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Virtual Laboratory Design for Learning Electro-Pneumatic Practices in Vocational High Schools

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Abstract: Teaching a subject in a vocational high school (VHS) requires specialized instructional design strategies. Recently, instructional VHS used a computer-based platform to teach theory and practice. The computer will assist teachers in creating instructional media. This study aims to design augmented reality-based virtual laboratory media for electro-pneumatic practicum learning in order to ease teachers and students to learn the pneumatic practice. It is specially designed for practical learning purposes. The method used in this research is research and development. The assessment results from Instructional design experts 4.5, material experts 4.5, media experts 4.4, and language experts 4.8. Based on the assessment of experts, this augmented reality-based virtual laboratory media is feasible to use. Next, the results of this study are a prototype of students' pneumatic practice tools installed on mobile phones consisting of eight worksheets. In the designed augmented reality media, 1) 3-dimensional pneumatics can be rotated in all directions so that students understand. 2) Pneumatic job sheet, where on the augmented reality media designed for the simulation circuit, there is an explanation of the components and how they work, and a simulation through markers.

Keywords: *Design instructional, electro-pneumatics, practical learning, virtual laboratory.*

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Introduction

The expanding worldwide issue necessitates teachers' efforts to be able to have skills and talents that are in line with the needs of the times. Teachers, at the forefront of the development of national education, serve as models for graduates, particularly vocational high school graduates (Cahyono et al., 2021). The characteristics of vocational high schools emphasize skills, competencies, the ability to compete, and the ability to operate by industry needs (Mahmudah & Santosa, 2021). As technology advances, teachers should be able to adapt by improving their skills. The goal is to train vocational high school instructors to deal with extreme cultural acculturation (Mahmudah, 2016). It is also found that 65% of the workforce will need reskilled by 2030. On this basis, teachers must be able to adapt to the evolution of the times in order to develop themselves and increase their competence. As a result, teachers gain information, improve their skills, and may eventually educate students in vocational high schools.

With the rise of knowledge societies and the accelerating pace of technological progress, it is increasingly important for communities to keep track of these changes and make their adaptations (Sutiman et al., 2022). One of the most distinctive aspects of today's information society is the widespread acceptance that applying scientific principles and innovations, implementing solutions to problems, and facilitating daily life are all part of the same field (Lam & Santos, 2018). Information technology (IT) refers to the use of computers and other electronic devices to collect and disseminate information (Richert et al., 2016). IT is also a subfield of production methods, tools, and information products, and it is defined as the practical application of theoretical understandings of these processes (Liu et al., 2020; Sukirman & Setiawan, 2022). All facets of human existence encompass the all-encompassing phrase "technology," and people are everywhere (Pavlova, 2009). Furthermore, technology can be employed as a tool to alleviate the cognitive burden incurred by humans while receiving and processing information. In addition, the technology can provide essential

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knowledge more efficiently than a tutorial and make it more accessible to the people who need it (Achuthan et al., 2018; Arifin & Setiawan, 2022; Hursen, 2011).

In the information era, technology is experiencing rapid development. Technological advances in the information age are expected to provide solutions to problems faced by humans to relieve various jobs. Likewise, in education, technological developments can make it easier for students and teachers to study the subject matter. In line with technological developments in the information era, many applications can be used in learning. The application is a virtual application with 3 Dimensions (3D). This application can facilitate and facilitate learning by providing hands-on/real experiences. A virtual environment with 3D in Education, in addition to facilitating the learning process, also facilitates learning. With 3D virtual media, students can learn anywhere, anytime, and it can be repeated until students desire an understanding. Virtual learning environments can be built with virtual objects to design simulations at the level of early childhood education to college. One of the educational institutions that are greatly facilitated by the existence of this virtual laboratory is vocational education. Vocational education is prepared to train graduates to have the ability to work in the industrial world and real work and business (Mubai et al., 2020). Educational engineering is based on several forms of learning, one of which is training and practical activities in the laboratory (Gomes & Bogosyan, 2009; Veljko et al., 2010). Therefore, the design of virtual laboratories and distance learning in education is a technique and key for digitization in engineering education (Achuthan et al., 2017; Richert et al., 2016).

Based on the results of needs analysis conducted in preliminary study at vocational high schools located in Bekasi city for the topic of electro-pneumatic practicum activities. From the observations of the electro-pneumatic practical learning process in the classroom, it was obtained that the media used by the teacher at that time were whiteboards, powerpoints, electrical practice job sheets -pneumatic and electro-pneumatic practice modules. Based on the results of the interviews and observations above, there are three things become problems in electro-pneumatic practical learning, namely: 1) students experience difficulties in assembling electro-pneumatic circuits from the job sheet provided by the teacher; 2) students find it difficult to imagine how airflow works in an electro-pneumatic circuit; 3) the media used by the teacher in practical learning using job sheets and practice modules is still difficult for students to understand.

Based on these problems, practicum activities in the electro-pneumatic subject still need to be optimized due to a lack of equipment, while many students are served for practice. They arrange job sheets according to electro-pneumatic working methods that are easy for students to understand. Therefore, so that students' ability to master skills and knowledge in practice can be optimal, practicum activities can be carried out using Volta to meet students' practical learning needs. A virtual laboratory is a medium with an interactive environment where experimental simulations can be carried out. The virtual laboratory has a unique characteristic with a place to experiment using tools that can manipulate objects relevant to certain scientific domains (Osti et al., 2021). Virtual laboratories are now becoming tools often used and commonly encountered in different learning situations (Achuthan et al., 2017; Lewis, 2014). Virtual laboratories are designed for learning by combining complex skills in various fields, namely interaction design, visualization, and pedagogy. This virtual laboratory involves designing and producing images, 3D environments, and interactivity that require programming and animation (Beata et al., 2019).

The virtual laboratory in this study is an electro-pneumatic augmented reality media design that can be installed on a mobile phone, making it easier for students to learn in a fun, comfortable, interesting way and have real experiences. The media in question is in the form of augmented reality media. Augmented reality media is a technology that combines two-dimensional or three-dimensional virtual objects into a real three-dimensional environment, then projects these virtual objects in real-time (Jacko & Andrew, 2010). Furthermore, the augmented reality media cannot wholly replace reality but only as a complement (Azuma et al., 2001). Augmented reality is one of the media technologies that can support the learning process with a combination of virtual objects, both 2 and 3 dimensions, in a real environment using a mobile phone camera or webcam. The advantages of augmented reality as a learning medium can provide interactive and meaningful learning processes because students can interact with virtual and real-time applications by experiencing real experiences. The experience of using augmented reality provides each perception with the imagination that students have in understanding the learning material. Augmented reality media can be problem- solving in practical subjects and make it easier for students to understand the material, how pneumatic components work, and practice electro-pneumatic circuits.

The existence of augmented reality media that is used to improve the practical activities of vocational high school students will positively impact students by increasing their knowledge. Thus, the competence of students in practical activities on electro-pneumatic practice increases. This is needed to face job competition in the real world. Augmented reality media provides benefits to stimulate competencies within students and science development. The rapid development of science and technology encourages humans to be creative and innovate in creating and developing learning media to help make it easier for students to understand the material in the learning process to achieve the expected learning objectives. Given the importance of practicum activities in the learning process, it is necessary to design a "virtual laboratory with augmented reality media for electro-pneumatic practice activities for vocational high school students."

Based on existing research results, it generally examines the use of augmented reality media in virtual laboratory classroom learning. In addition, the research that has been carried out also only discusses the importance of virtual reality in learning. From the results of research on augmented reality, some say that augmented reality media cannot replace real objects. From the results of the studies mentioned above, there are differences between the research that has been done and the research on the electro-pneumatic laboratory virtual learning media design in this study. The studies that have been carried out focus on implementing learning electro-pneumatic circuits.

Literature Review

There is an increasing demand for technological materials to be developed for use in science lectures (Çepni, 2016). The Ministry of National Education's curriculum reflects the demands and changes in this sector. According to the Ministry of National Education's new curriculum, science and engineering applications are attracting attention as new course content inside the science course. In the academic setting, technological applications assist students in making links between engineering and science, understanding interdisciplinary relationships, and developing their worldview through experiential learning (Ministry of National Education (MoNE), 2017). Science and engineering applications were added as the last unit of each period from fourth to eighth grade, and students were required to design new products after each semester. In these seminars, students began to study coding at an early age, where various coding tasks were put up for science and engineering instruction. Students' coding applications typically use simple programs that can be delivered with a simple command system. Encoding should not be limited to engineering education. Students can build their design feelings and creative ideas through basic practices, and they can apply this situation in any profession (Bulus & Basaran, 2019). The results showed that applications using technology in the physics laboratory influenced students' attitudes toward technology and information and communication technology. This research was conducted to see students' attitudes towards technology and applications that were newly designed in the physics laboratory, not to see the skills and achievements that students mastered after learning to use Arduino and fritzing applications.

The virtual laboratory in this study is a medium designed to facilitate practical learning on electro-pneumatic subjects in vocational high schools. The virtual laboratory is designed with augmented reality media consisting of several components assembled into one unified circuit. Electro-pneumatics is generally an automated operating system that applies the integration of pneumatic circuits in electronics. Pneumatics itself is a science that studies the technique of using compressed air. Another term is a system that hangs air with pressure to coordinate a propulsion force.

Along with the development of science, and a comprehensive understanding of the system in pneumatics, pneumatic elements experienced rapid development. The way pneumatics work is to use air as a medium where the availability of this air is abundant and can be returned to the atmosphere after completing its work on the system. Compressed air in a pneumatic system plays a role in several things, including determining the status of the processor, processing information, changing the actuator through the final control element, and working as the actuator itself.

Electro-pneumatics is the result of the development of pneumatics, which has a working principle of selecting pneumatic energy as the working medium (propulsion). As a control medium, electrical or electronic signals are used. The electrical signal is channeled to a coil installed on a pneumatic valve that can activate a switch or sensor whose limit switch has a function to connect or disconnect the signal. The signal transmitted to the coil will generate an electromagnetic field and activate the directional control valve (DCV) for the last element in the pneumatic series. Electro-pneumatics are often used in other fields of factory automation, namely assembly, distribution, and shipping facilities worldwide. The device is operated by an electro-pneumatic control system (González, et al., 2018; Pereyras, 2020; Stegman, 2021). This research conducted by Pereyras was developed to evaluate basic electro-pneumatic control systems assessment to study process control and industry in the Bachelor of Industrial Technology (BIT) elective subject as an educational tool. In this study, an augmented reality-based media control system was not designed. However, it is only using the existing basic electro-pneumatic control system.

Then for electro-pneumatics, pneumatic elements that operate using electricity and electronic circuits, electromagnetic and electro-control, electronic switches, and industrial computers are used to replace manual pneumatic power devices. A pneumatic control system consists of several components, including valves, sequencers (sequential), air barriers, etc. Furthermore, the electromagnetic control system has a control signal on the electrical components. Namely, there is an electric input button, proximity switch, relay, or programmable logic controller (PLC). Based on some of the opinions above, it can be concluded that electro-pneumatics is a system in automation operation that integrates pneumatic circuits in electricity.

The electro-pneumatic laboratory virtual learning media is designed to simulate electro-pneumatic practical learning in vocational high schools. This learning media is needed to give students an understanding of electro-pneumatic components, electro-pneumatic circuits, and how electro-pneumatic circuits work. With this electro-pneumatic virtual learning media, students can learn the components, circuits, and workings of electro-pneumatic before doing practical work in the laboratory. Thus, students must understand and have sufficient knowledge about electro-pneumatic circuits. A sufficient understanding of components, circuits, and how electro-pneumatic circuits work can minimize errors when

students carry out practical learning activities in the laboratory. The aim of designing this electro-pneumatic laboratory virtual learning media is to optimize students' ability to practice assembling electro-pneumatic circuits.

Using electro-pneumatic augmented reality learning media in laboratory practice greatly influences student learning outcomes, especially in the psychomotor and cognitive fields. By studying augmented reality media through a virtual laboratory, students, besides using their visual senses, also use their auditory senses because the augmented reality learning media that is designed not only displays a simulation of how electro-pneumatic works but is also equipped with a sound that explains how the circuit works. Thus, the learning outcomes that students remember can reach above 75%, according to Edgar Dale's cone of a learning experience (Heinich et al., 2001)

The design of a virtual learning media laboratory for augmented reality electro-pneumatic practicals at this VHS has several advantages in the practical learning process, such as:

1. The working process of the airflow in the electro-pneumatic circuit is obvious.
2. You do not have to use the internet network to operate the augmented reality media for this electro-pneumatic circuit.
3. This electro-pneumatic circuit augmented reality media can be learned anywhere and anytime repeatedly.
4. Electro-pneumatic circuit augmented reality media can be downloaded on a smartphone.
5. Augmented reality markers do not have to be printed but can be scanned from a cell phone/laptop/computer screen.

In addition to the design of the virtual laboratory, this electro-pneumatic augmented reality learning media also has its weaknesses.

1. Complex electro-pneumatic circuits require a more comprehensive design, thus requiring much money.
2. Because this application is on a smartphone, it is very susceptible to viruses, so students cannot learn the series.

Methodology

Research Goal

This study aimed to determine the feasibility of a virtual media augmented reality media laboratory designed for practicum activities for electro-pneumatic subjects in vocational high schools. The designed augmented reality media is expected to make it easier for students to participate in learning electro-pneumatic practice activities.

Research Design

A mixed-method research design uses data collecting, data analysis techniques, and quantitative and qualitative methodologies to find and write results. Mixed research is research in which researchers integrated qualitative and quantitative research approaches (Johnson et al., 2007; Tashakkori & Creswell, 2007; Tashakkori & Teddlie, 2003). Many methods use patterns when studying qualitative and quantitative data in a mixed method. These technique patterns also show three distinct situations in the study's collection, analysis, and interpretation sections: cases where qualitative data are prominent, cases where quantitative data are dominant, and a third case where both data are treated equally.

These circumstances instruct the researcher to make the data more relevant to the significance of researching the study phase. The mixed approach has a variety of study patterns. The mixed method pattern types were investigated to apply it correctly. The following mixed design pattern was the best fit for this study and was processed correctly. When a researcher collects and analyzes data in quantitative and qualitative methods, a next mixed design is created. Unlike other designs, the next mixed design can be extended by incorporating a quantitative step into the qualitative stages.

This research is often known as research and development (R & D). In field of education, it is a process of creating and validating educational products such as media, methods, and models according to the needs of the field (Gall & Borg, 1983). The development model used in this study adapts the analysis, design, develop, implement, and evaluate (ADDIE) development model (Branch, 2009), which includes five stages, namely the analysis, design, development, implementation, and evaluation stages.

Sample and Data Collection

The subjects of this study were 11th graders of state vocational high school of 5 Bekasi with a total of 24 students. The students consisted of 18 male students and six female students. In general, their age is between 16-19 years. When viewed from the economic ability of parents of students, the average is categorized as lower middle class. This research was conducted from June to August 2022. Electro-pneumatic augmented reality media before being tested on vocational high school students. Validation of the feasibility of augmented reality media was carried out with language experts (head of secondary laboratory school in Kebayoran), media experts (a lecturer in multimedia electronics and a lecturer in

learning media of master's program in educational technology and the chairman of the center for learning resources at Jakarta State University) and , materials experts (a vocational school teacher who taught electro-pneumatics and a lecturer in electrical engineering), and instructional design experts (a professor of Educational Technology and a professor of basic education from Jakarta State University). The electro-pneumatic augmented reality media trial was carried out at the state vocational high school of 5 Bekasi city with a one-to-one test of 3 students; for a small group (small group) it was carried out on five students, while a field trial (Field Trial) conducted on 16 students.

Analyzing of Data

The data obtained is then evaluated to find the hidden meaning behind the data. Researchers in this study need creative abilities to connect, construct, and build theoretical images through speculation to find the meaning of the research (Fraday, 2022; Komariah & Satori, 2014). Analysis means an attempt to break down a problem or subject of study into parts (decomposition) so that the structure/composition of the form of something described is visible so that the meaning or problem can be understood more clearly (Chu & Leung, 2003; Kholis et al., 2019; Komariah & Satori, 2014). Likert scale is used to measure attitudes, opinions, and perceptions of individuals or groups of individuals towards a particular incident. This formula is used to interpret the questionnaire data so that it can be transformed into a narrative form (Sugiyono, 2011). The Likert scale in this study was used to determine students' opinions of the ease and readability of augmented reality media in virtual learning electro-pneumatic practical laboratories. Miles and Huberman's data analysis is more methodical and consists of data reduction, data presentation, and formulation of conclusions (Komariah & Satori, 2014). Qualitative data analysis was carried out to obtain information on the survey and observation stages in analyzing the initial research needs in the field. After surveying at the beginning of the study schools for teachers and heads of departments, the data obtained was information on practical learning activities, the use of media and strategies in practical learning so far, the material practiced and the number of students who practiced, and the number of hours of practice for one week. Questionnaires were distributed to class XI students of vocational high school of 5 Bekasi city, as the object of research. The data obtained from the results of distributing the questionnaires are in the form of practical learning activities using augmented reality media. The results of distributing steamy questionnaires are comfort, clarity, convenience, and achieving practical goals using augmented reality media. Quantitative data analysis was conducted to see the feasibility of augmented reality media design from learning design experts, material experts, media experts, and language experts. The results obtained from the expert assessment are quantitative data to determine whether the augmented reality media used in practical learning is appropriate for use or not for use in the electro-pneumatic practical learning process.

Findings / Results

From the expert's assessment results, the instructional design got 4.5, which means this media is very good and feasible to implement. The assessment from the electro-pneumatic material expert got 4.5, which is very good and illustrates that the media can be applied to the learning process. The assessment from the media expert got 4.4, which was very well and deserved to be used, and the last assessment from the linguist got 4.8, which means it is very good and can be used. Based on the assessment results from these experts, it can be concluded that the prototype of this augmented reality media is feasible to be used in the Electro-Pneumatics practicum course.

Results of Instructional Design Expert's Assessment of AR-Based Electro-Pneumatic Materials

Electro-pneumatic practice materials and questionnaire sheets were provided to instructional design experts for assessment. The assessment results from design experts are used to improve the electro-pneumatic material design. Then, the learning material is revised according to the suggestions and input from expert's. The results of the expert's assessment of the design of electro-pneumatic learning practice materials using AR were very good. The results of the assessment can be seen in the table below.

Table 1. Recapitulation of Assessment Results by Instructional Design Experts

	Expert 1	Expert 2	Average
1 Accuracy formulation of general instructional objectives	5	5	5
2 Accuracy formulation of specific l instructional objectives	5	5	5
3 Relevance of specific instructional goals to general instructional goals	4	4	4
4 Sequences of electro-pneumatic practice materials	4.5	4	4.25
5 Relevance of practical electro-pneumatic learning strategies to general instructional goals	4	5	4.5
6 Learning content relevance to general instructional goals	5	4	4.5
7 Jobshet product technical quality practices	4.5	4	4.25
Overall average			4.5
Description			very good

The first instructional design expert was a professor of Educational Technology, Robinson Situmorang, who gave lectures on instructional design for both bachelor's, master's, and doctoral degrees in educational technology at Jakarta State University. The second instructional design expert is a professor of Basic Education, Syarif Sumantri, who gave lectures on instructional design and the doctoral degree in basic education at Jakarta State University. This instructional design expert assesses the feasibility of augmented reality media according to student characteristics and by general learning objectives; the assessment chart can be seen in the image below:

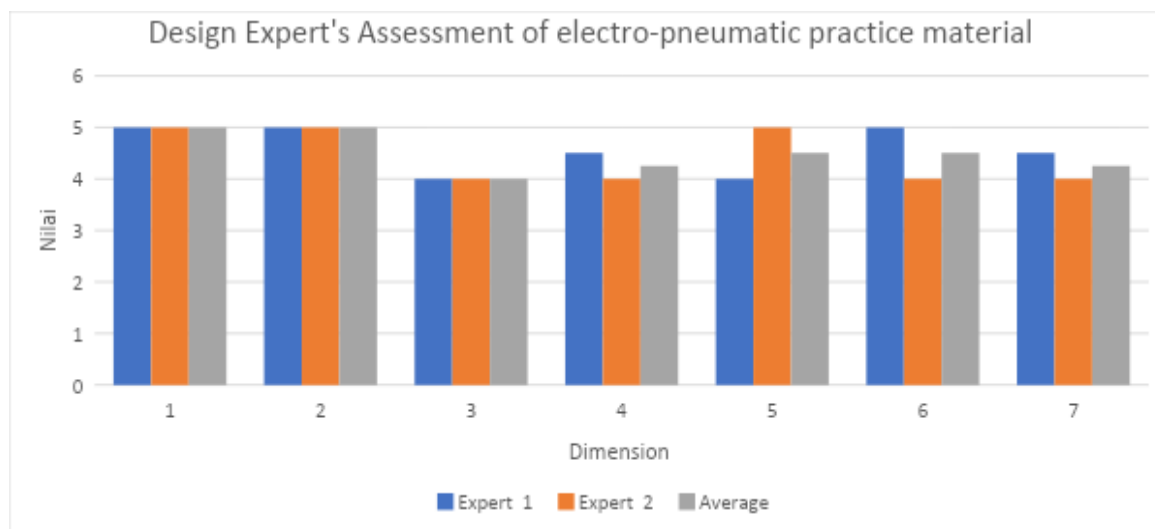


Figure 1. The Results of the Assessment from Learning Design Experts

The results of the learning design expert's assessment obtained a score of 4.5%; this means that augmented reality media is categorized as very good for use in electro-pneumatic learning practice activities for class XI at vocational high school students in Bekasi City. Referring to the assessment of learning, the design experts stated that it is feasible to be used in electro-pneumatic practical activities in order to improve student's skills and abilities in assembling electro-pneumatic circuits.

The Results of the Material Expert's Assessment of the Electro-Pneumatic Practice Material

The material for electro-pneumatic practice was assessed by two material experts, namely a vocational schoolteacher who taught electro-pneumatics and a lecturer in electrical engineering at the faculty of engineering, Jakarta State University, who taught electro-pneumatics. Questionnaire sheets were given to two material experts. The results of assessments from material experts are used to improve electro-pneumatic materials. Then, the practical learning material is revised according to suggestions and input from material experts. The results of the expert assessment of electro-pneumatic learning practice materials that use AR are very good. The results of the assessment can be seen in the table below.

Table 2. Recapitulation of Material Expert Assessment Results

No	Dimensions/Indicators	Expert 1	Expert 2	Average
1	Clarity in the formulation of general instructional objective	5	5	5
2	Clarity in the formulation of specific instructional objectives	5	5	5
3	Relevance of practical electro-pneumatic learning materials for instructional purposes	4	4	4
4	Adequacy of the scope of material to achieve learning objectives	4	4	4
5	The truth of the concept of electro-pneumatic practical learning materials	4.5	4.5	4.5
6	Up-to-date electro-pneumatic practical learning materials	4.5	4.5	4.5
7	The messages conveyed include pictures of components, electro-pneumatic circuits, how the AR circuit works according to the learning objectives	4	5	4.5
8	Drawings and electro-pneumatic practical circuits are self-explanatory and easy to recognize	4.5	4.5	4.5
9	Electro-pneumatic components, electro-pneumatic circuit drawings are in accordance with the electro-pneumatic concept	5	5	5
10	The accuracy of delivering electro-pneumatic material in AR media	4	4.5	4.25
11	The order of delivery of AR electro-pneumatic media material is appropriate	4.5	4	4.25

Table 2. Continued

No	Dimensions/Indicators	Expert 1	Expert 2	Average
12	Submission of electro-pneumatic learning material through AR media makes it easier for students to recognize components and understand how circuits work	5	4	4.5
13	Delivery of electro-pneumatic learning material through AR media makes it easier for students to repeat material to understand how work works	5	4	4.5
	Overall average			4.5
	Description			very good

Mr. Rafiudin assessed the electro-pneumatic material as the first subject matter expert and lecturer in pneumatics in the electronics engineering education study program, faculty of engineering, Jakarta State University. The second material expert is Mr. Rebo, a vocational school teacher who teaches electrical engineering at a vocational school and is also the head of the electronics department at vocational high school of 5 Bekasi City. The results of the material expert's assessment assess that the electro-pneumatic material using augmented reality media is by the general learning objectives, namely, to improve student" skills in assembling pneumatic circuits and are appropriate for students to use in data collection. The material expert chart can be seen below:

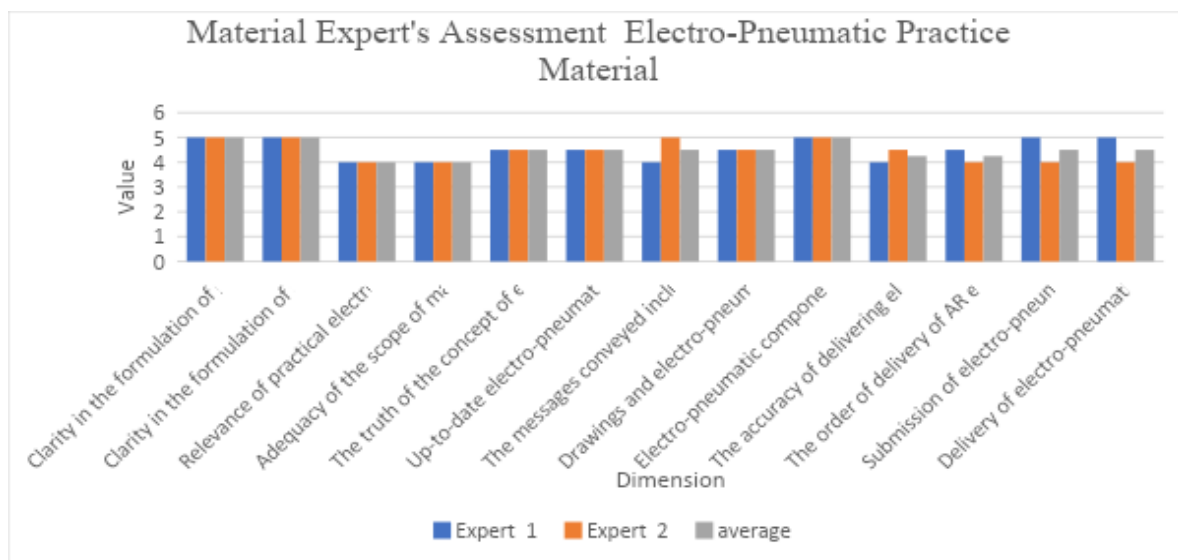


Figure 2. Expert Assessment of Electro-Pneumatic Material

The results of the material expert's assessment got a score of 4.5%; this means that augmented reality media is very good for use in electro-pneumatic learning practice activities for class XI students at vocational high school 5 in Bekasi City. The material was declared feasible with the expert's assessment; therefore, augmented media was designed according to the material contained in electro-pneumatic subjects. Thus, augmented reality media can be used in electro-pneumatic practical activities to improve student' skills and abilities in assembling electro-pneumatic circuits.

The Results of the Media Expert's Assessment of AR-Based Electro-Pneumatic Media

A questionnaire to assess AR-based electro-pneumatic media was given to learning media experts. Furthermore, the media expert's assessment results were used to revise the AR media according to expert advice. After the revision, the AR media, which contains electro-pneumatic practice material, will be tried out in one-to-one, small, and large groups. The recapitulation of the results of the media expert assessment can be seen in the table below:

Table 3. Recapitulation of Media Expert Assessment Results

No	Dimension	Expert 1	Expert 2	Average
1	AR learning media design	4.5	4.5	4.5
2	Quality of use of AR media	4	4.5	4.25
3	AR media feasibility	4.2	4.5	4.35
4	AR Media Effectiveness	4.5	4.5	4.5
	Overall average			4.4
	Description			Very good

The media expert validating the product given name as Mr. Cecep Kustandi who is a lecturer in learning media of master's program in educational technology and the chairman of the center for learning resources at the State University of Jakarta. The second media expert is Ms. Vina Oktaviani, a lecturer in multimedia electronics at Jakarta State University. The following is a picture of the evaluation diagram of electro-pneumatic learning media experts.

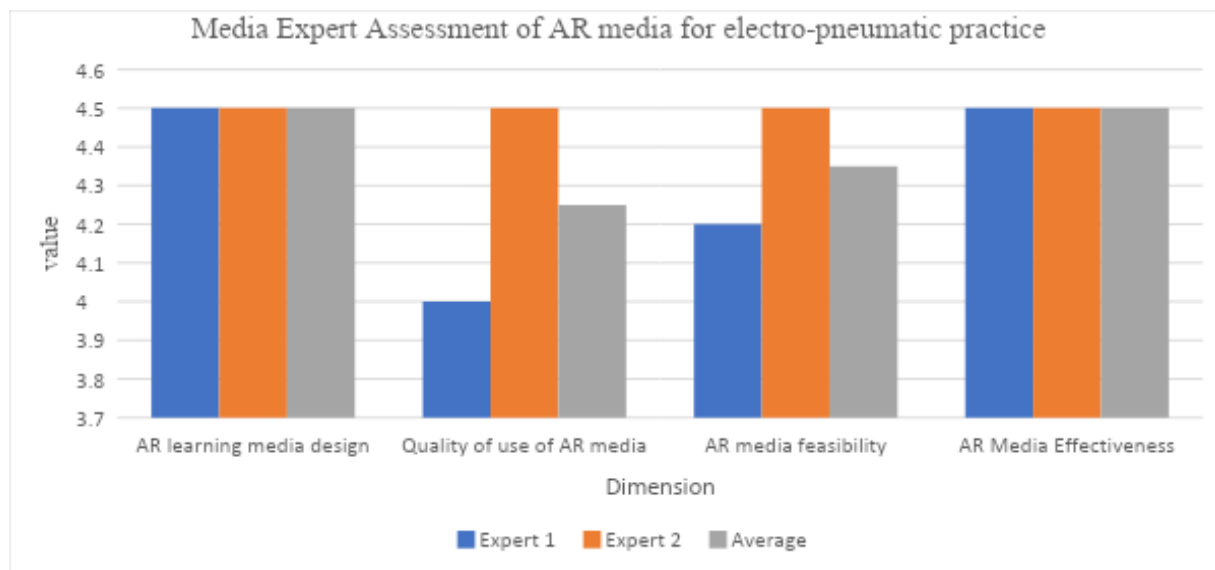


Figure 3. Assessment of Learning Media Experts

The results of the media expert's assessment obtained a score of 4.4%; this means that augmented reality media is very good and easy and can motivate students in practical electro-pneumatic learning activities for class XI vocational high school students of 5 Bekasi city. The assessment of the media experts declared that it is feasible as its design in line with the characteristics of students. It also can motivate and attract students to engage in electro-pneumatic practice activities. It is hoped that augmented reality media can improve student's skills and abilities in assembling electro-pneumatic circuits.

The Results of the Language Expert's Assessment of AR Instruments and Media

The results of the language expert's assessment of AR instruments and media. The ease and legibility of this AR media are to make it easier for students to understand and understand the use in practical electro-pneumatic learning activities. The scoring results can be seen in the table below:

Table 4. Recapitulation of the Results of Language Expert Assessments on AR Media

No	Dimension	Expert 1	Expert 2	Average
1	Writing	5	4.5	4.75
2	Word Choice	5	5	5
3	Spell perfected	4.5	5	4.75
4	Readability	4.8	4.8	4.8
	Overall average			4.825
	Description			Very good

The linguist was assessed by Mr. Ukim Komarudin, the former head of secondary laboratory school in Kebayoran, and now the head of educational development at laboratory school in Cibubur. He is also an Indonesian language teacher. The second linguist is Mrs. Yati Suwartini, head of Kebayoran laboratory junior high school and an Indonesian language teacher as well. The following is an overview of the linguist's assessment of AR media, which can be seen below:

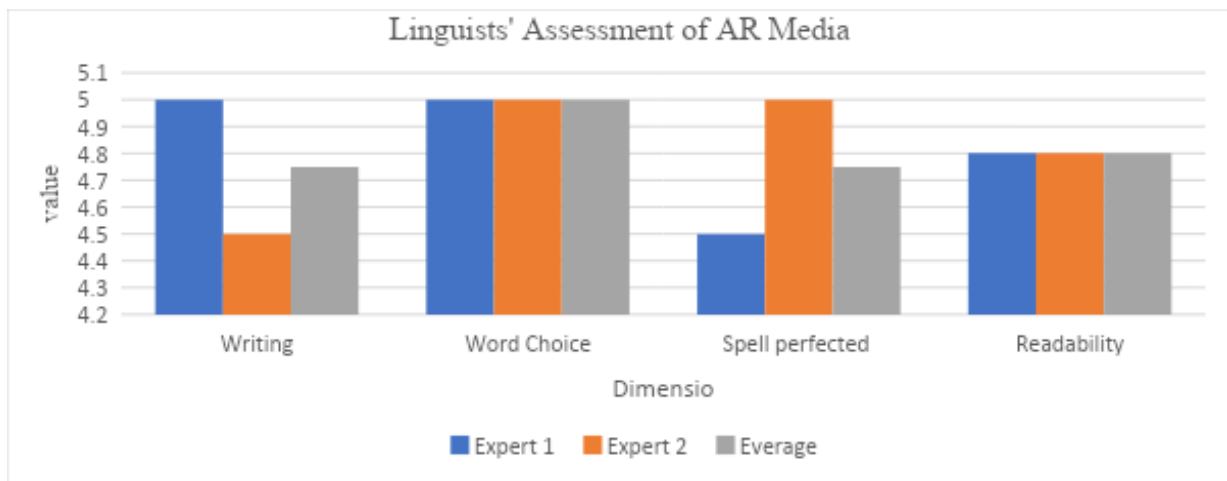


Figure 4. Augmented Reality Media Linguist Assessment

The results of the language expert's assessment got a score of 4.8%, which means very good. The ease of media and readability of instructions for using augmented reality media is easy for students to understand, so that students are motivated to carry out electro-pneumatic learning practice activities for class XI, vocational high school students of 5 Bekasi City. As the assessment of linguists declared to be feasible, the augmented reality media is expected to improve students' skills and abilities in assembling electro-pneumatic circuits.

Electro-Pneumatic Augmented Reality Media-Based Virtual Laboratory Design

An augmented reality-based virtual laboratory is designed using the AR.tic application on a mobile phone/smartphone by opening the Playstore on any mobile phone device, then downloading the AR.tic application on the AR.tic symbol smartphone device. After the application is downloaded and installed, the AR.tic symbol will appear on the smartphone screen. Open the AR.tic application and an electro-pneumatic job sheet 1-8 marker on a laptop screen or printed on paper or with other smartphone devices; the smartphone/mobile phone camera is scanned which job sheet image you want to view; after scanning, the image will appear as a 3-dimensional image of augmented reality design on electro-pneumatic components. This electro-pneumatic augmented reality media virtual laboratory was designed when operating and no longer needed an internet network to make it easier for students to learn anywhere and anytime. An internet network is needed when downloading smartphone/mobile phone applications, so it is very effective and efficient. Here is a virtual design view of the electro-pneumatic augmented reality laboratory:

1) *Job sheet 1 Control Single Acting Cylinder*

This circuit design uses 1 3/2 push button valve and one single-acting cylinder actuator. When the push button on valve 3/2 is pressed, the spool or valve on the valve is pushed and opens so that air can escape through the outlet port to the single-acting cylinder and push the piston forward. Then, if the push button is released, the spool will return to its original position with the push of the spring and block the air. When no air flows, the piston in the single-acting cylinder will recoil due to the force of the spring and push the remaining air out to be expelled through the valve's exhaust port.

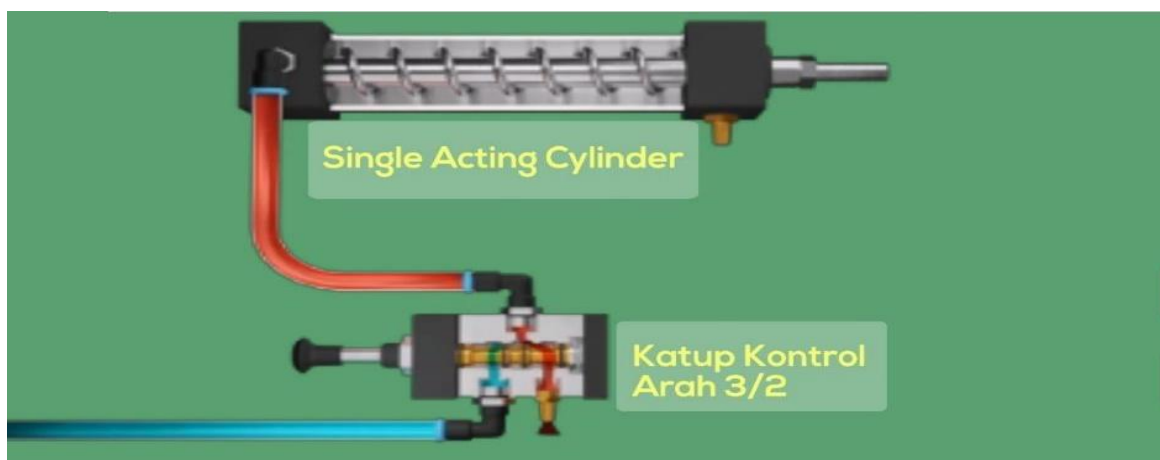


Figure 5. Job Sheet Control Single-Acting Cylinder Use A 3/2 Push Button Valve

2) Job sheet 2 Control and Double Acting Cylinder Using 3/2 And 5/2 Push Button Valve

The design in this circuit uses 1 3/2 push button valve (S1), 1 5/2 push button valve (S2), and single and double-acting cylinder actuators. In this circuit, two actuators are driven by different valves, where the 3/2 valve drives the single-acting cylinder, and the 5/2 valve drives the double-acting cylinder. In a single-acting cylinder, if S1 is pressed, valve 3/2 will activate and flow air into the cylinder to push the piston forward. Meanwhile, if S1 is released, the air will not flow into the cylinder, and the piston will retreat due to the push by the spring force. In double-acting cylinders, if S2 is pressed, valve 5/2 will activate and flow air from port 1 to port 4 to the double-acting cylinder and push the piston forward. Meanwhile, if S2 is released, the spool on the valve will shift, and the air on the valve will flow from port 1 to port two, which is then forwarded to the cylinder to push the piston backward.

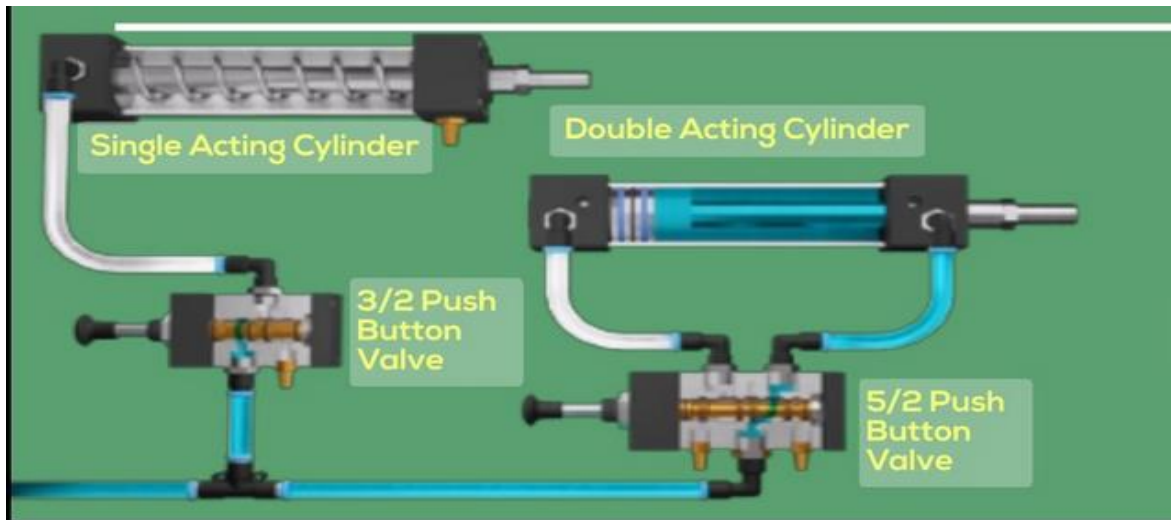


Figure 6. Single and Double Acting Cylinder Control Job sheet Using 3/2 and 5/2 Push Button Valve

3) Job sheet 3 Double Acting Cylinder Control Using 2 Pieces 3/2 Push Button Valve

The design in this circuit uses 2 3/2 Push Button Valves and 1 Double Acting Cylinder actuator. In this series of valves, S1 is used to push the piston forward, and S2 is used to push the piston backward. If S1 is pressed, air will flow into the cylinder and push the piston forward. If S2 is pressed, air will flow to push the piston back, but it must be in a state where S1 has been released.

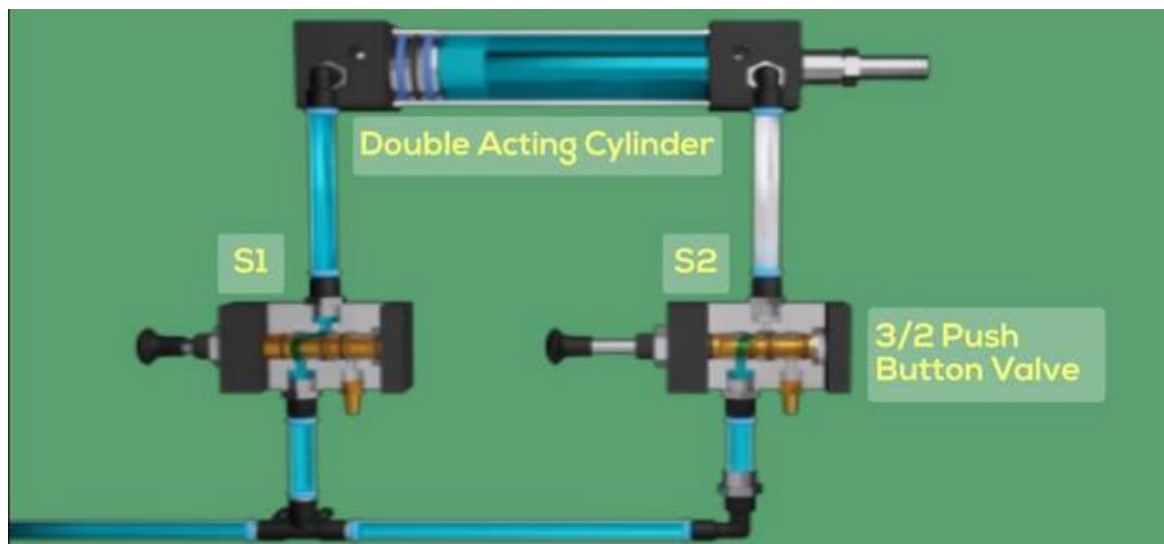


Figure 7. Double Acting Cylinder Control Job sheet Using 2 Pieces of 3/2 Button Valve

4) Job sheet 4 Double Acting Cylinder Control Using 3/2 Button Valve and 3/2 Roller Valve

The design in this circuit uses 1 3/2 push button valve (S0), 1 3/2 valve (S1) and 5/2 air pilot valve, and one double-acting cylinder actuator. In this circuit, the S0 valve is used to flow air to valve 5/2 from the left side so that air flows from port 1 to port 4, which flows into the cylinder and pushes the piston forward. When the piston advances and reaches its maximum limit, the tip of the piston will press the roller valve and activate S1 automatically. If S1 is active, air will

flow to the right side of the 5/2 air pilot valve to shift the spool. On valve 5/2, air will flow from port 1 to port two if the SO has been removed, so that air can flow into the cylinder and push the piston back to its original position.

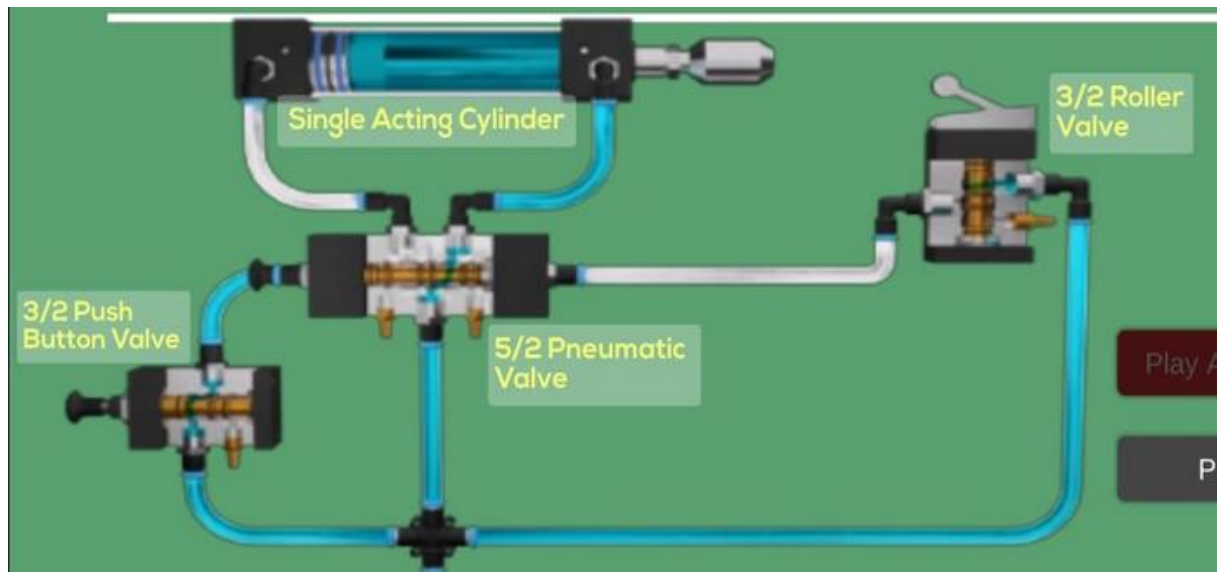


Figure 8. Double Acting Cylinder Control Job sheet Using 3/2 Button Valve and 3/2 Roller Valve

5) Job sheet 5 Control Double Acting Cylinder Using 3/2 Push Button Valve and 2 Pieces 3/2 Roller Valve

This circuit design uses 1 3/2 push button valve (SO), 2 3/2 roller valves (S1, S2), 5/2 air pilot valve, and one double-acting cylinder actuator. In this circuit 2, roller valves are installed at each of the minimum and maximum points of the piston. The roller valve, which is installed at the minimum point of the piston, has been automatically activated so that the SO valve (3/2 push button valve) is pressed; the air will flow to the left side of the 5/2 valve so that air can flow into the cylinder and push the piston forward. When the piston advances and reaches the maximum limit, the tip of the piston will press the roller valve and activate the second roller valve automatically. If the second roller valve is active, air will flow toward the right side of the 5/2 Air Pilot Valve to shift the spool. At valve 5/2, air will flow from port 1 to port two if the SO has been released, so air can flow into the cylinder and push the piston back to its original position.

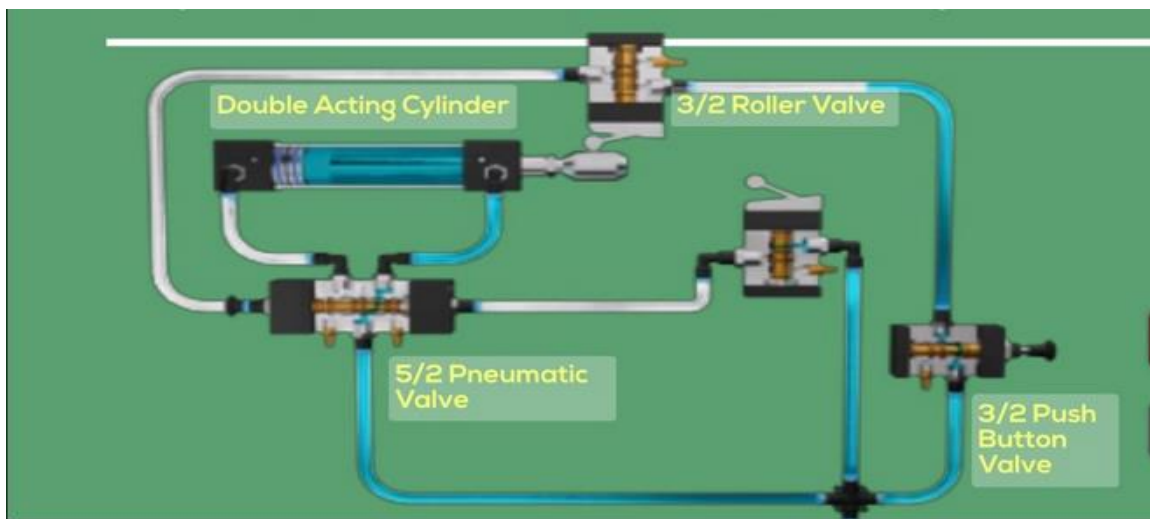


Figure 9. Double Acting Cylinder Control Job sheet Using 3/2 Push Button Valves and 2 3/2 Roller Valves

6) Job sheet 6 Double Acting Cylinder Control Using 3/2 Manual Valve, 5/2 Push Button Valve, Equipped with OR Valve, and Valve and Flow Control.

The design of this circuit uses various pneumatic components: 4 pieces of 3/2 push button valve, two pieces of 3/2 roller valve, one piece of 5/2 air pilot valve and valve, two pieces of flow control, and a double-acting cylinder actuator. If SO is active, air will flow to the AND valve but cannot flow from 2 directions to forward air to the roller valve and valve 5/2. If the SO valve is active, air will flow to the AND valve but cannot flow to the next valve because the AND valve requires air from 2 directions to forward air to the Roller valve and valve 5/2. If the SO and S1 valves are active, the air will flow into the first roller valve, which will be active and forward to the left side of valve 5/2 and flow into the cylinder to push the

piston forward. When the piston moves to the maximum point, the first roller valve will be deactivated, thereby cutting off airflow from the left side. Otherwise, the second roller valve will be active. If S2 or S3 is pressed on only one of them, air will be able to flow OR valve to the second roller valve, which has been activated and is continued to the right side 5/2 to push the piston backward. In this series, 2 Flow controls are also installed on both cylinder ports to regulate the forward and backward piston movement speed.

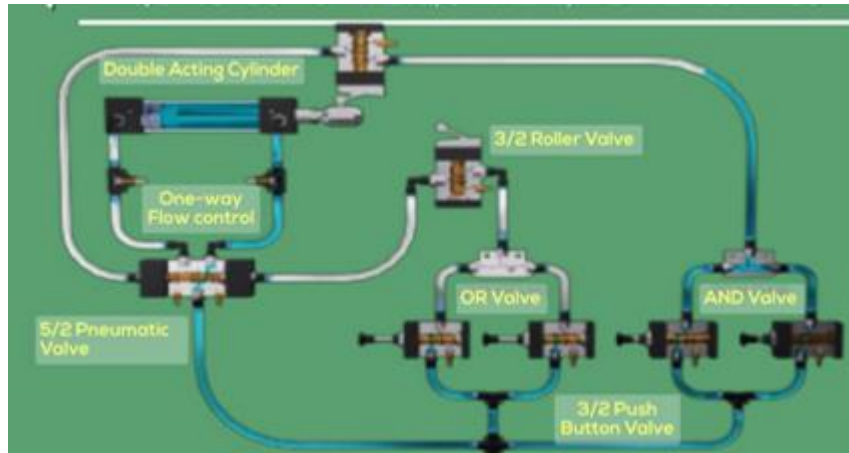


Figure 10. Double Acting Cylinder Control Job sheet Using 3/2 Manual Valve, 5/2 Push Button Valve, Equipped With OR Valve, and Valve and Flow Control.

7) Job sheet 7 Double Acting Cylinder Control Electrically Using 2 Push Buttons and a 5/2 Solenoid Valve.

This circuit design uses a 1 5/2-way double solenoid valve, two flow controls, and a double-acting cylinder actuator. In this circuit, the valve is electrically activated. In the electrical circuit, two push buttons are connected to the OV supply, and valve 5/2 is a switch to activate and deactivate the valve. Then, each activating side of valve 5/2 is connected to a +24V supply. After the electrical circuit is activated, if PB1 is pressed, Valve 5/2 will activate from the left side and push the spool to open the air path from port 1 to port four so that air will flow into the cylinder to push the piston forward. Conversely, if PB1 is released and PB2 is pressed, valve 5/2 will activate from the right side and open a path from port 1 to port two, so air can flow into the cylinder to push the piston backward.

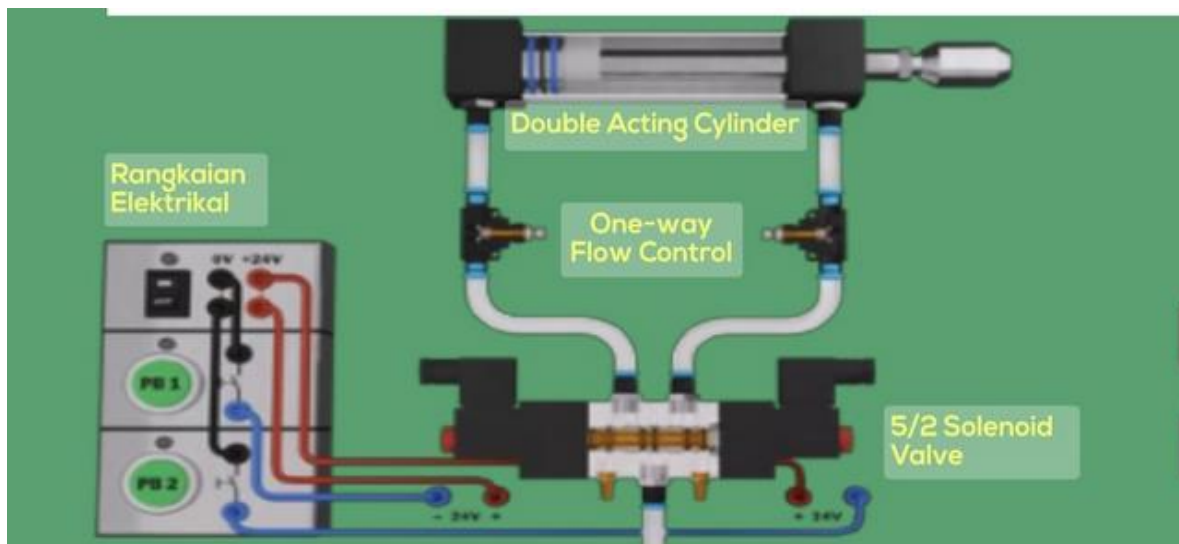


Figure 11. Job sheet 7 Electrically Controlling Double Acting Cylinders Using 2 Push Buttons and a 5/2 Solenoid Valve

8) Job sheet 8 Double Acting Cylinder Control Electrically Using 2 Timers, a Detten Switch, And 5/2 Way Double Solenoid Valve.

This circuit design uses a 1 5/2-way double solenoid valve, two flow controls, and a double-acting cylinder actuator. The electrical circuit has one push button (SO) and two timers (T1 and T2). The SO is connected to both timers, wherein the timer is connected to each side of the 5/2 valve actuation. If the electrical circuit is activated and SO is pressed, T1 will activate and start counting down for 3 seconds. At the same time, the valve is also active, and the piston will move forward while the timer is still running. If T1 finishes counting down for 3 seconds, T2 will automatically activate and count down for 3 seconds. At the same time, the valve will activate from the reverse side, and the piston will be pushed back. If T2

finishes counting down, T1 will be active again, and the piston will be pushed forward. This will continue to repeat itself, taking place alternately as long as the SO is still active. This circuit is made to make a pneumatic circuit that can work as a flip-flop.

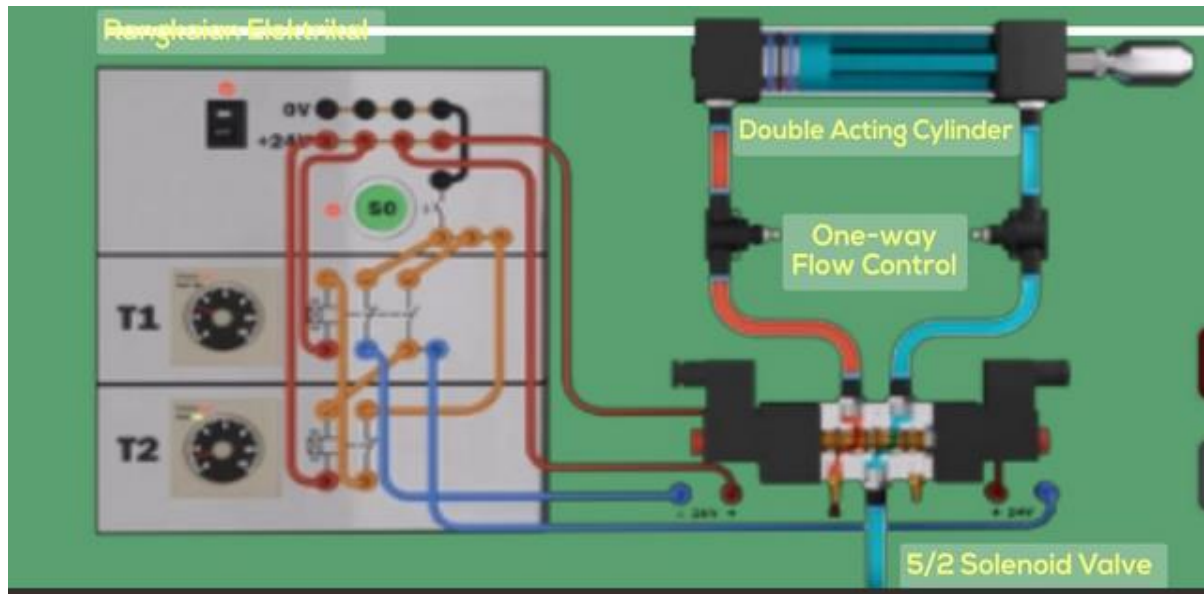


Figure 12. Job sheet 8 Electrically Controlling Double Acting Cylinders Using 2 Timers, a Detten Switch, And 5/2 Way Double Solenoid Valve.

Test Results of Electro-Pneumatic Augmented Reality Media

The assessment results of the one-to-one test with three students after using augmented reality media in the electro-pneumatic practicum activity, five statements must be corrected because they get a score of 1 out of 3 people who take the test. These items are 8, 9, 15, 30, and 33. This means that the statement items must be revised. These items may be corrected or no longer be used for data collection for small groups. The overall student assessment of augmented reality media from the one-to-one test can be seen in Figure 13.

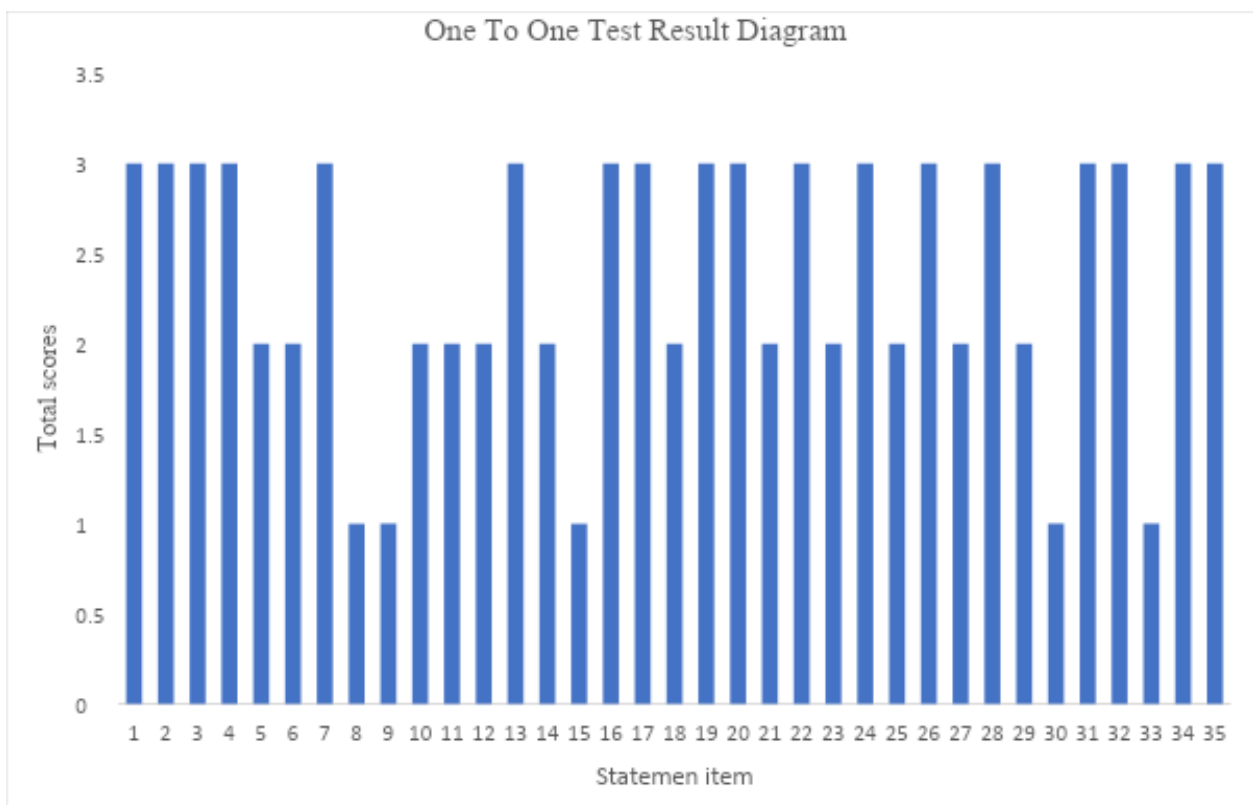


Figure 13. One-to-One Test Result Diagram

Furthermore, after the one-to-one test, the test is carried out in small groups. From the results of small group assessments with five students, four statements had to be corrected after using augmented reality media in electro-pneumatic practicum activities because they scored 1 and 2 out of five students who filled out the questionnaire 1, 14, and 21. This means that the statement items must be revised. The student's assessment of augmented reality media as a whole from the results of small groups can be seen in Figure 14.

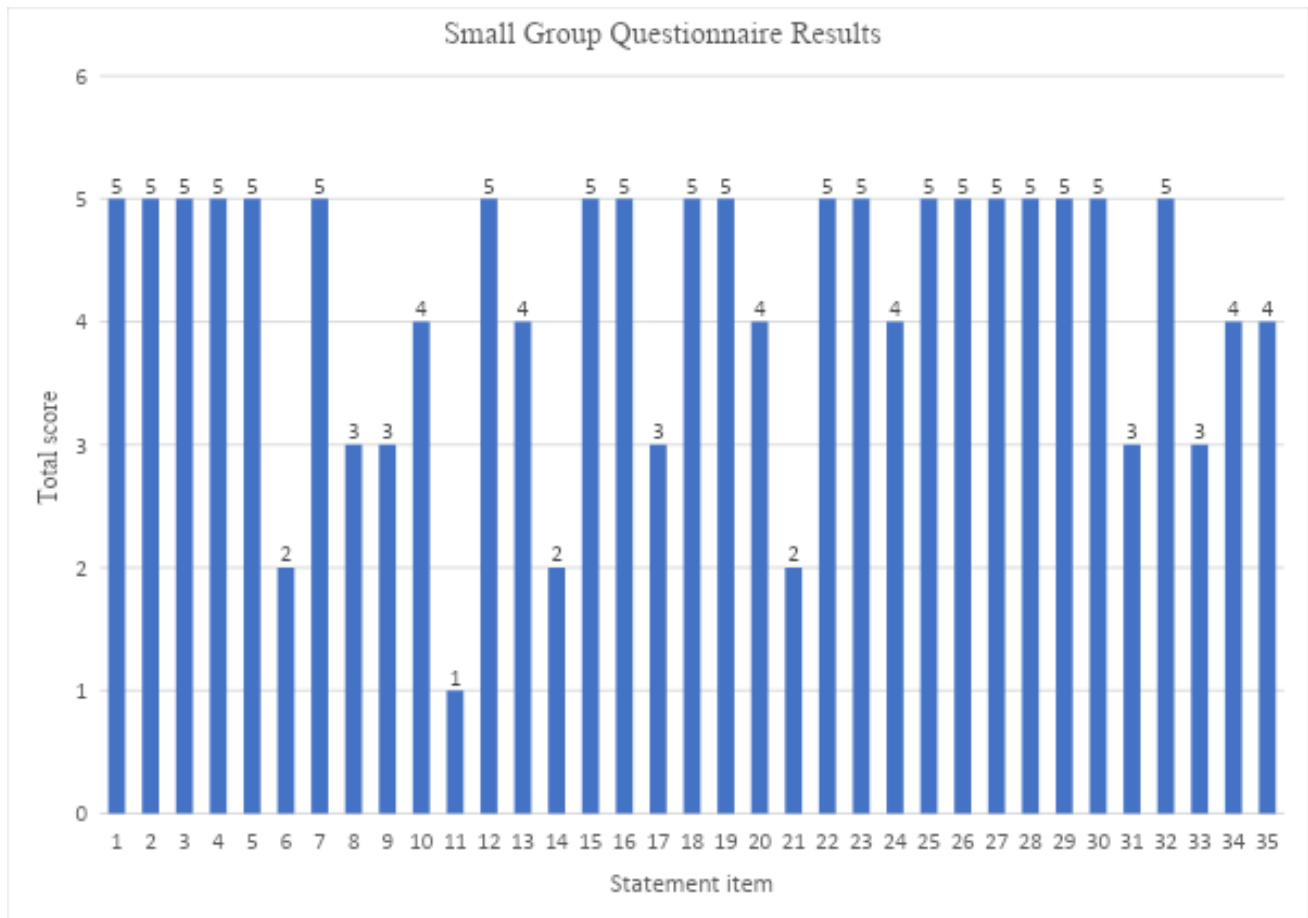


Figure 14. Small Group Questionnaire Result

Pneumatic augmented reality dissemination for large groups was carried out on 16 students by providing a completed questionnaire. From the results of large group assessments, students, after using augmented reality media in electro-pneumatic practicum activities, all instruments got a pretty good score, so this pneumatic augmented reality media can be used for dissemination to other vocational high schools than vocational high school of 5 Bekasi City. The results of student assessments of augmented reality media in large groups are shown in Figure 15.

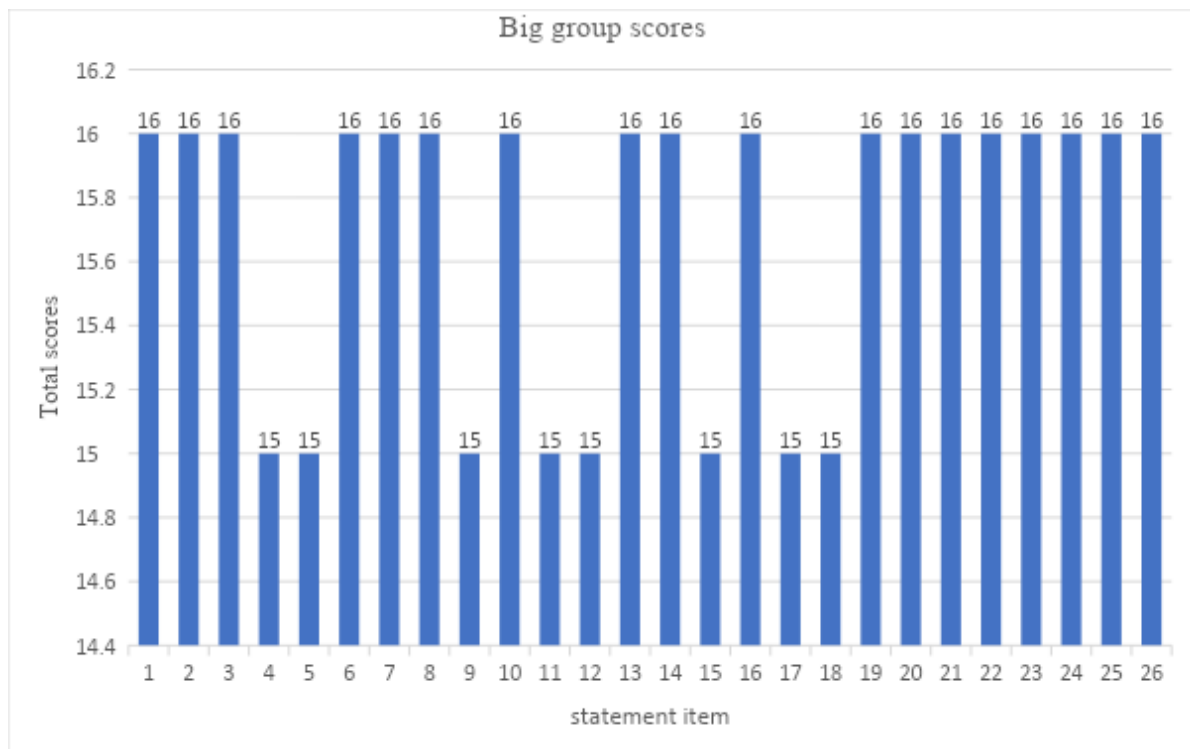


Figure 15. Big Group Questionnaire Results

Discussion

This augmented reality-based virtual laboratory is designed to facilitate students in practical activities on electro-pneumatic subjects in vocational high schools. Virtual laboratories also expand learning opportunities for their students without the limits of space and time (Mirauda et al., 2021). The virtual laboratory is attractively designed with instructions so that students can easily operate augmented reality media on mobile phones/smartphones that are downloaded to the application via the play store, namely AR.tic. Virtual Teaching or virtual laboratories will not replace regular teaching or workshops. They can complement traditional classroom and laboratory resources (Lewis, 2014; Raman et al., 2022). An electro-pneumatic augmented reality-based virtual laboratory is designed to provide a solution so that students can easily understand and practice pneumatic circuits because the practical tools available are very limited, and also to minimize errors and equipment damage when assembling components. It saves time during practical activities so that the learning process runs efficiently and effectively, motivates students to learn independently wherever and whenever students can repeat learning materials to understand and understand even though there is no teacher present; due to this, augmented reality media can be downloaded on a mobile phone/smartphone that can be taken anywhere. Virtual laboratories can provide balanced knowledge with low operating cost practices and motivate students (Damasceno et al., 2017). Display media with 3D is like real equipment, making it easier for students to learn components, how each component works and how pneumatic circuits work. Virtual laboratories in the learning process can help students learn an object that cannot be presented in class. Using a virtual laboratory, students learn to use industrial equipment in a virtual form (Mahmudah & Santosa, 2021).

With his research team, Domenica said virtual laboratories could also be designed for techniques to monitor and train accurate standards in viewing water discharge in open channels that have been successfully tested on samples from the private and public sectors. The results can speed up mobility and measure and manage rivers with the right equipment and methodologies, thereby saving on-site survey costs and time (Mirauda et al., 2021). The use of computer simulation is growing rapidly in the field of education; likewise, the learning design for electro-pneumatic control on the movement of the bending machine. It is built on electrical components with real pneumatics in a virtual classroom laboratory with FluidSIM software. The simulation results show that the pneumatic system parameters function adequately (Diego et al., 2019; Vujičić et al., 2020). A systematic review of 25 empirical research papers on the potential of virtual laboratories (V-Labs) from 2009-2019 resulted in more novelty than in designing learning to increase student motivation, exploring individual experiences, and providing personal or environmental characteristics given to social learning (Reeves & Kent, 2021). Digital learning is based on virtual laboratories with machine designs using a multiplatform unity video game that recommends potential tools to improve the conceptualization of electromagnetism courses on on-campus learning and distance training (Carlos et al., 2019; González et al., 2018). Virtual laboratories are also designed for distance learning in engineering education for the development of electrical machines and engineering equipment (EVEE) to facilitate the learning process by having real-world experiences. This virtual laboratory design presents the machine architecture, for

its users, for the leading actor roles in both the general and administrative sections (Evstatiev et al., 2019; Marshal et al., 2021).

The studies mentioned above are like AR media designed in this study to develop electro-pneumatic practical activities using information/digital technology-based media in the form of learning videos, augmented reality, and virtual reality and are both used in education. The difference between the previous and current research is that the augmented reality media design used in this virtual class is that AR media is equipped with instructions for use, and there is an instructor's sound and music. When using AR media, an internet network is no longer needed to be able to scan markers if the application has been downloaded on a smartphone/mobile learning. This AR media design is still used in one school and has not been tested in other schools. This research did not explore individual student experiences and was not used for distance learning.

The virtual laboratory is designed in such a way that it is interesting and motivating to be able to facilitate student learning properly. Learning can be done anytime and anywhere; learning is fun because learning is impersonal, to individualize each student. Students have the right to their way of learning, describing the form of data that is often known as education (Hussin, 2018). Therefore, the world of education continues to transform, inseparable from vocational education, in providing meaningful learning facilities to improve each student's individualistic skills and abilities to face challenges in the information age as it is today.

In general, research on augmented reality media in virtual laboratories is more inclined to the importance of augmented reality media in learning. This study focused on mastering components, how electro-pneumatics work, and electro-pneumatic circuits for vocational high school students. It is hoped that after participating in learning using augmented reality media in virtual laboratory classes on electro-pneumatic material, students will be skilled in carrying out practical activities in real laboratories.

Conclusion

The design of the virtual electro-pneumatic laboratory based on augmented reality succeeded as expected. This design has been assessed by experts (learning design experts, materials experts, media experts, and linguists), who generally give a very decent rating. This electro-pneumatic virtual laboratory is needed in vocational high schools for practical learning, so an electro-pneumatic virtual laboratory is essential. An AR-based electro-pneumatic virtual laboratory is easy for students to learn repeatedly because this application can be installed on smartphone/mobile learning. With this convenience, students are expected to be able to master skills following the competencies demanded in the curriculum. Thus, students achieving competency can be reached relatively quickly at a low cost.

Recommendations

Recommendations from the results of this study are for further research to be carried out and focused on more complex electro-pneumatic circuits; this augmented reality media is limited to smartphones. It can be done with other applications such as virtual reality; this research design was tested only on one; schools located in big cities; therefore, it is hoped that further research can be carried out in several schools spread across urban and rural areas; Augmented reality-based virtual laboratories can be designed for practical activities in other subjects.

Limitations

Due to the difficulty in conducting research, this study is limited to variables and the incompleteness of constructing the syntax and prototype towards ICT development used as media for an instructional process for the vocational high school, especially in virtual reality in laboratory-based form. As a result, additional research is expected to uncover other variables that significantly affect learning outcomes. Furthermore, the insignificant effect of students' improvement on practical skills should be re-examined using a larger and more representative media to acquire better results.

Acknowledgments

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Authorship Contribution Statement

Sukardjo: Oversees the study framework, instrument development, data analysis, and manuscript revision. Khasanah: Data analysis, paper writing, English proofreading, data gathering, evidence, and data input. Rahmat: Responsible for data analysis, manuscript drafting, and correction. Khaerudin: Data collecting and data visualization/presentation in text. Setiawan: English proofreading, manuscript review typing, correction, and publication submission.

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