AT-TAKLIM : Jurnal Pendidikan Multidisiplin E-ISSN : 3062-9489
https://journal.hasbaedukasi.co.id/index.php/at-taklim
Halaman : 161-174

DESIGN OF MICROCONTROLLER TRAINER BASED ON INTERNET OF THINGS (IoT)

Alifia Putri Harkha*[1], Hendra Hidayat[2]
Universitas Negeri Padang, Padang, Indonesia[1,2]
Email*: *alifiaputriharkha1603@email.com*

Keywords

Microcontroller Trainer, Internet of Things, Vocational Education, ADDIE Model, Practical Learning.

Abstrak

The rapid advancement of technology, particularly in the industrial sector, necessitates innovative educational tools to enhance students' practical skills. One crucial aspect of technical education is microcontroller programming, which is fundamental in the development of automation and IoT-based systems. However, conventional learning methods, which rely heavily on theoretical instruction and simulations, present challenges in understanding abstract microcontroller programming concepts. This study aims to design and develop an Internet of Things (IoT)-based microcontroller trainer to support practical learning for students at SMK Negeri 1 Bukittinggi. The research follows the Research and Development (R&D) approach using the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) model. The study includes needs analysis, prototype design using simulation tools, hardware development, validation by experts, and a practicality test involving students. Validation results indicate that media experts rated the trainer at 93.08%, while material experts provided an average rating of 83.85%, categorizing the trainer as highly valid. Furthermore, student practicality tests resulted in a 90.36% feasibility score, confirming the trainer's effectiveness in enhancing students' understanding of microcontroller programming. These findings suggest that the developed IoT-based microcontroller trainer is a viable educational tool that aligns with industry demands and modern learning methodologies.

1. INTRODUCTION

The rapid development of technology is an unavoidable aspect of everyday life. This technological advancement has affected various aspects of people's lives, especially the industrial sector, which continues to develop to increase efficiency and production.

One of the emerging developments is the utilisation of Internet of Things (IoT) technology. This technology is used in various domains to develop smarter, more efficient, and cohesive systems. Internet of Things (IoT), facilitates real-time connectivity of devices that enhance many human activities more efficiently [1].

Internet of Things (IoT)-based microcontroller systems are widely used for automatic connection and control of objects [2]. This technology operates by transmitting data over the internet, allowing various devices to be connected in the same function. The system offers many advantages, including real-time monitoring and control, improved work efficiency, automation assistance, and data available from a single location. The system is adaptable and suitable for applications ranging from small to large scale [3].

The number of educational institutions that have not maximised and equipped students to face technological advances, especially in microcontrollers and the Internet of Things (IoT), learning that can help students become individuals who are proficient and able to adapt to the demands of the world of work . Difficulty understanding abstract and complicated concepts is a problem in learning microcontroller programming [4].

Law number 20 of 2003 concerning the National Education System aims to establish a strong and respectable educational framework as a social institution, thus enabling all Indonesian citizens to develop into human beings who are able to adapt to an ever-changing environment. Vocational High Schools (SMK) have an important role in the Indonesian National Education System, especially in the preparation and development of Human Resources (HR) [5]. SMK graduates are expected to be able to compete in the world of work and industry through their competencies. Vocational education aims to produce professional experts who are able to adapt to advances in the industrial sector. Therefore, productive learning in SMK must be in line with the needs of the industrial sector to ensure successful learning outcomes and the achievement of specific competencies [6].

SMK Negeri 1 Bukittinggi is one of the Vocational High Schools in the technology and engineering group that offers a variety of expertise programmes. SMK Negeri 1 Bukittinggi has 9 majors, one of which is Audio Video Engineering. The Audio Video Engineering Department (TAV) is a department that studies electronics that extends to industry. In the TAV department, there are various subjects, one of which is

Microcontroller Programming. Microcontroller Programming is one of the subjects in the TAV expertise competency which must be studied by class XI and has implemented an independent curriculum.

Based on experience and observations made in the Audio Video Engineering department of SMK Negeri 1 Bukittinggi in the Implementation of the Educational Field Experience Program (PPLK) for the July-December 2024 period, it shows that Microcontroller Programming subjects have long been integrated in the curriculum. However, the learning process is still dominated by conventional methods, where Microcontroller Programming subjects are mostly delivered in the form of theory and supported by learning media such as videos. In practical activities, students are more directed to use simulation software, while this subject requires microcontroller trainer tools that are in accordance with the times to support practical learning.

The limited quantity and completeness of practical components also pose challenges in facilitating an effective learning process [5]. To adapt to the industrial era 4.0, it is necessary to develop an IoT-based microntroller trainer as a new suggestion that is relevant to industrial needs, so that learning becomes more applicable and supports student competence in facing the latest technological challenges (Alyafi et al., 2021).

To overcome these problems, a tool is needed in the form of an IoT-based microcontroller trainer that facilitates students of SMK Negeri 1 Bukittinggi in the practice of Microcontroller Programming, hence the idea or idea of the author to make 'Designing an Internet Of Things (IoT) Based Microcontroller Trainer'. With this IoT-based Microcontroller trainer, it is hoped that it can improve the competence of students needed in the industrial workforce.

2. METHODS

The Research conducted in the design and manufacture of Internet of Things (IoT) based microcontroller trainer tools uses the R&D (Research and Development) method which focuses on research and development. The R&D method implemented in this study uses the analysis, design, development, implementation, and evaluation (ADDIE) method . However, in this study, the implementation stage was not implemented because this stage requires a long time to implement. the following are the steps of the development process in the ADDIE model according to [7]:

A. Analysis Phase

In the first stage, the method used was observation. From the results of this observation, we can know the needs analysis and goal analysis. The description of the analysis stage is:

1) Needs analysis based on the results of observations can be known what is needed in making products.
2) Analysis of the objectives of the observations made is that the resulting media trainer can help educators in the learning process and make it easier for students to understand the material presented.

B. Design Phase

In the second stage, after drafting a product design that includes important aspects such as the shape, pattern, and packaging to be applied, the next step is to create a prototype design. This prototype serves as the initial model of the planned product. Once the prototype has been made, it is important to conduct a trial run first using simulation tools such as Wokwi or Proteus. Through these trials, we can evaluate the performance and functionality of the product before it is mass-produced. This way, we can identify and fix potential problems that may arise, so that the final product produced can better fulfil the expectations and needs of users.

C. Development Phase

In the third stage, after the design process is complete, the development stage begins with the creation of learning media prototypes. This prototype is then validated by experts to ensure its quality. Validation is conducted by media experts who evaluate the design and functionality aspects of the tool, as well as by material experts who assess the suitability of the learning content with curriculum standards and student understanding. The assessment results from these experts are crucial to identify areas that require improvement.

Based on the feedback and suggestions received during the validation process, the researcher made revisions to the learning media. The purpose of this revision is to Improving the shortcomings detected, both in terms of technical and material content, so that the learning media becomes more effective and ready for further testing.

After making improvements, the researchers continued with the practicalisation test stage, which is testing the tool in real conditions in the school environment. This stage aims to evaluate the practicality of the tool when used by students and teachers. This test process also includes collecting feedback from users regarding the ease of use, benefits, and effectiveness of the tool in improving students' understanding of microcontroller material.

D. Evaluation Phase

In the final stage of development, products that have gone through the trial process will be evaluated to determine their feasibility. This evaluation aims to assess whether the product meets the set standards and is ready for widespread use. If the evaluation results show that the product has not met the eligibility criteria, then the next step is to make improvements and refinements. This improvement process includes in-depth analysis of aspects that need to be improved, both in terms of design, functionality, and content. After the improvements are made, the product will be tested again to ensure that all identified deficiencies have been addressed. The purpose of this series of evaluations and improvements is to ensure that the final product not only meets user expectations, but can also function optimally in its context of use. Thus, the product can be categorised as feasible and ready to be applied in real situations, providing maximum benefits to users.

After all stages have been completed, the validation process is then carried out which includes media expert validation and material expert validation as well as the practicality test. Data analysis used from the results of material expert validation and media expert validation as well as the practicality test using the formula:

$$P = \frac{f}{n} \, x \, 100$$

Description:

P = Percentage of validity

F = Number of scores from data collection

N = Maximum score

From the results of the above analysis, the percentage obtained will show the level of feasibility with criteria according to [8] in table 1:

Table 1.

Percentage of Validity Criteria

Presentase	Kriteria
P > 80 %	Very Valid
60% < P ≤ 80%	Valid
40% < P ≤ 60%	Moderately Valid

20% < P ≤ 40%	Less Valid
P ≤ 20%	Invalid

Source: (Febriani, Elvia and Handayani, 2021) Modified

3. RESULT

In the educational process, especially at the Vocational High School (SMK) to university level, the use of trainers as learning tools has become a common practice. Trainers are expected to improve learners' practical skills, so it is very important to ensure the feasibility and quality of the trainers used. However, it is often found that schools have trainers, even though the equipment no longer meets the eligibility standards for use. Therefore, the author took the initiative to develop a learning media trainer that meets the needs, by utilising the ADDIE development model. This model, designed by Robert Maribe Branch, includes five main stages, namely: analysis, design, development, implementation, and evaluation. The use of the ADDIE model aims to design and develop educational products effectively and efficiently so as to improve the quality of training media used in educational institutions.Tahap

A. Analysis Phase

The analysis phase in the trainer development process consists of two main components, namely needs analysis and goal analysis. In the needs analysis, an observational approach was applied to identify the various elements required in the manufacture of the trainer. This includes the materials used, the design of the trainer panels, as well as training on packaging the product. The needs analysis plays a crucial role, as the success in creating a quality product is highly dependent on the materials used on a deep understanding of existing needs.

Table 2.

Result of needs analysis

No	Komponen	Jumlah
1.	ESP32 DEV Kit 1	1 Buah
2.	Sensor Ultrasonik	4 Buah
3.	Sensor Gas MQ-2	1 Buah
4.	Sensor Infrared	1 Buah
5.	Sensor DHT 22	1 Buah
6.	LCD 16X2	1 Buah

7.	Servo Sg20	1 Buah
8.	LED	13 Buah
9.	Relay	2 Buah
10.	Buzzer	1 Buah
11.	Resistor	14 Buah
12.	Kapasitor	3 Buah
13.	Dioda	2 Buah
14.	Motor L298N	2 Buah
15.	Motor DC dan Roda	4 Buah
16.	Terminal Blok 2 Channel	3 Buah
17.	Terminal Blok 3 Channel	2 Buah
18.	Fuse 5A	1 Buah
19.	Fuse Holder	1 Buah
20.	Step Down	1 Buah
21.	PCB	1 Buah
22.	12C	1 Buah
23.	Pin Header Round Head Female	4 Buah
24.	Pin Header Round Head Male	118 Buah
25.	Kabel Jumper	60 Buah
26.	Akrilik 3mm (20cm x 15cm)	2 Buah
27.	Switch	1 Buah
28.	Spaiser	11 Buah
29.	Solder	1 Buah
30.	Timah Solder	1Buah

The results of the analysis aim to design a trainer learning media product on Microcontroller Programming, which is intended as a learning tool for Programming and Microcontroller subjects at SMKN 1 Bukittinggi, especially for grade 11 Electronics Engineering majors who have implemented the Merdeka Curriculum.

B. Design phase

Once the analysis stage is complete, the next step is to design and assemble the trainer design. This process includes several essential components, including the acrylic chassis, motor drive, microcontroller board, as well as other supporting modules such as motor drivers and communication modules. Careful design of each element aims to ensure the functionality and aesthetics of the trainer, so that it can be used effectively as a learning tool

1) Trainer Chassis Design

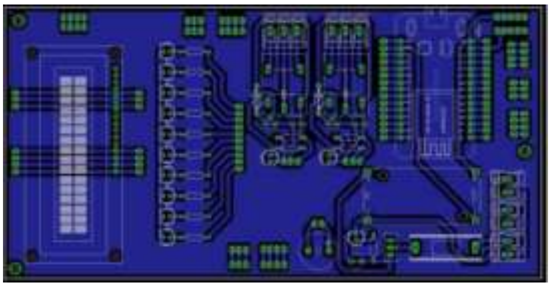

Figure 1. Trainer Chassis Design

2) PCB Design

This PCB is designed with an optimum layout to ensure connections between components function properly and efficiently. Circuit paths are designed as efficiently as possible to minimise interference and ensure circuit stability. Each component is accurately connected according to its function, so that it can be effectively utilised in the trainer.

Figure 2. PCB Design

C. Development phase

At this stage, the design is realised into the final product. After the production process is complete, the product is then validated to assess its feasibility level and ensure that the results obtained are in accordance with the predetermined standards.

a. Product manufacturing

1. Transfer layout to PCB

Layout Transfer to PCB is done by transferring the circuit design that has been printed on specialised paper to the surface of the PCB board using a heating method, such as an iron or laminator, to ensure the copper paths stick precisely before the etching process is performed.

Figure 3. Transfer Layout to PCB

2. Etching process

At this stage, unnecessary copper parts on the PCB board are removed using an etching solution. PCBs that have had their designs transferred are immersed in ferric chloride solution. ($FeCl_3$) or ammonium persulfate which will dissolve copper that is not protected by toner or resist. This process is done by gently stirring or shaking the solution so that the etching takes place evenly. Once the unwanted copper is fully dissolved, the PCB is cleaned and dried before going into the next stage.

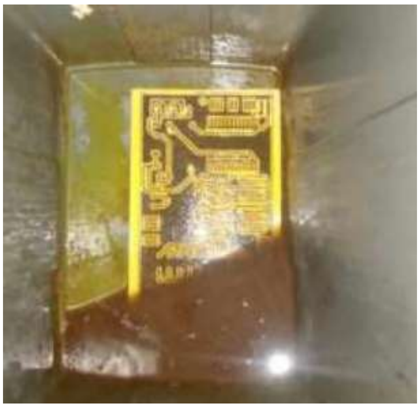

Figure 4. Etching Process

3. PCB Surface Smoothing

At this stage, the surface of the PCB that has gone through the etching process will be smoothed using fine sandpaper. This aims to remove any residual toner, remove oxidation on the copper layer, and ensure a cleaner and flatter surface. Thus, the soldering process can be performed more optimally, ensuring a good electrical connection between components.

Figure 5. PCB Surface Smoothing

4. Assembly

The next step is to assemble the trainer which is carried out starting from drilling the pcb board which has gone through the etching process, installing components on the pcb board and soldering the trainer components.

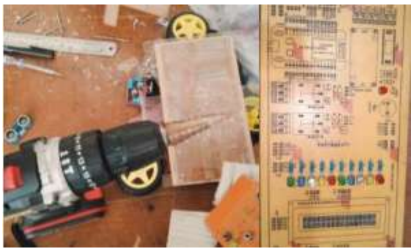

Figure 6. Trainer Assembly

5. Final Result

After completing the assembly process, the trainer is then checked again to ensure that each connection path has been connected, after which the trainer is ready to proceed to the next step, which is testing the validity of the trainer.

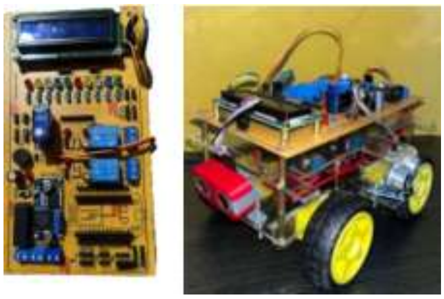

Figure 7. Assembly Result

In testing the feasibility of the trainer involves media experts and material experts who will provide general assessments and input related to the trainer learning media developed. The purpose of this test is to get feedback and evaluation of the trainer that has been made, so that it can be used as a guide in producing a decent and quality trainer.

The results of the validation of media experts assessed by lecturers of Electronic Engineering at Padang State University get a percentage of 93.85% which is included in the very valid category, while the validation of media experts assessed by teachers of SMK Negeri 1 Bukittinggi gets a percentage of 92.31% which is included in the very valid category. so that the total average of the results of the media expert validation assessment by lecturers and teachers is 93.08%.

Table 3

Media Expert Validation Results

Statement	Media expert	
	lecturer	teacher
Neat installation of components on an internet-based microcontroller trainer of things	5	4
The layout of the components on the trainer is organized, making it easier for students to understand the material studied	5	5
The attractiveness of the trainer appearance IoT-based microcontrollers are good overall.	4	5
Placement of writing containing information about the parts of the trainer can be read easily	4	5
The trainer is easy to operate by students	4	4
The trainer is safe to use when learning	5	5
Systematic presentation of material in the trainer is good	4	4
Trainer as a whole have a good job	5	4
The use of trainers can increase student attention towards teaching materials	5	5

Using a trainer can increase learning motivation student	5	5
Clarity of instructions for use trainer for students	5	4
Ease of replacing or repairing components if damage occurs	5	5
Stability of connections between microcontrollers, sensors and communication modules in the trainer	5	5
Total Score	61	69
Validity Percentage	93,85%	92,31%
Average		93,08%

The results of the material expert validation assessed by the Electronics Engineering lecturer at Padang State University received a percentage of 76.92% which is included in the valid category, while the validation of the material expert assessed by the teacher of SMK Negeri 1 Bukittinggi received a percentage of 90.77% which is included in the very valid category. so that the total average of the results of the material expert validation assessment by lecturers and teachers is 83.85%.

Table 4

Materi Expert Validation Results

Statement	Materi expert	
	lecturer	teacher
The material is relevant to student competencies	4	5
Clarity of the material presented	4	5
Continuous delivery of material	4	5
The material is supported by appropriate learning media	4	4
Completeness of internal material	5	4
Appropriateness of giving examples in the material	4	4
Use of appropriate language and easy to understand	4	4

Material supported by relevant pictures and illustrations	4	4
Trainers help students understand IoT concepts practical	5	4
Trainers improve students' skills in	4	5
microcontroller programming		
Trainers use methods interactive and interesting learning	4	5
The trainer provides bait feedback on student understanding	4	5
Learning sessions help students apply the material directly	4	5
Total Score	50	59
Validity Percentage	76,92%	90,77%
Average		83,85%

Furthermore, the results of the learner practicality test conducted by XI TAV class students of SMK Negeri 1 Bukittingi with a total of 20 students as respondents got a percentage of 90.36% so that this microcontroller trainer learning media was very feasible to use.

4. CONCLUSIONS

Design of Microcontroller Trainer Based on Internet of Things (IoT) is very feasible to use as learning media at SMK Negeri 1 Bukittinggi this is because from the results of the level of media validation by lecturers get a total of 93.85% and media validation by teachers get a total of 92.31% while the results of material expert validation by lecturers get a total of 76.92% and material validation by teachers get a total of 90.77% so that in the practicality stage with 20 respondents of class XI TAV students SMK Negeri 1 Bukittinggi get a positive response with a percentage of 90.36%.

5. REFERENCES

Satriyo Cahya Rachmanda and T. Aprilianto, “Rancang Bangun Alat Pemberi Pakan Ikan Konsumsi Otomatis Berbasis Mikrokontroler,” *J. Sist. Komput. Asia*, vol. 1, no. 01, pp. 82–94, 2023, doi: 10.32815/jiskomsia.v1i01.33.

H. Aji and A. Kautsar, “Perancangan Alat Pendeteksi Kebocoran Gas Berbasis

Mikrokontroler PIC16F84A," *J. Tek. Inform. Stmik Antar Bangsa*, vol. IV, no. 12, pp. 106–112, 2018.

M. Nur R, I. Fresha A, and R. Dian A, "Aplikasi Sensor Ultrasonik HC-SR04 Guna Mendeteksi Jarak Penumpang Kereta Api di Era New Normal," *National Conference PKM Center Sebelas Maret University*. pp. 236–240, 2020.

I. Sumadikarta and M. M. Isro'I, "Mobile Application , arduino NodeMCU ESP8266.," *J. Ilm. Fak. Tek. LIMIT'S*, vol. 16, no. 1, 2020.

P. Trainer, P. Mikrokontroler, T. Mikrokontroler, and A. Uno, "ARDUINO UNO PADA MATA PELAJARAN TEKNIK PEMOGRAMAN MIKROPROSESOR DAN MIKROKONTROLER KELAS XI TEI DI SMKN 1 NGAWI Zainal Mujib Ansori S1 Pendidikan Teknik Elektro , Fakultas Teknik , Universitas Negeri Surabaya Lilik Anifah Jurusan Teknik Elektro , Fakultas," vol. 11, pp. 69–78, 2021.

I. Maulana, U. Rosalina, M. A. Setiawan, G. A. Suryadi, S. Widya, and U. Purwokerto, "Peningkatan Motivasi dan Keterlibatan Siswa melalui Pembelajaran Berbasis Embodied Learning pada Materi Internet of Things (IoT) Enhancing Student Motivation and Engagement through Embodied Learning Based Learning in Internet of Things (IoT) Education," vol. 4, no. 5, pp. 195–206, 2024.

W. Handayani, M. A. Effindi, and ..., "Pengembangan Modul Ajar Arduino pada Materi Dasar-Dasar Mikrokontroler di SMK Darul Istiqomah," *J. Educ. ...*, vol. 2, no. 1, pp. 40–49, 2022, [Online]. Available: https://journal.trunojoyo.ac.id/jedumatic/article/view/24528%0Ahttps://journal.trunojoyo.ac.id/jedumatic/article/viewFile/24528/9178

A. Febriani, R. Elvia, and D. Handayani, "Pengembangan alat evaluasi pembelajaran kimia berbasis komputer menggunakan wondershare quiz creator pada materi larutan penyangga," *ALOTROP*, vol. 5, no. 2, pp. 191–197, 2021.