Tarbiyah wa Ta'lim: Journal of Education and Learning Research
https://journal.iain-samarinda.ac.id/index.php/Tarbiyawat/index
e-mail: jtarbiyahwatalim@gmail.com
March, 2025. Vol. 12, No. 1
p-ISSN: 2338-4530
e-ISSN: 2540-7899
pp. 129-138

DEVELOPMENT OF IOT-BASED AUTOMATION MODULES TO IMPROVE LEARNING OUTCOMES IN ELECTRICAL INSTALLATION AT SMK SIDOARJO

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Submitted: 23 August 2024 ; Revised: 2 December 2024 ; Accepted: 16 February 2025

Abstract

Vocational education plays a crucial role in preparing students to adapt to the rapid advancements in technology. This study aims to analyze the effectiveness, practicality, and impact on learning outcomes of a teaching module for an automation system of electrical lighting installation based on the Internet of Things (IoT). The research employs a Research and Development (R&D) design, focusing on students from the Electrical Power Installation Engineering program at SMK Negeri 1 Sidoarjo. Data collection techniques include surveys and pretest-posttest assessments. Statistical analysis was performed using SPSS software, with normality tests, homogeneity tests, T-tests, and ANOVA. The results indicate that the teaching module achieved an 85% validation rate, with material expert validation at 84.1% and pretest-posttest reliability at 83.3%. Data distributions were normal ($\rho = 0.200$) and homogeneous ($\rho = 0.997$). The results also showed significant effects on learning outcomes ($\rho = 0.000$). Both the effectiveness and practicality ratings for the module were 84.4%. Furthermore, cognitive, affective, and psychomotor learning outcomes of students were significantly improved. This study emphasizes the importance of innovative learning materials in enhancing student performance in vocational education.

Keywords: teaching module, learning outcomes, electrical lighting installation

Abstrak

Pendidikan vokasi memiliki peran penting dalam mempersiapkan siswa untuk beradaptasi dengan kemajuan teknologi yang pesat. Penelitian ini bertujuan untuk menganalisis keefektifan, kepraktisan, dan dampaknya terhadap hasil belajar menggunakan modul ajar sistem otomasi instalasi penerangan listrik berbasis Internet of Things (IoT). Penelitian ini menggunakan desain Research and Development (R&D), dengan sampel peserta didik dari program Teknik Instalasi Tenaga Listrik di SMK Negeri 1 Sidoarjo. Teknik pengumpulan data menggunakan angket dan soal pretest-posttest. Analisis statistik dilakukan dengan perangkat lunak SPSS, dengan uji normalitas, uji homogenitas, uji T, dan ANOVA. Hasil penelitian menunjukkan bahwa modul ajar mencapai tingkat validasi sebesar 85%, dengan validasi ahli materi sebesar 84,1% dan reliabilitas soal pretest-posttest sebesar 83,3%. Data penelitian berdistribusi normal ($\rho = 0{,}200$) dan homogen ($\rho = 0{,}997$). Hasil penelitian juga menunjukkan adanya pengaruh signifikan terhadap hasil belajar ($\rho = 0{,}000$). Rating keefektifan dan kepraktisan modul ajar masing-masing sebesar 84,4%. Selain itu, hasil belajar dalam ranah kognitif, afektif, dan psikomotorik peserta didik meningkat secara signifikan. Penelitian ini menegaskan pentingnya bahan ajar yang inovatif untuk meningkatkan hasil belajar peserta didik dalam pendidikan vokasi.

Kata kunci: modul ajar, hasil belajar, instalasi penerangan Listrik.

How to Cite: Kudriyanto, M. R., et. al. (2025). Development of IoT-Based Automation Modules to Improve Learning Outcomes in Electrical Installation at SMK Sidoarjo. *Tarbiyah wa Ta'lim: Jurnal Penelitian Pendidikan dan Pembelajaran*, *12*(1) 129-138. doi: https://doi.org/10.21093/twt.v12i1.9077

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INTRODUCTION

In the digital and industrial era 4.0, the world of education, especially in the field of vocational education, is faced with great challenges to produce competitive human resources (HR) who are ready to face the industrial world. Vocational education, such as those found in Vocational High Schools (SMK), is one of the most important institutions in preparing young people who have skills and knowledge that are relevant to industrial needs. One aspect that becomes the main focus in SMK education is the ability to utilize technology that continues to grow. In Indonesia, one technology that is now growing rapidly is the Internet of Things (IoT), which has become an integral part of various industrial sectors (Budihartono et al., 2023). In this context, SMKs have an important role in introducing and teaching the latest technology to students so that they can adapt quickly.

Vocational High Schools aim to develop students' competencies so that they are ready to enter the world of work (Maryanti et al., 2020). To achieve this goal, the education curriculum in SMK is designed with a proportion that focuses more on practical learning than theory. Based on the current system, about 70% of learning time in SMK is used for practice and 30% for theory. This practice-based learning approach is believed to help students master the technical skills required by industry. However, in the implementation of learning in SMK, there are many challenges, one of which is the decline in learning outcomes in certain subjects, such as Electrical Lighting Installation (IPL). It is important to find solutions to improve student learning outcomes, especially in facing the challenges of rapid technological development (Ferri et al., 2020).

One way to improve learners' learning outcomes in IPL subjects is to use innovative and creative learning media (Kvilhaugsvik et al., 2022). Effective learning media can help make it easier for students to understand the concepts taught and improve their practical skills. In this case, the use of technology such as IoT in teaching modules can be a solution to improve the quality of learning in SMK. Internet of Things (IoT) is a technology that allows physical devices to connect and communicate with each other through the internet network. The application of this technology in education, especially in SMK, is expected to have a positive impact on improving students' technical skills (Budiarto et al., 2024). Several studies have shown that the use of technology in learning can significantly improve students' interest and learning outcomes (Dunn & Kennedy, 2019).

The development of IoT-based teaching modules for Electrical Lighting Installation subjects is expected to provide a more interesting and in-depth learning experience (Martin, 2021). By using this technology, students not only learn in theory, but also directly practice the installation and operation of electrical lighting systems integrated with IoT. The use of teaching modules that combine the concepts of theory and practice can have a positive impact on students' understanding of IPL material and improve their technical skills. Based on the results of previous studies, technology-based teaching modules have the potential to improve student learning outcomes in vocational subjects (Lytvyn et al., 2020). By developing teaching modules that integrate IoT technology, it is expected to provide a learning experience that is more relevant to current industry needs.

One example of the application of IoT in vocational education is the use of IoT-based trainer kits. This trainer kit allows learners to operate the electric lighting system automatically, which will provide a more real and applicable learning experience. Although some vocational schools, such as SMK Negeri 1 Sidoarjo, do not yet have a trainer kit with automatic operation, they already have a manual trainer kit that can be used for basic learning (Aryanto et al., 2023). With the IoT-based automatic trainer kit, students can better understand the basic principles of automation systems, which is an important skill in the industrial world that is increasingly leading to automated systems (Martin, 2021).

In a study conducted, they developed an IoT-based 3-phase electrical lighting installation trainer to improve student learning outcomes at SMKN 3 Surabaya (Abichandani

et al., 2022). The results showed that the use of IoT-based trainers can improve students' understanding of the concepts and applications of electrical lighting installations, as well as significantly improve their learning outcomes. The trainer equipped with IoT technology allows learners to observe and control the electrical lighting installation system in real-time, which provides a more interactive and practical learning experience (Ismayati et al., 2023).

In addition, research conducted on the development of electrical lighting installation trainers with the concept of "smart building" in IPL subjects at SMK Negeri 1 Driyorejo also showed positive results (Raman et al., 2023). This research produced a trainer that is not only valid and practical but also effective in improving student learning outcomes. This "smart building" based trainer allows students to learn about smart concepts in lighting installations, which are in accordance with technological developments in the industrial world. Thus, the use of high technology-based trainers can be a solution to improve the quality of learning in SMK (Rijanto & Aji, 2023) (Marquardt & Kearsley, 2024).

Another study conducted by Fakhruddin et al., (2019) also showed the potential of technology-based learning media in improving learning outcomes. In this study, they developed a problem-based learning model using Macromedia Flash 8 software for IPL subjects. The results show that this learning model can improve learners' critical thinking skills, which in turn affects the improvement of their learning outcomes. The problem-based learning model gives learners the opportunity to solve real problems related to lighting installation, thus improving their practical skills (Orji, 2021).

In addition, the implementation of the Merdeka curriculum at SMK Negeri 1 Sidoarjo also provides flexibility for educators to choose learning tools that suit the needs and interests of students. This curriculum provides the freedom to adapt learning methods and media that are more in line with technological developments and the industrial world, including the use of IoT-based media. With this more flexible approach, it is expected that learning in SMK can be more optimal and relevant to the needs of students in the future (Bunyamin et al., 2022).

Through the application of more advanced technology in teaching modules, such as the use of IoT in learning electrical lighting installation, SMK can improve the quality of vocational education in Indonesia. By utilizing existing technology, students not only gain theoretical knowledge but also practical skills needed in the world of work. The growing IoT technology also opens up opportunities for SMKs to create innovations in learning that can help students to be better prepared for the increasingly complex and technology-based industrial demands (Jugembayeva & Murzagaliyeva, 2022).

Based on the background that has been described, the researcher plans to conduct research with the title "Development of Teaching Modules for Electrical Lighting Installation Automation Systems Based on the Internet of Things to Improve Student Learning Outcomes in the Electrical Power Installation Engineering Department at SMK Negeri 1 Sidoarjo." This study aims to develop teaching materials in the form of teaching modules and worksheets for class XI majoring in Electrical Power Installation Engineering (TITL) which integrates IoT technology in the learning process. By using the Project Based Learning (PJBL) model, it is expected that students can develop creative thinking skills and significantly improve their learning outcomes.

METHODS

This research applies a Research and Development (R&D) research design. According to (Dewi et al., n.d.) the Research and Development (R&D) research method is a research method used to produce certain products and test the effectiveness of these products. The product trial in this study used a One Group Pretest-Posttest Design. This research uses the ADDIE development model developed by Almelhi, (2021). The ADDIE development model can be applied to learning devices in the form of learning modules and jobsheets. The development stages are systematic and easy to understand in carrying out the development of

learning devices. There are five stages in the ADDIE development model, the five stages of development are analysis, design, development, implementation, and evaluate.

Researchers used the One Group Pretest-Posttest Design research design. One Group. Pretest-Posttest Design can be described as shown below

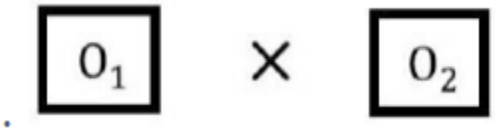

Figure 1. One Group Pretest-Posttest Design

O1 : Pretest score / before treatment
X : Implementation of interesting and innovative canva-based e-modules
O2 : Posttest score / after treatment

The research was conducted based on observations and interviews conducted at SMK Negeri 1 Sidoarjo, East Java. This research was conducted from January 2024 to April 2024. The population in this study were 209 students majoring in Electrical Power Installation Engineering (TITL) at SMK Negeri 1 Sidoarjo consisting of 73 students for class X TITL, 64 students for class XI TITL, 72 students for class XII TITL. While the sample in this study were students majoring in Electrical Power Installation Engineering (TITL) class XI totaling 70, consisting of 31 students for class XI TITL 1 and 33 students for class XI TITL 2.

The main tools for data collection in this study are interviews and student response questionnaires. So that the problem can be known before the research is carried out and used as a background for research, the researcher conducts an interview to explore related information at SMK Negeri 1 Sidoarjo, especially in the Electrical Power Installation Engineering (TITL) expertise program. In addition, this activity also aims to find out what is needed as material for developing teaching modules and jobsheets. While the questionnaire is used to obtain respondents' answers regarding the feasibility of teaching modules. The independent variable in this study is the electrical lighting installation teaching module while the dependent variable is the learning outcomes of students.

The data analysis technique in this study uses normality test, homogeneity test, T test, and anova hypothesis test. Normality test is a statistical process used to evaluate whether the data sample or observed data comes from a normal distribution or not. Homogeneity test is a statistical process used to test whether the variances of two or more data groups are the same or not. This test is a requirement before conducting other tests such as the T Test and ANOVA (Analysis of Variance). T Test or also can be called Paired Sample T Test is a test used to compare the difference between 2 means of 2 paired samples with the assumption of normal distribution data. ANOVA (Analysis of Variance) is a statistical technique used to compare the means of 2 or more samples of data to see if there is a significant difference between the samples

RESULTS AND DISCUSSION

This research produces a product in the form of an *Internet of Things* (IoT)-based Electrical Lighting Installation Automation System (IPL) Teaching Module. This IoT-based IPL Automation System teaching module was made to solve the problem of the lack of improvement in student learning outcomes in phase F of the Electrical Power Installation Engineering department in the Electrical Lighting Installation (IPL) subject. This module has been approved and declared feasible by the validator.

Figure 2. Teaching Module Cover

This module, titled "Internet of Things Based Electric Lighting Installation," is designed as part of the curriculum in the Electrical Power Installation Engineering concentration. It is tailored specifically for students who are learning about advanced electrical systems and their integration with modern technology. The module not only introduces IoT-based electric lighting systems but also provides a comprehensive overview of the year of its creation, school level, and grade level for better clarity and organization. This structure ensures that the content is appropriately aligned with the educational objectives for the targeted students, offering a clear roadmap for both instructors and learners.

The primary goal of this module is to make learning IoT technology more accessible and engaging for students. IoT technology has become an integral part of various industries, including electrical engineering, where it is used to create smart and efficient systems. By incorporating IoT into the curriculum, this module seeks to bridge the gap between theoretical knowledge and real-world applications, enabling students to understand how these technologies are applied in everyday life. With this approach, students are not only taught the fundamental concepts but also gain hands-on experience, which enhances their learning process and prepares them for the workforce.

Additionally, this research has resulted in the development of a jobsheet that complements the teaching module. The jobsheet provides practical exercises related to IoT-based Electrical Lighting Installation (IPL) that directly align with the topics covered in the module. These practical exercises are designed to deepen students' understanding of the material and enable them to apply the theoretical knowledge in real-world scenarios. Each section of the jobsheet outlines clear learning outcomes and objectives that correspond with the curriculum standards, ensuring that students meet the desired competencies by the end of the course. The jobsheet emphasizes project-based learning, encouraging students to complete projects within a set timeframe, fostering critical skills such as time management, problem-solving, and collaboration.

By utilizing both the module and the jobsheet, students are provided with a comprehensive, structured learning experience that promotes active learning and skill development. The focus on IoT not only makes the content more relevant to current technological trends but also enhances students' readiness for the evolving demands of the electrical

engineering industry. This research, therefore, contributes significantly to both academic and practical training, preparing students to excel in a rapidly advancing field.

Table 1. Instrument Validation Results

No.	Instrument	Rating Result (%)	Criteria
1	Teaching Module Validation	85%	Very Valid
2	Material Expert Validation	84,1%	Very Valid
3	*Pretest-Posttest* Question	83,3%	Very Valid

Based on the instrument validation results shown in Table 1, it can be concluded that the research instruments used in this study have a very good level of validity. The teaching module obtained a validation rating of 85%, which is included in the "Very Valid" category. Similarly, the material expert validation, which received a score of 84.1%, and the validation of the pretest-posttest questions which reached 83.3%. These values indicate that the instruments used in this study are reliable and suitable for use in data collection. This high validity provides confidence that the instruments used to measure students' learning outcomes are in accordance with the expected standards and are effective in the context of this study.

Table 2 SPSS Normality Test Results

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	0.089	64	0.200*	0.976	64	0.253
Posttest	0.096	64	0.200*	0.975	64	0.207

Table 2 shows the results of the normality test using the Kolmogorov-Smirnov and Shapiro-Wilk tests. The significance value for the pretest and posttest data is 0.200 for both, which means that the data is normally distributed. In statistical analysis, the normality test is used to ensure that the data collected follows a distribution that conforms to parametric assumptions. In this case, the results of this normality test confirm that the data obtained from the pretest and posttest can be further analyzed by parametric statistical methods.

Table 3. SPSS Homogeneity Test Results

Test of Homogeneity of Variances					
		Levene Statistic	df1	df2	Sig.
Preetest-Posttest	Based on Mean	0.195	11	50	0.997
	Based on Median	0.131	11	50	1.000
	Based on Median and with adjusted df	0.131	11	37.500	1.000
	Based on trimmed mean	0.194	11	50	0.997

Furthermore, Table 3 shows the results of the homogeneity test used to test whether the pretest and posttest data have uniform or homogeneous variances. The significance value of 0.997 in the Levene test indicates that the pretest and posttest data have a homogeneous variance, which means there is no significant difference in data variability between groups. This homogeneity is very important in statistical analysis because it ensures that data from the various groups in this study can be compared fairly without the influence of different variances.

Table 4. SPSS T Test Results

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair	Pretest - Posttest	30.54	8.8357	1.1045	32.7540	28.3398	27.658	63	0.000

Table 4 displays the T-test results to see the difference between the pretest and posttest scores. The very small significance value of 0.000 indicates that there is a very significant difference between the pretest and posttest scores. This difference indicates that the intervention or treatment provided through the use of the IoT-based IPL automation teaching module has a significant effect on improving student learning outcomes. Therefore, this teaching module is proven effective in improving students' learning outcomes in the subject of Electrical Lighting Installation.

Table 5 SPSS ANOVA Test Results

ANOVA					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	648.774	13	49.906	1.632	0.000
Within Groups	1529.253	50	30.585		
Total	2178.027	63			

Table 5 shows the results of the ANOVA test used to test for differences between different samples. The significance value of 0.000 indicates that there is a significant difference between the samples tested in this study. This result indicates that the treatment given in this study, which involved the use of the IoT-based teaching module, had different effects on each group of learners tested.

In addition, the results of the teaching module effectiveness test recorded at 84.4% indicate that the IoT-based IPL automation system teaching module is very effective in learning. This proves that this teaching module meets the criteria as a good learning tool and can be used in teaching at SMK. The practicality of the teaching module is also reflected in the 81.8% rating, which shows that this teaching module is very practical and easy to apply in teaching and learning activities, making it easy for students to understand the material presented.

Finally, students' learning outcomes showed a significant improvement. The increase in pretest-posttest scores obtained by students indicates that they managed to understand the material better after using the IoT-based teaching module. In addition, the learners' attitude and psychomotor assessments also showed improvement, which was reflected in the increase in practical results from jobsheet 1 to jobsheet 2. This increase shows that this teaching module not only affects cognitive learning outcomes, but also the affective and psychomotor aspects of students. Therefore, it can be concluded that the use of this teaching module can improve overall learning outcomes, both in the cognitive, affective, and psychomotor domains of students.

Overall, the results of this study indicate that the use of IoT-based IPL automation system teaching modules is effective, practical, and has a positive effect on improving learning outcomes.

CONCLUSIONS AND SUGGESTIONS

Based on the results of research and discussion regarding the improvement of student learning outcomes that have been described previously, it can be concluded that there are high effectiveness criteria in the use of teaching modules for electrical lighting installation automation systems in class XI students majoring in TITL. Based on the calculation results of 84.4% which shows that it exceeds the rating value of 80% with sufficient criteria. There are criteria of practicality that are very practical in the use of teaching modules for electrical lighting installation automation systems in class XI students majoring in ITTL. Based on the calculation results of 84.4% which shows that it exceeds the rating value of 80% with practical assessment criteria. There is an increase in learning outcomes in the cognitive, affective, and psychomotor domains. The increase in learning outcomes in the cognitive domain is in the form of increasing pretest-posttest scores carried out by students. The improvement of learning outcomes in the affective domain is in the form of increasing the attitude assessment of students when carrying out *jobsheet* 1 practicum then compared to *jobsheet* 2. Increased learning outcomes in the psychomotor domain in the form of increased assessment of student performance when carrying out *jobsheet* 1 practicum then compared to *jobsheet* 2 practicum.

Educators have a very important role in improving the abilities, character, and performance of students during teaching and learning activities. Thus students will have the knowledge, attitudes, and work ethic that are ready to be used in the industrial world later. Researchers suggest that in future studies related to improving student learning outcomes to develop media or devices that are used more interestingly so that students are interested in the material presented.

ACKNOWLEDGMENTS

I would like to thank all those who have provided assistance and support in the completion of this article. My deepest gratitude goes to Dr. Subuh Isnur Haryudo, S.T., M.T. for being my advisor, as well as to Mr. Fendi Achmad, S.Pd., M.Pd. and Ms. Yulia Fransisca, S.Pd., M.Pd. for acting as examiners and providing valuable input. I would also like to thank my parents who always provide motivation, courage, and endless support in my every step. Last but not least, I would like to thank my friends who have always provided moral support and encouragement throughout this process. Without the help and encouragement from all these parties, I would not have been able to complete this article properly.

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