conduct user respondent tests. The study was conducted from April to August 2019. The research subjects were students of Mechanical Engineering Education in semester IV and VI of 30 students. The data collection method is done by observation and questionnaire. The data analysis technique used in this study is a quantitative descriptive analysis technique. This research is a development study using the 4D model, namely (1) definition, (2) design, (3) development, (4) dissemination. Each stage is elaborated as follows.

Defining Stage

In the defining phase, the researchers conducted a research observation to determine the learning conditions in pneumatic hydraulic courses with 32 students in Universitas Ageng Tirtayasa (Untirta)'s vocational engineering education. The result of observation shows that there are no practice learning media that use instructional media in detail so that learning on competence understands components and comprehends a series of theories and simulations using the software. It has become a problem for students in the process of acquiring knowledge about hydraulics and pneumatics. Therefore, research about learning media is needed in the form of a simulator. It is because the original equipment requires expensive funds. Simulator becomes a strategic alternative to overcome these problems in an effort to improve students' knowledge and skills in pneumatic hydraulic competence. The simulator that was developed was based on a dual design on electro-pneumatic material. The dual design is the addition of mechanical media that is explaining the components and circuits.

Design Stage

Based on the results of preliminary studies that have been carried out, it is necessary to conduct a study regarding the development of instructional media in the form of a dual-designed-based electro-pneumatic simulator. The characteristic of an electro-pneumatic simulator based on dual design is the addition of mechanical functions for valves and circuits. The development of a pneumatic electro simulator based on dual design aims to improve students' understanding of the concepts and workings of components and circuits. Therefore, the development of a dual design-based media simulator is one of the strategic solutions to address these problems.

Development Stage

After making the simulator is complete, the next stage is testing. The testing step is in the form of an expert assessment of the media and material. Based on expert input, the media and material were revised to make it more precise, effective, easy to use, and have high technical quality.

Data collection was performed after the instruments validated by expert judgment. The data obtained were tabulated to make it easier to process and analyze data. The tabulated data are quantitative data. After the data were tabulated, the average score was calculated by converting the assessment score. Table 1 is a score conversion. The data that has been calculated and produced data in the form of a feasibility level are qualitative data.

Table 1. Range of Percentages and Qualitative Criteria (Source: Ali, 1998)

No.	Interval	Criteria
1.	81.25% < score ≤ 100.00%	Very good
2.	62.50% < score ≤ 81.24%	Good
3.	43.75% < score ≤ 62.49%	poorly
4.	25.00% < score ≤ 43.74%	Bad

This research was declared successful if the results obtained from the questionnaire were in the range of 62.50% <score ≤ 81.24% and 81.25% <score ≤ 100% or in the "Good" and "Very Good" criteria. If the results were in the range of 25.00% <score% 43.74% and 43.75% < score% 62.49% or in "Poor" and "Bad" criteria, then the it was inappropriate.

Dissemination Stage

The last stage is dissemination stage. It is carried out by disseminating this information to students of Mechanical Engineering Education in Faculty of Teacher Training and Education, Sultan Ageng Tirtayasa University, and publication through scientific journals.

RESULTS AND DISCUSSION

The result of the development of the instructional media simulator electro-pneumatic system is performed in this study with a development model consisting of four phases of activities, namely: (1) Defining, (2) Designing, (3) Developing, (4) Disseminating.

The results obtained at the defining phase are as follows: (1) the instructional process is difficult to understand because the learning is theoretical. When the theory has been understood, students do not necessarily understand with practical learning. (2) The method used is quite good, but its application is still not optimal. (3) The media used is only an application that cannot explain the components and mechanism of action directly, so by using an application, the students do not understand it. Based on the results of observations of lecturers, learning media of electro-pneumatic simulators is needed to facilitate electro-pneumatic learning. This research was divided into two stages, namely the stage of making learning media products and the learning media testing phase. The product produced is an electro-pneumatic system simulator and companion material in the form of an electro-pneumatic manual book.

Figure 1. Front View of the Simulator

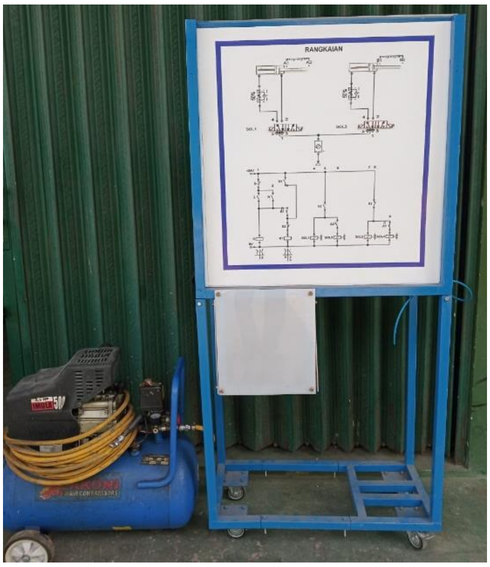

Figure 2. Rear View of the Simulator

As for the results obtained during the design process, the researchers create and prepare the designs after obtaining data from observations. The data obtained in the design process are: (1) an electro-pneumatic system simulator based on dual design, (2) testing is carried out to test the feasibility of the learning media product.

The results of the preliminary study analysis indicate that the development of the simulator aims to improve students' understanding of the components and electro-pneumatic circuit. Simulator development refers to these results to produce a pneumatic simulator based on the dual design as supporting media for electro-pneumatic practice. Figure 1 and Figure 2 show the results of the development of an electro-pneumatic simulator based on dual design, as a result of the research.

Figure 1 shows the front view of the simulator. The front view presents an electro-pneumatic circuit that can be used by students in conducting experiments on an electro-pneumatic function. Figure 2 is a dual design that is set to meet the needs of students in understanding the function and workings of the valve and actuator components with the addition of valve and cylinder characteristics that can be changed according to the circuit being made. The valve and cylinder can be shifted manually to move the working fluid flow to the desired actuator movement.

Testing is done using a questionnaire with a total of four levels of scores. Then, the media is given to media experts and material experts (teachers from SMK YPWKS Cilegon and lecturers form the department of Electrical Engineering Education of Untirta) to determine the validity of the product and the level of eligibility of the product made. Questionnaires are also given to users to assess products that are made, so they know the level of eligibility of users. The questionnaire was consulted with expert judgment so that it could be used for data collection.

The results obtained from the process of developing instructional media products in this study are electro-pneumatic simulators equipped with electro-pneumatic manuals book. They are produced through several stages as follows.

Observation of Students as Users to Find Out Their Average Height

It is aimed at making the product can be appropriately used, and students feel comfortable in learning practices. The first step is designing an electro-pneumatic simulator frame as needed with Solid Work and Photoshop software. Electrical pneumatic simulators consist of double-acting actuators, DC limit switches, 24/2 solenoid 24 volts, LED lights, 8-foot 24 Volt relays, air service units, push buttons, power supply, and compressors. The designed electro-pneumatic simulator is the development of a simulator from several previous researchers. The development carried out in this research is in the form of a simulator display with an attractive dual design system that makes it easier for students to understand. The front view of the simulator display is presented in Figure 3. The circuit is designed to make it easier for students to understand how the original circuit works in the form of an electro-pneumatic simulator. The simulator can be designed to perform a function of moving an object by having simultaneous movements according to the series made by students.

Figure 3. Front View of the Simulator Display

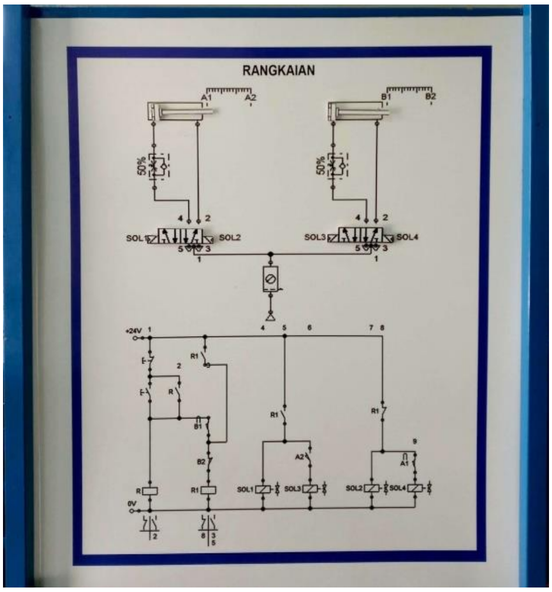

Figure 4. Rear View of the Simulator Display

One design is in front with the appearance of the original components that can be operated (Figure 3), and another design in the rear for the circuit (Figure 4). After drawing each position in accordance, then it is immediately printed. After printing is then measuring and cutting the acrylic and electro-pneumatic simulator frame. The printed sticker has component symbols directly affixed to the acrylic. After the sticker is placed on the acrylic, each component is immediately installed in accordance with their respective positions.

The rearview displays the circuit simulator with valves and cylinders which can be changed manually to show the direction of the fluid. The rearview function is essential to increase student knowledge in understanding the working principle of each component and the function of components in a series. Students can know the flow of working fluid by looking at the symbol direction of the valve, which affects the cylinder position. The dual design function is crucial to improve the basic understanding of student circuits so that, with this simulator, it can improve students' knowledge and understanding of electro-pneumatic material.

Creating a Pneumatic Electro Simulator Equipped with a Manual Book for Students

It is created for students to help them implementing learning practices referring to the syllabus for electro-pneumatic competence. The manual aims to provide information on how to operate the simulator. It presents information on various types of circuits that can be made through a simulator.

The results of the dissemination carried out during the process of data collection on the feasibility of the media are as follows. The researchers explain the learning media to student representatives as users. In addition to users, researchers also explained this learning media to teachers of pneumatic-hydraulic subjects and lecturers to support pneumatic-hydraulic subjects for later use as an alternative learning media in teaching. Figure 5 shows a student conducting experiments on the developed media. He composes a circuit to a particular function. The piston will move simultaneously to push to perform a certain function.

Figure 6 shows a student studying the function and workings of valves. When the valve is moved manually, the piston must be moved manually as well because there is a fluid flow that must be adjusted in the circuit. The existence of this simulation can improve students' understanding of the basic concept of pneumatic components.

Based on the results of the socialization, researchers get results in the form of comments related to the media, that this media is very helpful for students so that it can be used as an electro-pneumatic learning media. The eligibility criteria are derived from the average of the data obtained from respondents. The level of eligibility is determined from the average obtained and then converted to the formulated score table (Ali, 1998). There are four levels of the score on the questionnaire, with the lowest score of 1 and the highest of 4 on each answer.

Data obtained from media experts and material experts are then analyzed. Data analysis that was carried out resulted in the average score, total score, and level of eligibility. Data of media experts were analyzed so that the total score obtained on the simulator display criteria was a total score of 88, a maximum score of 108, and a percentage of 81%. These percentages are included in the Very Eligible category. Table 2 shows the data acquisition for each criterion filled out by media experts.

The mean score of all criteria is calculated to find out the overall score of the criteria taken from the validator. After knowing the average score, the results are compared with the percentage score conversion table to determine the feasibility level. Based on the average number of validator scores getting 84% of the maximum 100%, it can be categorized as "Very Good".

Based on the diagram in Figure 7, the results of feasibility data obtained by reviewing the design and technical quality of the simulator display are 81%, which is included in the category of "Very Good". The results of design criteria are 83%, which is included in the category of "Very Good ", and the results of the technical quality are 86%, included in the category of "Very Good ". These data were obtained from three media experts, namely lecturers and teachers who are experts in the field of learning media. Data obtained from the three experts were then averaged with 84% results, which means that of the three criteria, the electro-pneumatic simulator media received the category of "Very Good".

Figure 5. A Student Composing an Electro-Pneumatic Circuit on the Front of the Simulator Function

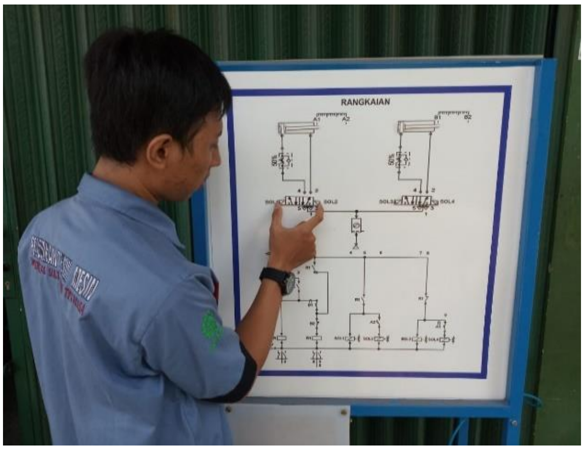

Figure 6. A Student Composing an Electro-Pneumatic Circuit on the Rear of the Simulator Function

Table 2. Data Analysis of Media Expert Assessment Results

No.	Criteria	Total Score	Total Score Maximum	Percentage (%)	Criteria
1.	Simulator Display	88	108	81%	Very good
2.	The design	80	96	83%	Very good
3.	Technical Quality	83	96	86%	Very good
Average Amount		251	300	84%	Very good

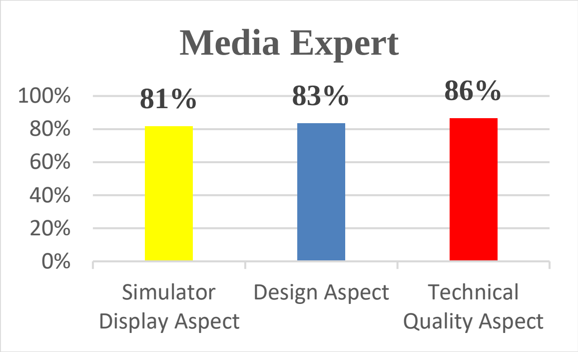

Figure 7. Diagram of Media Expert Test Validation Results

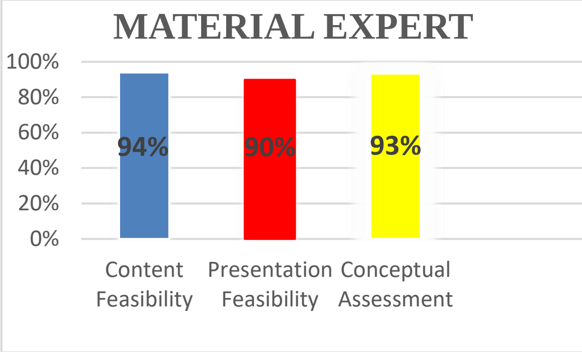

Figure 8. Diagram of Expert Test Expert Material Validation Results

Table 3. Data Analysis of Material Expert Assessment Results

No.	Criteria	Total Score	Total Score Max	Percentage (%)	Criteria
1.	Content Feasibility Aspect	124	132	94%	Very good
2.	Presentation Aspect	97	108	90%	Very good
3.	Aspect of Contextual Assessment	56	60	93%	Very good
	Average Amount	277	300	92%	Very good

Table 4. Data Analysis of User Assessment Results

No.	Criteria	Total Score	Total Score Max	Percentage (%)	Criteria
1.	Content Feasibility Aspect	830	960	86%	Very good
2.	Display Simulator Aspect	828	960	86%	Very good
3.	Design aspects	392	480	82%	Very good
4.	Technical Quality Aspects	424	480	88%	Very good
	Average Amount	2474	2880	86%	Very good

The mean score of all criteria is calculated to find out the overall score of the criteria taken from the validator. After knowing the average score, the results are compared with the percentage score conversion table to determine the feasibility level. As presented in Table 3, the average number of validator scores obtained 92% of the maximum of 100%, and it can be categorized as "Very Good".

Based on the diagram in Figure 8, data on the content worthiness and the feasibility of presentation and conceptual assessment are obtained. The result of the eligibility criteria of content is 94%, which means in the category of "Very Good". The result of the eligibility criteria of presentation is 90%, which means in the category of "Very Good", and on the result of the conceptual assessment is 93%, which means in the category of "Very Good ". These data were obtained from three material experts, namely lecturers and teachers who are experts in the electro-pneumatic system material. Data obtained from the three experts were then averaged with 92% results, which means that of the three criteria, the electro-pneumatic system simulator media received the category of "Very Good".

The mean score of all criteria is calculated to find out the overall score of the criteria taken from the validator. After knowing the average score, the results are compared with the percentage score conversion table to determine the feasibility level. As presented in Table 4, the average of the validator's scores is 86% of the maximum 100%, and then it can be categorized as "Very Good".

Based on the diagram in Figure 9, the feasibility data in terms of the feasibility of the content, simulator appearance, design, and technical quality were obtained. The result of the content eligibility criteria is 86%, which is included in the category of "Very Good". The display criteria of the simulator obtained 86%, which means that it is included in the category of "Very Good". The design criteria obtained 82%, which means in the category of "Very Good", and the technical quality criterion obtained 88%, which means it belongs to the category of "Very Good". These data were obtained from 30 students who join and had taken the pneumatic hydraulic courses. The data obtained were analyzed with the result of 86%, which means that the four criteria of the electro-pneumatic system simulator media are in the category of "Very Good".

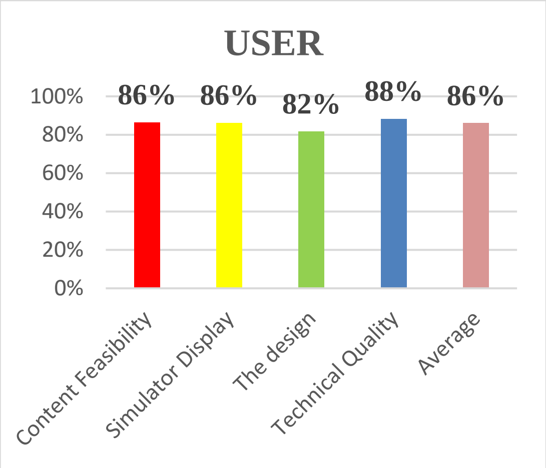

Figure 9. Diagram of Student User Validation Test Results

CONCLUSION

Based on the results of the research and discussion previously explained, it can be concluded that: (1) The development of electro-pneumatic simulator learning media produces two main components, namely (a) the working system in the electro-pneumatic system, in which, there are dual pneumatic electro system design components, namely original components that can be operated, and the working system of the airflow rate that moves on the electro-pneumatic system; and (b) electrical circuit, in which, there is an electrical system of electro-pneumatic system components that can be assembled by students or users. These two components serve as a learning media simulator for electro-pneumatic systems based on dual design. (2) The results of the feasibility test for learning media of pneumatic electro system simulators conducted by media experts are 84%, included in the category of "Very Good" in terms of the simulator display design, design, and technical quality. The results of the feasibility test on the learning media of pneumatic electro system simulators conducted by material experts are 92%, included in the category of "Very Good" in terms of the criteria of content, the feasibility of presentation, and contextual assessment. The results of the user feasibility test on the learning media of the pneumatic electro system simulator conducted by 30 students from mechanical engineering education Untirta are 86%, included in the category of "Very Good" in terms of content eligibility, simulator appearance, design, and technical quality.

The development of pneumatic simulator media based on the dual design as supporting media for electro-pneumatic practice has immense benefits for increasing students' understanding of electro-pneumatic circuit and components. Thus, the existence of this simulator is expected to be able to increase students' understanding efficiently because they do not have to present original products that require high costs. This media simulator becomes a strategic answer to create learning that is almost similar to the original and can increase the efficiency of the price and time spent.

REFERENCES

Ahmadi, A. (2005). *Strategi belajar mengajar*. Pustaka Setia.

Ali, M. (1998). *Strategi penelitian pendidikan*. Angkasa.

Anderson, R. H. (1987). *Pemilihan dan pengembangan media untuk pembelajaran*. Rajawali.

Bahar, A. (2017). Redesign sistem pneumatik silinder unloading untuk pergantian arah feeding dengan installation direction vertical, horizontal, dan inclined. *Jurnal Teknik Mesin*, *5*(2), 209–216.

Balau, A., Caruntu, C., & Lazar, C. (2011). Simulation and control of an electro-hydraulic actuated clutch. *Mechanical Systems and Signal Processing*, *25*(6), 1911–1922. https://doi.org/10.1016/j.ymssp.2011.01.009

Clarke, L., & Winch, C. (2007). *Vocational education: International approaches, developments and systems*. Routledge.

Djohar, A. (2007). Pendidikan teknologi dan kejuruan. In *Ilmu dan aplikasi pendidikan* (pp. 1285–1300). Pedagogiana Press.

Fatkhurrokhman, M., Leksono, S. M., Ramdan, S. D., & Rahman, I. N. (2018). Learning strategies of productive lesson at vocational high school in Serang City. *Jurnal Pendidikan Vokasi*, *8*(2), 163–172. https://doi.org/10.21831/jpv.v8i2.19485

Hudallah, N. (2010). Rancang bangun sistem pneumatis untuk pengembangan modul-modul gerak otomatis sebagai media pembelajaran. *Jurnal Teknik Elektro*, *2*(1), 8–22. https://doi.org/10.15294/jte.v2i1.1583

Jamaludin, J., & Khairudin, M. (2017). Pengembangan trainer elektropneumatik pada kompetensi mengoperasikan sistem kendali elektropneumatik. *Jurnal Pendidikan Teknik Elektro*, *7*(2), 108–116. http://journal.student.uny.ac.id/ojs/index.php/elektro/article/view/8662

Khoshnevis, B. (1994). *Discrete system simulation*. McGraw Hill.

Kurniawan, R. (2008). Rekayasa rancang bangun ssistem pemindahan material otomatis dengan sistem elektro pneumatik. *Jurnal Energi Dan Manufaktur*, *2*(1), 42–47. https://ojs.unud.ac.id/index.php/jem/article/view/2263

Li, B., Gao, L., & Yang, G. (2013). Evaluation and compensation of steady gas flow force on the high-pressure electro-pneumatic servo valve direct-driven by voice coil motor. *Energy Conversion and Management*, *67*, 92–102. https://doi.org/10.1016/j.enconman.2012.11.004

Najjari, B., Barakati, S. M., Mohammadi, A., Fotuhi, M. J., Farahat, S., & Bostanian, M. (2012). Modelling and controller design of electro-pneumatic actuator based on PWM. *International Journal of Robotics and Automation (IJRA)*, *1*(3), 125–136. https://doi.org/http://dx.doi.org/10.11591/ijra.v1i3.565

Najjari, B., Barakati, S. M., Mohammadi, A., Futohi, M. J., & Bostanian, M. (2014). Position control of an electro-pneumatic system based on PWM technique and FLC. *ISA Transactions*, *53*(2), 647–657. https://doi.org/10.1016/j.isatra.2013.12.023

Oladapo, B. I., Balogun, V. A., Oyegoke, S., Adeoye, A. O. M., Ijagbemi, C. O., Afolabi, S. O., Daniyan, I. A., Akinola, S. O., Simeon, A. P., & Uchegbu, I. D. (2016). Experimental analytical design of CNC machine tool SCFC based on electro-pneumatic system simulation. *Engineering Science and Technology, an International Journal*, *19*(4), 1958–1965. https://doi.org/10.1016/j.jestch.2016.08.010

Raharjo, R. (2013). Rancang bangun belt conveyor Trainner sebagai alat bantu pembelajaran. *Jurnal Teknik Mesin*, *4*(2), 15–26.

Rubio, E. R., Hernandes, L., Aracil, S. R., Roque, S., & Guerra, J. A. (2009). Implementation of decoupled model-based controller in a 2-DOF pneumatic platform used in low-cost driving simulators. *2009 Electronics, Robotics and Automotive Mechanics Conference (CERMA)*, 338–343. https://doi.org/10.1109/CERMA.2009.22

Sadiman, A., Rahardjo, R., Haryono, A., & Rahardjito, C. (2010). *Media pendidikan (Pengertian, pengembangan, dan pemanfaatannya)*. Raja Grafindo Persada.

Setiadi, A., Yuliatmojo, P., & Nurhidayat, D. (2018). Pengembangan aplikasi Android untuk pembelajaran pneumatik. *Jurnal Pendidikan Vokasional Teknik Elektronika*, *I*(1), 1–5.

Syaefrudin, N. (2016). Pengembangan media pembelajaran trainer kit sensor dan aktuator untuk meningkatkan hasil belajar. *Jurnal Pendidikan Teknik Mekatronika*, *6*(3), 258–267.

Tafakur, T., & Solikin, M. (2018). Electronic spark advance ignition system simulator as instructional media for assisting electrical practices on automotive field. *VANOS Journal of Mechanical Engineering Education*, *3*(1), 43–50. https://doi.org/10.30870/vanos.v3i1.3377

Taylor, G. R., & MacKenney, L. (2008). *Improving human learning in the classroom theories and teaching practices*. Rowman & Littlefield Education.

Wiyanto, T., Samani, M., & Sugiyono, S. (2017). The developing teaching practice model as an effort to improve the quality of mechanical engineering vocational school teachers. *Jurnal Pendidikan Vokasi*, *7*(3), 349–363. https://doi.org/https://doi.org/10.21831/jpv.v7i3.17923