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The Effectiveness Analysis of Using an IoT-based Sensor and Transducer Trainer as A Learning Media for Teachers and Students in Vocational Schools

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Abstract: The objective of this study is to determine the effectiveness of the use of IoT-based sensor and transducer trainer learning media for teachers and students. This Research uses research and development method with output in the form of IoT-based sensor and transducer trainer. The research and development steps used are the ADDIE model, based on the sequence of steps this research has been at the implementation and analysis stages. The results of the validity and reliability test of the instrument items show a value of $p < 0.05$ indicating that the correlation is very significant $p < 0.05$ indicating that the correlation is very significant. While the average value of Pearson's correlation to the total amount is 0.77 indicating that the relationship between all instrument items is very strong. The results of the analysis using the t test showed a significant difference between the pretest and posttest ($t = -9.271$, $p < 0.001$). The increase in student test results is greatly influenced by the use of media that is needed and in accordance with student learning patterns related to sensor and IoT material.

Keywords: *Effectiveness, Sensor and Transducer Trainer, Internet of Things (IoT), Learning Media*

1. Introduction

Learning media is one of the most important tools in today's modern learning process. One of the characteristics of modern learning is by applying information technology in teaching and learning activities so that teachers are required to be able to use various technology-based supporting devices that can facilitate the learning process in the classroom. [1]. Teachers' ability to master various technology applications can improve their professionalism to achieve learning outcomes, these capabilities can be in the form of web-based learning [2], the use of various online learning platforms [3], and the use of trainers as learning media [4], media trainer berbasis Internet of Things (IoT) [5] and other digitalized learning tools.

The integration of technology in learning can make students more active in finding and expanding the scope of learning, and can develop the skills they need according to the demands of the industrial world. Some of the impacts of using technology in learning are that students are more actively involved in learning and feel comfortable with technology [6], Another impact is that the learning process can be carried out through a flipped classroom where students can study the material at home and then carry out the discussion process, and exercises on campus [7]. The role of the teacher in the classroom has also changed, the teacher is better known as a facilitator who can help students to be more active and encourage students in the process of critical thinking and decision making in the problem solving process.

One of the current industry 4.0-based technology developments that has been widely used in education is the Internet of Things (IoT). The utilization of Internet of Things (IoT) technology in education has opened new opportunities and changed the learning paradigm significantly. By connecting various devices and physical objects to the internet, IoT technology allows the creation of a more connected, interactive, and intelligent learning environment [8,9]. In the classroom, teachers can use IoT devices to increase student engagement by dynamically presenting learning content, detecting students' level of understanding in real-time, and providing timely feedback. Among the forms of IoT-based learning innovations that can be used is using the Web of Things (WoT) platform [10], IoT devices in the form of trainers for sensor and transducer monitoring systems [5,11], as well as several other IoT devices that are self-made at a fairly low cost using Arduino and Raspbery Pi for smart home applications [12] and in the learning process [13,14].

The research that we have conducted in the last 3 years has produced an Internet of Things (IoT)-based sensor and transducer trainer that can be applied in distance learning both at school and on campus. The trainer consists of various sensors and other control devices such as relays. In addition, the type of controller used is ESP32 with features that can support wifi or Bluetooth connections so that it is very easy to connect to the internet. There are several

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studies that support the application of IoT-based trainers in learning, including the use of IoT-based trainer and remote lab learning media that are suitable for distance learning [15], use of learning kits consisting of various IoT components for the creation of basic, intermediate and expert applications based on Arduino [16], development of an IoT kit for online learning and can help students do practicum at home without having to go to school [17]. Based on previous research, the use of IoT in learning is very appropriate especially in certain conditions such as distance learning, remote monitoring and control systems for various electronic devices and for other intelligent system needs.

The urgency of our research is of course very useful for fulfilling the needs of distance learning, especially in sensor and transducer practicum lessons through the use of trainers as IoT-based learning media. At present, of course, it is still rare to find practicum learning devices that support distance learning. So far, teachers and students only use simulation-based virtual online software or applications to conduct practical experiments remotely [18,19,20]. Of course, this simulation method is very suitable if the practicum equipment in the laboratory is still limited. The purpose of this research is to develop a distance learning device on IoT-based sensor and transducer practicum, and determine the effectiveness of using IoT-based sensor and transducer trainer learning media on teachers and students in vocational high schools.

2. Methods

This research uses a research and development method with the output in the form of an IoT-based sensor and transducer trainer. This research will develop a trainer that can be used to increase students' basic understanding of industrial instrumentation that they can control remotely by utilizing IoT technology. In addition, a jobsheet and guidebook will be developed that can be used as instructions for practicum use. The research and development steps used are the ADDIE model [21], Based on this sequence of steps, this research has been at the implementation and analysis stages.

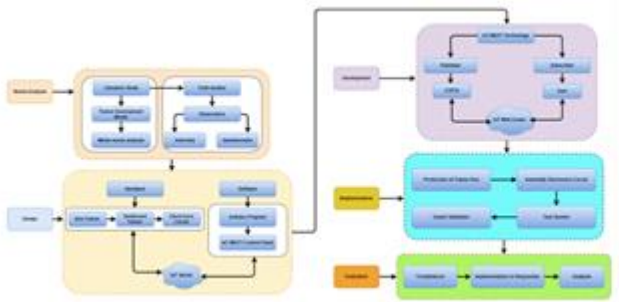

Fig 1. IoT-based sensor and transducer trainer development model

Based on the picture of the IoT-based sensor and transducer trainer development model, the following will explain in detail each stage:

Analysis

The analysis stage is intended to analyze the needs of learning media that can support distance learning. Activities carried out at this stage are conducting literature studies, identifying trainer development models and analyzing the needs of learning media in vocational high schools that have the same competency relevance.

Design

The activity carried out at this stage is to design (design) the IoT-based sensor and transducer trainer learning media. Making this design is divided into two, namely hardware and software. Making hardware designs using one of the 3D design software with the appropriate shape and size and placement of sensor components. The software design uses Arduino IDE software that has installed the library of each type of sensor and the needs of android-based monitoring applications.

Development

Trainer development is carried out through the manufacture of hardware and software followed by a feasibility test of learning media. This is done to find out the results of the design that has been implemented into a real form by testing one by one system or circuit in the trainer. This test is also carried out based on Arduino by creating a temperature sensor reading program and seeing the results on the LCD display or monitor display.

Implementation

At this stage, finishing the IoT-based sensor and transducer trainer learning media is carried out. Finalization of Jobsheet and Guidebook for the Use of Sensor and Transducer Trainer which is then validated by media experts and material experts. The implementation stage is carried out through workshop activities for teachers and students to determine the effectiveness and ease of use of IoT-based trainer media.

Evaluation

At this stage, activities are carried out to analyze the results of the implementation of IoT-based sensor and transducer trainer learning media. Analysis activities also include construction validation and content validation by experts and practitioners. Experts used to validate, namely: technology and vocational education experts who are experienced in developing learning media/products to be developed. The practitioners in question are SMK teachers of productive subjects, and DUDI practitioners. Therefore, this stage also aims to consider the quality of the design developed by making decisions through careful consideration.

Respondents in this study were productive teachers majoring in electronic engineering at SMKN 2 and SMKN 10 Makassar, as well as students majoring in electronics from each school. The data collection technique in this study was to use a questionnaire distributed to teachers and students. The validation sheet is used by expert validators to assess the feasibility of materials and learning media for IoT-based sensor and transducer trainers made. The guidebook and trainer are declared valid if the average assessment of the validator is in the good or very good category. Conversely, if the average score of the validator's assessment is in the unfavorable or very unfavorable category, improvements (revisions) will be made based on the validator's input until it reaches the good category.

3. Results and Discussion

Instrument Validity and Reliability Analysis

Instrument validity and reliability tests are used to ensure that the instruments used to collect data in research are in accordance with the research objectives and provide accurate and consistent data. The validity test method used is Pearson's Correlation which will measure the relationship between one variable and another [22]. In this study, each instrument item will be related to the total number of values obtained from each respondent. There are 16 instrument items which are divided into two general aspects, namely the media aspect which is given the abbreviations Md.1 to Md.7. Likewise, the material aspects are given the abbreviations Mt.1 to Mt.9. Table 2 shows the relationship matrix between each instrument item and the total score.

Table 2. Pearson's Correlations of Variables

Variable			Md. 1	Md. 2	Md. 3	Md. 4	Md. 5	Md. 6	Md. 7	Mt. 1	Mt. 2	Mt. 3	Mt. 4	Mt. 5	Mt. 6	Mt. 7	Mt. 8	Mt. 9	Total
1.	Md. 1	Pearson's r	—																
		p-value	—																
2.	Md. 2	Pearson's r	0.899	—															
		p-value	< .001	—															
3.	Md. 3	Pearson's r	0.408	0.367	—														
		p-value	0.074	0.112	—														
4.	Md. 4	Pearson's r	0.343	0.308	0.840	—													
		p-value	0.139	0.186	< .001	—													
5.	Md. 5	Pearson's r	0.167	0.257	0.408	0.343	—												
		p-value	0.482	0.274	0.074	0.139	—												
6.	Md. 6	Pearson's r	0.343	0.308	0.840	1.000	0.343	—											
		p-value	0.139	0.186	< .001	< .001	0.139	—											
7.	Md. 7	Pearson's r	0.408	0.367	1.000	0.840	0.408	0.840	—										
		p-value	0.07	0.11	< .00	< .00	0.07	< .00	—										

Table 2. Pearson's Correlations of Variables

Variable		Md. 1	Md. 2	Md. 3	Md. 4	Md. 5	Md. 6	Md. 7	Mt. 1	Mt. 2	Mt. 3	Mt. 4	Mt. 5	Mt. 6	Mt. 7	Mt. 8	Mt. 9	Total
		4	2	1	1	4	1											
8. Mt. 1	Pearson's r	-0.042	0.043	0.408	0.343	0.583	0.343	0.408	—									
	p-value	0.862	0.858	0.074	0.139	0.007	0.139	0.074	—									
9. Mt. 2	Pearson's r	0.153	0.105	0.688	0.840	0.153	0.840	0.688	0.153	—								
	p-value	0.519	0.660	< .001	< .001	0.519	< .001	< .001	0.519	—								
10. Mt. 3	Pearson's r	0.153	0.105	0.688	0.840	0.153	0.840	0.688	0.153	1.000	—							
	p-value	0.519	0.660	< .001	< .001	0.519	< .001	< .001	0.519	< .001	—							
11. Mt. 4	Pearson's r	0.408	0.367	1.000	0.840	0.408	0.840	1.000	0.408	0.688	0.688	—						
	p-value	0.074	0.112	< .001	< .001	0.074	< .001	< .001	0.074	< .001	< .001	—						
12. Mt. 5	Pearson's r	0.343	0.308	0.840	1.000	0.343	1.000	0.840	0.343	0.840	0.840	0.840	—					
	p-value	0.139	0.186	< .001	< .001	0.139	< .001	< .001	0.139	< .001	< .001	< .001	—					
13. Mt. 6	Pearson's r	0.408	0.367	1.000	0.840	0.408	0.840	1.000	0.408	0.688	0.688	1.000	0.840	—				
	p-value	0.074	0.112	< .001	< .001	0.074	< .001	< .001	0.074	< .001	< .001	< .001	< .001	—				
14. Mt. 7	Pearson's r	0.408	0.367	1.000	0.840	0.408	0.840	1.000	0.408	0.688	0.688	1.000	0.840	1.000	—			
	p-value	0.074	0.112	< .001	< .001	0.074	< .001	< .001	0.074	< .001	< .001	< .001	< .001	< .001	—			
15. Mt. 8	Pearson's r	0.408	0.367	1.000	0.840	0.408	0.840	1.000	0.408	0.688	0.688	1.000	0.840	1.000	1.000	—		
	p-value	0.074	0.112	< .001	< .001	0.074	< .001	< .001	0.074	< .001	< .001	< .001	< .001	< .001	< .001	—		
16. Mt. 9	Pearson's r	0.375	0.257	0.408	0.343	0.375	0.343	0.408	0.167	0.153	0.153	0.408	0.343	0.408	0.408	0.408	—	
	p-value	0.103	0.274	0.074	0.139	0.103	0.139	0.074	0.482	0.519	0.519	0.074	0.139	0.074	0.074	0.074	—	
17.	Pearson	0.52	0.49	0.95	0.90	0.52	0.90	0.95	0.46	0.73	0.73	0.95	0.90	0.95	0.95	0.95	0.50	—

Table 2. Pearson's Correlations of Variables

Variable		Md. 1	Md. 2	Md. 3	Md. 4	Md. 5	Md. 6	Md. 7	Mt. 1	Mt. 2	Mt. 3	Mt. 4	Mt. 5	Mt. 6	Mt. 7	Mt. 8	Mt. 9	Total
Total	's r	1	1	4	5	1	5	4	0	1	1	4	5	4	4	4	0	
	p-value	**0.019**	**0.028**	**< .001**	**< .001**	**0.019**	**< .001**	**< .001**	**0.041**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**< .001**	**0.025**	—

Based on the p-value in table 2, each instrument item correlated with the total number has a p value <0.05 indicating that the correlation is very significant. While the average value of Pearson's correlation to the total amount is 0.77, indicating that the relationship between all instrument items is very strong so that if the value of a variable increases, the others also tend to increase and vice versa. [23].

In the reliability test using Cronbach's alpha, an estimated value of 0.948 was obtained. This value indicates that the items in the instrument have very high internal consistency. All items measure the same construct very well in a unidimensional context.

Table 3. Frequentist Scale Reliability Statistics

Estimate	Cronbach's α
Point estimate	0.948
95% CI lower bound	0.898
95% CI upper bound	0.976

Note. Variables Md. 4 and Md. 6 correlated perfectly. Variables Md. 3 and Md. 7 correlated perfectly. Variables Mt. 2 and Mt. 3 correlated perfectly. Variables Md. 3 and Mt. 4 correlated perfectly. Variables Md. 7 and Mt. 4 correlated perfectly. Variables Md. 4 and Mt. 5 correlated perfectly. Variables Md. 6 and Mt. 5 correlated perfectly. Variables Md. 3 and Mt. 6 correlated perfectly. Variables Md. 7 and Mt. 6 correlated perfectly. Variables Mt. 4 and Mt. 6 correlated perfectly. Variables Md. 3 and Mt. 7 correlated perfectly. Variables Md. 7 and Mt. 7 correlated perfectly. Variables Mt. 4 and Mt. 7 correlated perfectly. Variables Mt. 6 and Mt. 7 correlated perfectly. Variables Md. 3 and Mt. 8 correlated perfectly. Variables Md. 7 and Mt. 8 correlated perfectly. Variables Mt. 4 and Mt. 8 correlated perfectly. Variables Mt. 6 and Mt. 8 correlated perfectly. Variables Mt. 7 and Mt. 8 correlated perfectly.

The results of the data analysis mentioned earlier support the hypothesis that the instruments used in this study have good validity and reliability. Therefore, this instrument can be used to measure the variables to be studied with significant results. The instrument items in the media aspect contain the ease of using the sensor and transducer trainer learning media, the ease of operating the media, increasing student motivation and creativity in learning, increasing student curiosity, and the use of media greatly supports student learning. While the material aspect contains several instrument items that will assess the suitability of the material on the jobsheet with the desired student competencies, the clarity of the use of language and instructions, and various types of pictures and tables in the jobsheet. Both aspects will dig deeper into the use of IoT-based sensor and transducer trainer learning media for students and teachers at SMK.

Analysis of the Effectiveness of Using IoT-Based Sensor and Transducer Trainers

The use of IoT-based sensor and transducer trainers as learning media can provide new learning experiences for students, especially in utilizing IoT technology which is one of the indicators of the development of Industry 4.0. So that we can introduce at the same time the working principle of IoT technology when we want to control and read data remotely to save time and money. The benefit of this IoT trainer in classroom learning is to introduce various IoT components such as sensors, controllers, cloud, and user interfaces.

Based on the questionnaire data that has been distributed to teachers and students, their response to the use of the sensor and transducer trainer is very good. From the previous explanation, there are 2 main aspects that want to be known in this study, namely aspects of the use of trainer media and material aspects. The percentage value obtained from the teacher's response to the use of learning media is 91% with a very strong category, while in the material aspect a value of 93% is obtained with a very strong category. Overall, the response of teachers and students to the use of media is very good, this shows that the use of IoT trainer media is very suitable for use in vocational schools with electronic engineering majors. Figure 2 shows the matrix of the relationship between the instrument items that are strong between one another with the visualization of the graphical increase. However, among the instrument items there are those that show a not too significant increase in the relationship even though from the visual we can see the graph between the items tends to rise.

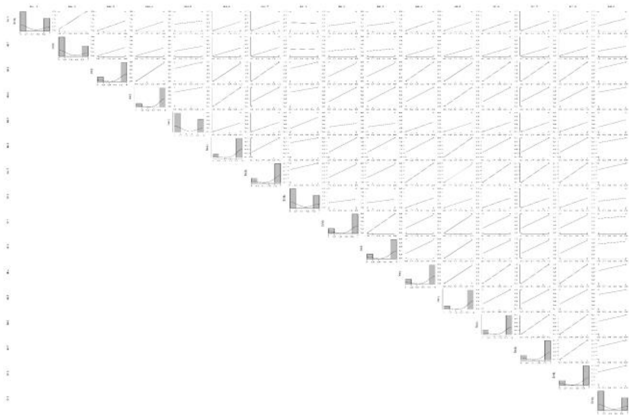

Fig 2. Correlation Plot of media and material aspects instrument items

Comparison of Learning Outcomes Before and After the Use of Trainers

At the end of this research we want to measure the success rate of using IoT-based sensor and transducer trainer learning media for students as target respondents who will use the trainer as a learning tool at school. The level of success is seen from the comparison of student learning outcomes before and after using the trainer as a learning tool. The results of the analysis using the t test showed a significant difference between the pretest and posttest. Before being given the material, students are directed to do pretest questions first, the average student score obtained is 49, while after being given the material using the trainer, the average score increases to 72. The increase in student test results is greatly influenced by the use of media that is needed and in accordance with student learning patterns related to sensor and IoT material. The time span used in data collection is very short, namely 5 hours in the laboratory, so it can be concluded that if students are given more time in using the trainer as a learning media, it will increase their skills and knowledge of materials and competencies in accordance with the curriculum for Electronic Engineering majors in vocational high schools.

Table 4. Paired Samples T-Test

Measure 1		Measure 2	t	df	p
Pretest	-	Posttest	-9.271	19	< .001

Note. Student's t-test.

The t-test results (t = -9.271, p < 0.001) indicate that this difference is highly significant. This indicates that the use of trainers in learning has had a substantial positive impact on student learning outcomes [24].

Table 5. Test of Normality (Shapiro-Wilk)

			W	p
Pretest	-	Posttest	0.917	0.086

Note. Significant results suggest a deviation from normality.

The results of the normality test using Shapiro-Wilk show that the p value = 0.086 is greater than the predetermined significance level (p = 0.05), so it can be concluded that the research data is normally distributed. This shows that this research data is appropriate for further testing to determine student learning outcomes between pretest and posttest.

The results of this study have important implications in the context of education that the use of trainers can be an effective tool to significantly improve student learning outcomes. This strengthens the argument that the appropriate use of technology and learning media can help achieve better learning objectives in various educational contexts.

4. Conclusion

Based on the research data, it can be concluded that the Internet of Things (IoT)-based sensor and transducer trainer is very appropriate for use in the Electronics Engineering Department at SMKN 2 and SMKN 10 Makassar vocational high schools with the results of teacher responses in the media aspect averaging 91% with a very strong category, while in the material aspect the score is 93% with a very strong category. The success rate of using the trainer on student learning outcomes is seen from the comparison between before and after the use of the trainer as a learning tool. The results of the analysis using the t test showed a significant difference between the pretest and posttest (t = -9.271, p < 0.001). Before being given the material, students are directed to do the pretest questions first, the average student score obtained is 49, while after being given the material using the trainer, the average score increases to 72. The increase in student test results is greatly influenced by the use of media that is needed and in accordance with student learning patterns related to sensor and IoT material. Further research is the development of IoT-based media trainers using a wireless sensor network system that allows the use of many sensors and is more effective.

Acknowledgments

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