Embedded System Training Kit for Artificial Intelligence

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***Abstract*—Ever-developing science and technology require us always to be ready to adapt. The current challenging era is Society 5.0, which places a strong emphasis on harnessing human potential to overcome diverse challenges, including the development of Artificial Intelligence (AI) technology. Therefore, to improve the quality of human resources, this paper proposes the development of an artificial intelligence training kit based on embedded systems according to industry needs. The development of a training kit utilizing the RnD method was accomplished through the use of the ADDIE (analysis design, development, implementation, and evaluation) model. This model encompasses analysis, design, development, implementation, and evaluation. The technology of the training kit combines fuzzy logic, Artificial Neural Network (ANN), and image processing, consisting of hardware, software, and job sheets. The controller used to process embedded systems is the ESP32 board. Arduino UNO is used to execute the training results of the artificial intelligence system. The training kit performance test results show that all AI programs run optimally, and each component can function according to performance indicators. A group of subject matter and media experts evaluated the feasibility of the project and determined it to be very feasible, with a score of 83.64% and 86.67%. In addition, a feasibility test was conducted with 38 respondents, resulting in a score of 83.35%, and it was categorized as a very feasible tool. The effectiveness of the training kit applied to the experimental class resulted in a post-test mean score of 89.58, while the control class mean score was 76.39, so the AI training kit showed more effectiveness.**

***Keywords*—Artificial Intelligence (AI) training kit, ADDIE model, embedded system, fuzzy logic, Artificial Neural Network (ANN), image processing**

I. Introduction

The rapid development of science and technology requires us to always be ready to adapt, especially in this digitalization era. One form of this change is the era of Society 5.0, which was adopted from the Industrial Revolution 4.0 [1]. Society 5.0 focuses on humans solving various social challenges and problems using technological innovations [2, 3]. The Japanese government introduced Society 5.0 at the World Economic Forum in Davos, Switzerland, to address the focus on society, technology, medical services, and educational services [4]. The concept of Industrial Revolution 4.0 and Society 5.0 has little difference. Industrial Revolution 4.0 uses artificial intelligence, big data, and IoT, while Society 5.0 focuses on the human component so that it is noticed in the use and design of technology [2].

Education has an important role in developing the industrial era and Society 5.0, especially in advancing the quality of human resources [5]. Learning does not only study cognitive abilities but also includes several personal and social skills. These skills are known as 4C (critical thinking, creativity, collaboration, and communication), which can be honed in learning [6]. The teaching and learning process has five important aspects: objectives, subject matters, methods, media, and learning evaluation. These five components synergize with each other. Using one of the learning methods will affect the aligned learning media type, considering three other important components (objectives, subject matters, and evaluation). Learning media can increase learning motivation, generate new desires, stimulate learning, and psychologically influence learning participants [7]. Educators decide how to use media to enhance the learning experience. .

One type of media often applied in the teaching and learning process is the training kit [8]—utilization of training kits to achieve learning objectives, especially in vocational education. Vocational education is an educational program that aims to fulfill the requirements of the job market. . It will positively contribute to the world of productive work, producing goods and commodities with economic value. In the industry, currently, there is a boom in implementing the Industrial Revolution 4.0, which focuses on artificial intelligence. When it comes to electronic engineering vocational education students who practice in the industry, there are many complaints related to the need for more competency of these practitioners, especially in mastering intelligent control. The most frequent reason practitioners give is that the teaching obtained in schools and industry does not match in terms of subject matter and equipment [9]. There is a gap between the competence of students and the needs of human resources in the industry, so teachers must be more intense in providing subject matter according to what is in the industry. Teachers must also be smart in using media to present subject matter.

Several studies have been conducted on developing training kits or applying AI to students. Research conducted by Nahrowi *et al.* [10] on developing Atmega16 microcontroller training for vocational high schools shows a very feasible tool for improving the abilities of industrial electronics engineering study program students. The development of other learning media for social arithmetic media carried out by Murdianto *et al.* produced In-Math media, which is very feasible to be applied to the learning process [11]. Another example of AI media development carried out by Prabowo and Arifin [12] is the development of Arduino nano-based fuzzy logic control learning media in the intelligent control system practice course. This research produces fuzzy logic control learning media for improving students' learning abilities.

Based on the explanation above, to overcome the gap between electronics engineering students and the needs in industry, especially in the field of artificial intelligence, research is proposed to develop an embedded system training kit for artificial intelligence according to industrial needs. This training kit summarizes the intelligent system subject matter and discusses conventional control, fuzzy logic,

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Artificial Neural Network (ANN), and image processing. The training kit developed consists of training tools, a job sheet, and intelligent control subject based on observations. The designed training kit comprises several sensors, microcontrollers, and actuator components.

II. Literature Review

A. Embedded System

The embedded system is an information processing system embedded into a particular product [13]. This technology is becoming popular because it has several advantages [14, 15]. Computing components in this system have many kinds of microcontrollers that can be used according to specification requirements, such as ATmega ICs, Arduino ICs, Intel ICs, and so on [16]. The application of embedded systems that we often encounter is in cars, motorbikes, household electronic equipment, and airplanes. Embedded systems have the advantages of saving energy and costs, real-time timers, and multi-mode operation [17, 18]. The embedded system block diagram generally is shown in Fig. 1.

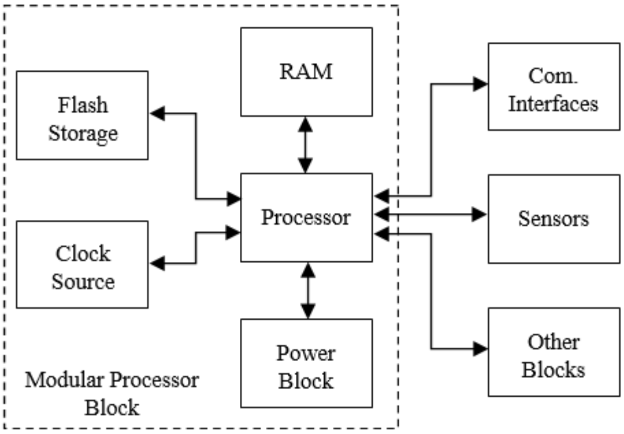

Fig. 1. Basic embedded system block diagram.

B. Artificial Intelligence Practicum

In this era of modern technology, various applications in sophisticated industrial fields utilize artificial intelligence technology [19]. Artificial intelligence is a computer or machine behavior that can mimic human behavior and ways of thinking in processing decision-making [12]. The various application branches of AI analyzed in this study are fuzzy logic, artificial neural networks, and image processing. This AI system is arranged in a media training kit to be applied in the practicum process [20, 21]. Using media during practicum can bring up a desire to learn and new interests, increase motivation, stimulate learning activities, and even psychologically influence students [22].

Fuzzy logic consists of sets that are an expansion of conventional set theory. Fuzzy logic is a logic set theory developed to overcome the concept of values between truth and false. The output result of the fuzzy logic is not always constant with the input on the system. Furthermore, the resulting fuzzy logic value is true (1) or not (0), and all possibilities are between 0 and 1. Fuzzy logic broadly consists of input, processing, and output [23].

Artificial Neural Network (ANN) is a type of computational science that carries out artificial intelligence learning processes. The ANN process uses certain calculation techniques to think, make the right decisions and take actions, like humans' thinking patterns. ANN components all have similarities to biological neural networks. ANN also consists of neurons, and there are connections between these neurons. The neuron will send the information it receives through its output connections to other neurons. This relationship has value (information) or is often known as weight.

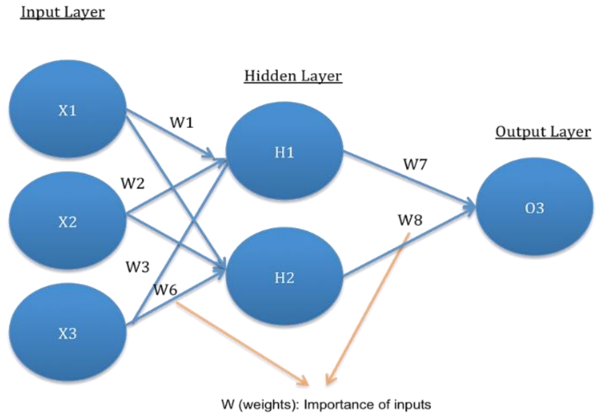

Fig. 2. ANN architecture.

Image processing involves using a technique to transform an input image into a different output image, through signal processing. There are various types of image processing in artificial intelligence, such as using Convolutional Neural Network (CNN) algorithms, utilizing frameworks (mediapipe, OpenCV, TensorFlow), etc. In this study, it focuses more on the use of the mediapipe framework for hand processing. This method is commonly used for image processing of hand gestures. The first process is palm detection, and the program can detect the presence of hands. The next process is precisely detecting 21 key points in the detected hand. The program will calculate the value of each key point, which will later be used as a basis for grouping the types of hand gestures the user wants to detect [24].

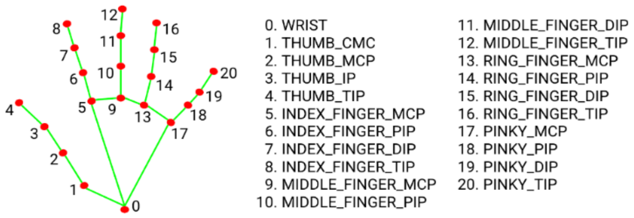

Fig. 3. Hands landmark mediapipe.

III. Research Method

The overall aim of this research is to produce a training kit for intelligent system practice so that it can overcome the competency gap between electronics engineering students and industry needs. Following the objectives, it uses the Research and Development (RnD) method with the ADDIE (analysis design, development, implementation, and evaluation) model [25]. Fig. 4 is a diagram of the development stages using the ADDIE model with several modifications to the flow according to research needs.

The first stage is analysis and the need for training development research, including observations/interviews related to problems in the field, research requirements, feasibility, and effectiveness. This needs analysis aims to obtain information for developing learning media for artificial intelligence training kits based on the industry's needs for AI materials. The second stage, design, is designing a framework carried out by each member based on a needs analysis. The design stages are determining subject matter specifications, mapping navigation structures, making sketch programs, hardware designs, job sheet designs, and packaging designs. The third stage is the development and implementation carried out by each member. The steps in this stage are product development, validation, testing (performance, feasibility, effectiveness), and revision. The last stage before producing the final product that the researcher carried out was evaluation. The researcher conducted a critical analysis of the developed training kit, which included measuring the achievement of product development, looking at the impact on learning, and measuring what had been achieved.

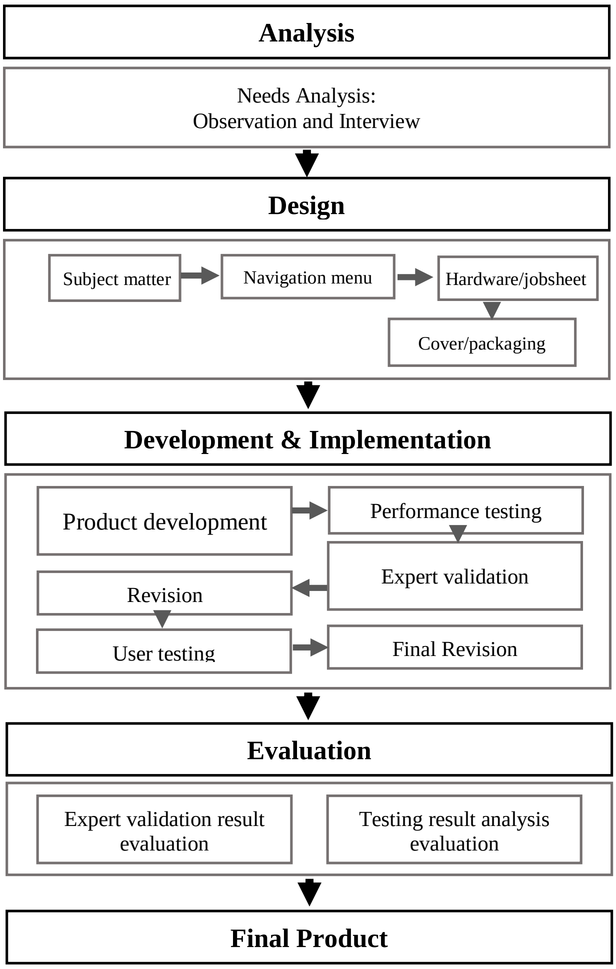

Fig. 4. Development stages.

A. Respondent of the Study

This study used lecturers from the Department of Electronics and Informatics Engineering, Faculty of Engineering, UNY, as validator instruments, media experts, and subject matter experts. The proportion of validator instruments is two lecturers, media experts, and material experts are one each lecturer. The training kit trial subjects were from the Department of Electronics and Informatics Education students. User tests on a small scale were carried out to test the instrument and on a large scale to test feasibility. Testing is carried out by students who have/are currently taking Intelligent Systems Practice or Artificial Intelligence Practice courses. Students first use the training kit device and then provide an assessment.

B. Research Instrument

Valid, accurate, and reliable data are obtained from research instruments. Validity and reliability are required for a questionnaire research instrument to be considered valid and trustworthy [26]. The stages of content validity and construct validity carried out the validity test. Content validity indicates a statement, task, or item in a test or instrument that can represent the overall and proportional behavior of the sample subject to the test [27, 28]. Calculation of item scores (X) and total scores (Y) to be able to find out whether each instrument item is valid or not Eq. (1). The correlation used in the inter-interval data relationship test is Pearson's (r) Product moment correlation.

$$r_{xy} = \frac{n\sum XY - \left(\sum X\right)\cdot\left(\sum Y\right)}{\sqrt{\left\{n\sum X^2 - \left(\sum X\right)^2\right\}\cdot\left\{n\left(\sum Y\right)^2\right\}}} \quad (1)$$

n: the number of data pairs X and Y

Reliability comes from the word reliable, which means to be trusted/reliable. The instrument is categorized as reliable if it is used several times to measure the same object and produces the same data. The reliability test was carried out by utilizing interval consistency centered on the items in the instrument [29], and testing used the Alpha-Cronbach technique. The following is the reliability test formula and the coefficient category with the Alpha Cronbach technique Eq. (2).

$$r_i = \left(\frac{k}{k-1}\right)\cdot\left(1 - \frac{\sum \partial_b^2}{\partial_t^2}\right) \quad (2)$$

r_i: Reliability

K: number of statement items

$\sum \partial_b^2$: number of grain variances

∂_t^2 : total variance

C. Training Kit Feasibility

Data were obtained using a statement questionnaire to get information on the feasibility of an artificial intelligence training kit based on an embedded system. Data processing is done by changing the answers from the questionnaire (qualitative data) into quantitative data [11]. Data conversion was carried out using the 5 Likert scale with provisions of very not good (1), not good (2), sufficient (3), good (4), and very good (5). The total score obtained is calculated in the form of a percentage with the formula:

$$\text{Percentage (\%)} = \frac{\text{total score obtained}}{\max(\text{total score})}\ 100\% \quad (3)$$

The results of the percentage show the feasibility level of the media training kit. Media is feasible if it has a minimum score of 61%. The feasibility scale is shown in Table 1.

Table 1. Feasibility scale

No	Feasibility Percentage	Category
1	0%–20%	Very unfeasible
2	21%–40%	Unfeasible
3	41%–60%	Sufficient
4	61%–80%	Feasible
5	81%–100%	Very feasible

D. Training Kit Effectiveness

Pretest is an initial test to determine how much students' skills and abilities understand the practicum. These results will then be compared with students' learning outcomes after treatment. The pretest was given to students, both in the experimental class and in the control class. After that, treatment was given to the experimental class. The treatment is using artificial intelligence training kits in intelligent systems practice courses. This treatment aims to determine the effectiveness of the media training kit developed [10]. The post-test was carried out to see an increase in learning outcomes in the intelligent systems practice course after being given treatment. Data is compared with the value achieved during the pre-test, whether the results achieved increase, are the same, or decrease. Data between the control and experimental classes were also compared to determine the effect of the media [30].

IV. Results and Discussion

A. Training Kit System Design

Input from this training kit system uses several sensors based on curriculum requirements. According to the switch instructions, the sensor sends a signal to the main microcontroller or Arduino. Initially, the main microcontroller used was the ATmega 1284p type. After the revision stage, making the ESP32 board the main microcontroller. This change is intended so the system can process images from the SD Card. Meanwhile, Arduino is used to process fuzzy logic programs, ANN, or image processing results programmed with a PC using serial pins. An overview of the training kit system block diagram is shown in Fig. 5.

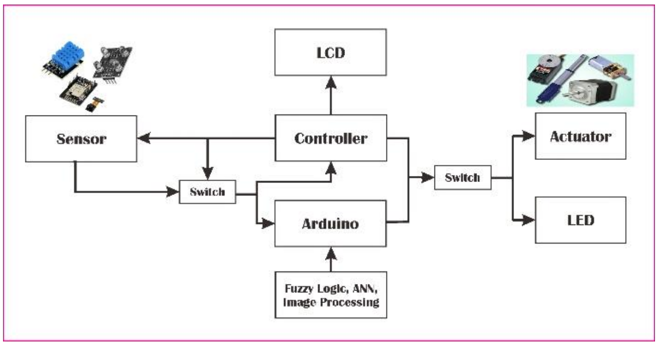

Fig. 5. System block diagram.

Based on the system design and subject matter, a menu was created to facilitate navigation of the subject matter when operating this embedded system-based training kit. The design is a chart and is the basis for making sketches of learning media programs. The subject topic of the discussion consists of fuzzy logic, artificial neural networks, and image processing. The subject matter of this discussion has been divided into eight main menus so that the menus on the training tools are more organized. The main menu is divided into sub-menus in the form of subject matter practicum objectives, circuit schematics, and simulations. The types of subject matter presented on each menu are different. To find out more complex subject matter menu designs, here is a training kit menu navigation flowchart:

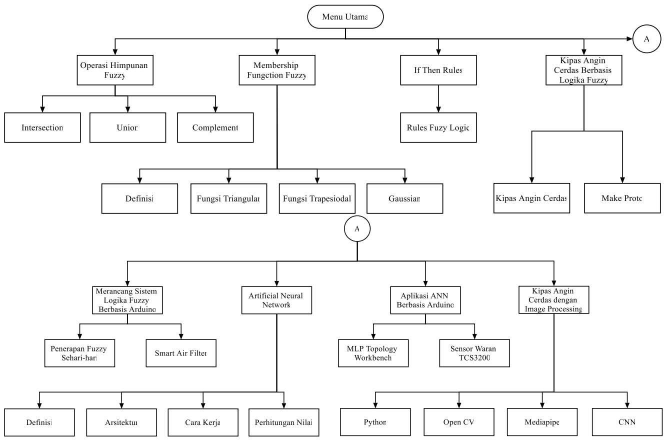

Fig. 6. Navigation menu flowchart.

B. Hardware Design

The training kit consists of two parts, the control block and the assembly block. The control block is a place to control the resources of sensors, actuators and contain discussion subject matter. The assembly block is a place for assembling sensors, Arduino UNO, and output components. The training kit is designed to use 12V DC power, including a power supply adapter, so that the input power can use AC 220, 110, or 12V DC power supply. The layout design for the artificial intelligence hardware training kit can be seen in Fig. 7.

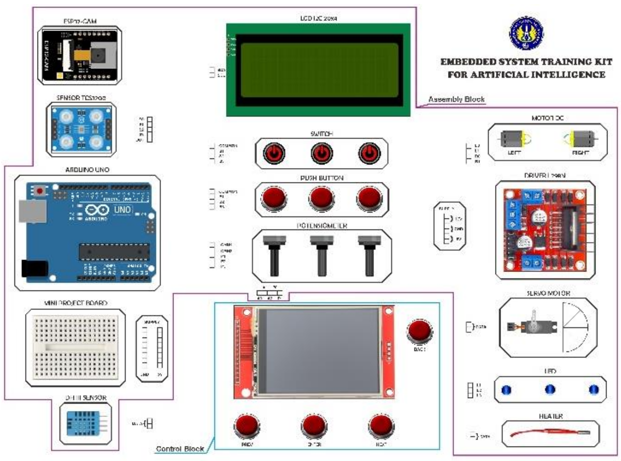

Fig. 7. Training kit layout.

The assembly block of the artificial intelligence training kit was developed using several inputs, namely DHT11 temperature and humidity sensors, TCS3200 color sensors, and ESP32-CAM. There are also buttons, switches, and potentiometers that can be used as inputs. Arduino UNO is a microcontroller that will conduct ANN training and process fuzzy logic training results from Matlab. ESP32-CAM is based on IoT to capture images, process them, and send them to a PC.

The control block in the training kit contains subject matter with instructions for students to practice artificial intelligence. The firmware on the control block is designed based on the flowchart in Fig. 6. This block also controls each sensor's power supply, thereby reducing string errors. Thin film transistor liquid crystal display (TFT LCD) is used to improve the display quality of this embedded system. Navigation is achieved using four buttons: previous, enter, next, and back. . The microcontroller used for the brain training kit system is the ESP32 Board which has memory and pin specifications according to the designed software and hardware.

C. Smart Fan Based on Fuzzy Logic

Some fuzzy logic practicum jobs are contained in the training kit, one of which is the smart fan project. This practicum uses temperature and humidity input variables by utilizing the DHT11 sensor. The fuzzy logic system is designed using MATLAB to make the design graphics more visible, then converted using the website Make Proto into Arduino files (.ino). The conversion results are adjusted to the hardware input and output requirements. The smart fan block diagram is shown in Fig. 8.

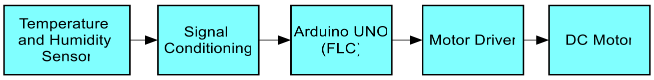

Fig. 8. Smart fan block diagram.

The input from the DHT11 sensor enters Arduino through the signal processing stage. Arduino, programmed with Fuzzy Logic Control (FLC), sends an output signal to the motor, and the LCDs the resulting value. The FLC system is developed using MATLAB with a flexible input range of temperature (22 ℃–35 ℃) and humidity (40RH–95RH). The system generates output Pulse Width Modulation (PWM) values ranging from 0 to 255. The rules are made with nine rules using the AND operator, as shown in Fig. 9.

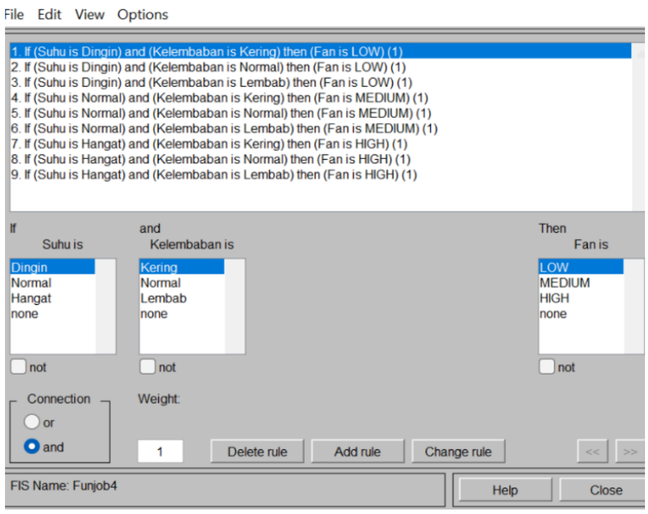

Fig. 9. Smart Fan Rule

Researchers and practicing students who produced a unified system completed the FLC design process. The system was tested using a heater to increase the temperature and a humidifier to increase the humidity. The data displayed by the LCD is then entered in Table 2 and compared with fuzzy reasoning in MATLAB.

Table 2. Smart fan test results

No	Temp. (℃)	Humidity (RH)	Output (PWM) Arduino	Output (PWM) MATLAB	Voltage (V)
1	23.40	60.00	38.18	38	0.75
2	23.40	59.00	39.29	39.3	0.77
3	24.80	60.00	91.28	91	1.79
4	25.30	59.00	106.65	107	2.09
5	26.20	58.00	118.97	119	2.33
6	29.80	52.00	150.74	151	2.96
7	30.80	47.00	198.67	198	3.90
8	31.30	46.00	218.76	219	4.29
9	31.60	45.00	220.02	220	4.31
10	34.20	41.00	220.14	222	4.32

The result of testing the smart fan based on fuzzy logic matches the values that appear on the LCD and MATLAB fuzzy reasoning. Values for temperature and humidity according to conditions in the field. Output results follow the fan speed indicator that has been designed. The comparison of the two PWM values provides a similar difference between the Arduino and MATLAB. The analog output value is based on the Arduino PWM output divided by 255 times 5 Volts.

D. ANN Application Using Arduino

Artificial Neural Network (ANN) is one type of artificial intelligence algorithm in this training kit. There are several ANN practicums, one of which is system training for practicum predicting colors using the TCS3200 sensor. The color is detected through the use of a sensor that is integrated with the programmed Arduino UNO. The results of this reading will appear on the serial monitor, and then the data will be labeled according to the color that is read. Examples of colors that are predicted are yellow, cyan, green, magenta, and white. The dataset taken is a little, only about 4 data for each color because this system is simple and considers training time. The value in the RAW data column results from reading the TCS3200 sensor with color intensity (red, green, blue). These results are then trained using the MLP Topology Workbench website.

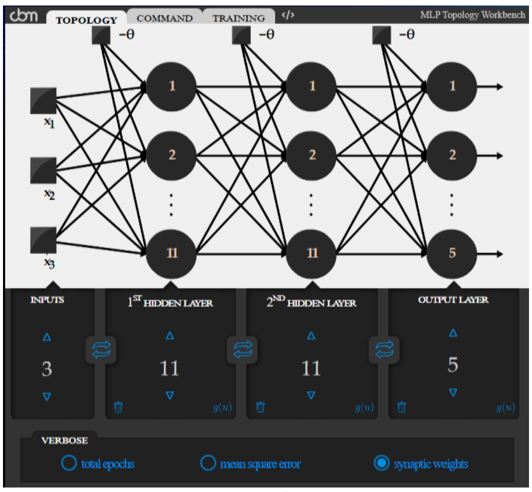

Fig. 10. ANN model for color training.

The ANN model uses 3 input layers, 11 hidden layer 1 and hidden layer 2, and 5 output layers. The ANN system is then inserted with a dataset that has been made, and then training is carried out. The results of the training can be seen in Fig. 11.

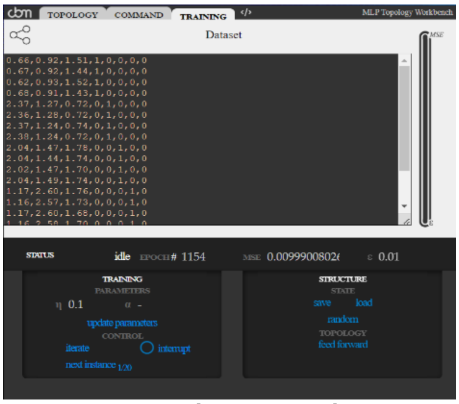

Fig. 11. Color training results.

Color training uses 20 data, 4 for each color, using 1154 epochs or batch training times. The Mean Square Error (MSE) value of 0.00999 is close to 0, so the probability of system error is minimal. The results of this training are in the form of a specific value and then entered the programmed Arduino UNO. The system was tested using a color reading engine, as shown in Table 3.

Table 3. Color prediction based on ANN test results

No	Color Paper	Prediction Result	Accuracy
1	White	White	100%
2	Yellow	Yellow	100%
3	Green	Green	100%
4	Magenta	Magenta	100%
5	Cyan	Cyan	100%
6	Blue	Cyan	0%
7	Red	Magenta	0%

The color prediction system that has been designed successfully predicts color. The experiment was carried out by trying five colors with 100% accurate results on the colors that had been trained. Two colors were added during the testing process, blue and red, but the results were 0% accurate. Based on this experiment, it can be concluded that the system can predict according to the color that has been trained.

E. Image Processing Application

Image processing is a type of AI with various processing models such as Convolutional Neural Network (CNN), the mediapipe framework, etc. The practicum in the artificial intelligence training kit utilizes the mediapipe framework with Python. Data using computer vision can come from a programmed ESP32-CAM or laptop webcam. The video data is then read in Python, using Python IDLE or Visual Studio software. Reading results were sent to Arduino UNO to process the fan. After the system can run, it is tested, and the results are shown in Table 4. For example, hand gesture 3 produces a fan speed of 153, shown in Fig. 12.

Table 4. Image processing test result

No	Value	PWM Output
1	0	0
2	1	51
3	2	102
4	3	153
5	4	204
6	5	255

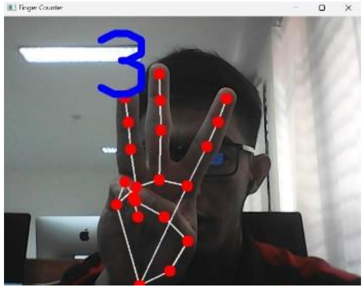

Fig. 12. Image processing testing.

Images processed on fan control based on image processing use the mediapipe framework in Python. The practitioner only needs to give a hand gesture and read it through the camera as in the experiment. Arduino then converts the results of hand gestures to produce PWM values. It can be concluded that this image-processing system operates optimally.

F. Performance Testing

The performance test is the process of testing the ability of the artificial intelligence training kit that has been developed. The performance consists of testing the tool components and displaying the training kit menus. The results of the practicum program have been described previously. The test results of the tool components are shown in Table 5.

Table 5. Component test result

No	Component	Competence	Result	Information
1	ESP32	Firmware installed	Succeed	Firmware designed with Arduino IDE
2	ESP32	Follow pin instruction	Succeed	Pin successfully performs an instruction
3	ESP32	System Mainboard	Succeed	The system operates optimally
4	ESP32-CAM	Record video	Succeed	The data read is in the form of a video
5	ESP32-CAM	Send image	Succeed	Data sent by utilizing IP
6	Arduino	Firmware installed	Succeed	Practicum firmware, Fuzzy design results, and ANN results
7	LCD Caracter	Display character	Succeed	According to program instructions
8	LCD TFT	Display content, pictures, etc.	Succeed	The LCDs instructions from the ESP32 clearly
9	Sensor DHT11	Read temperature and humidity	Succeed	The reading results are appropriate
10	Color Sensor	Read color	Succeed	RGB color values read with Arduino
11	Motor	Rotated	Succeed	Motor with LM298N driver rotates left/right
12	Heater	Heat	Succeed, Overheat	The 12V voltage makes the heater overheat and changed to 5V
13	LED	Light up	Succeed	LED hidup sesuai instruksi program
14	Power Supply	Supplying	Succeed	Adaptor power supply 12V
15	IC Regulator 7805	Regulating voltage 5V	Changed	Output 5V worked but overheated (up to 120 ℃)
16	Step Down LM2596	Regulating voltage 5V	Succeed	Generates 5V

Based on the testing of the artificial intelligence performance training kit, it appears that the system was able to function at its best. . 1805 regulator IC also underwent replacement due to overheating; it could affect other components. Overall, almost all components of the training kit have successfully operated according to the achievement indicators.

Focusing on the training kit control section, the software system's performance is tested by trying every menu entered in the ESP32. Several times the sketch was changed to maximize the results of the product menu display. This testing process is based on a system flowchart previously designed. All programming results with the Arduino IDE successfully display menus and sub-menus on the TFT LCD. The results displayed are in the form of characters, images, and/or animated images.

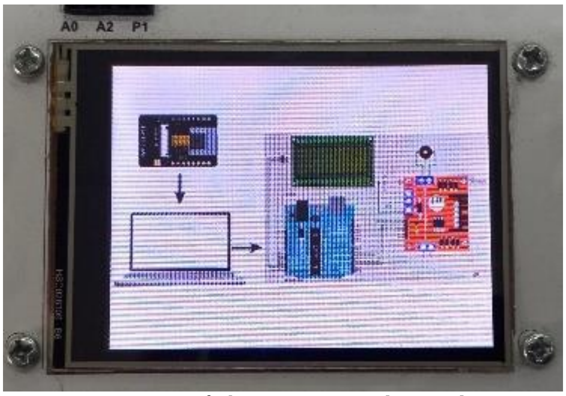

Fig. 13. One of The TFT LCD Display Results.

G. Instrument Testing

Instrument testing consisted of validity and reliability tests obtained from respondents. Respondents first used the training kit in the intelligent system practice course and artificial intelligence practice. Classes that provide assessments are Class A1 of Electronics Engineering Education Study Program/2021, Information Technology Study Program/2020, and several students from other classes who meet the criteria. A summary of the test results from 28 respondents so that the validity value of each instrument item is shown in Table 6.

Table 6. Instrument validation from respondent

Item Number	Total Score	Pearson (R_{xy})	Validity
1	119	0.677	Valid
2	116	0.710	Valid
3	116	0.557	Valid
4	123	0.475	Valid
5	112	0.380	Valid
6	117	0.571	Valid
7	115	0.440	Valid
8	115	0.733	Valid
9	115	0.762	Valid
10	117	0.722	Valid
11	120	0.435	Valid
12	118	0.793	Valid
13	116	0.518	Valid
14	121	0.727	Valid
15	115	0.651	Valid
16	114	0.757	Valid
17	111	0.650	Valid
18	115	0.785	Valid
19	116	0.677	Valid
20	113	0.775	Valid
21	116	0.754	Valid
22	118	0.828	Valid
23	116	0.606	Valid
24	119	0.621	Valid
25	116	0.769	Valid
26	115	0.721	Valid
27	118	0.689	Valid
28	118	0.650	Valid
29	116	0.720	Valid
30	114	0.554	Valid
31	116	0.726	Valid

Twenty-eight respondents did instrument testing so that the Pearson value (r table) with a significance level of 5% is 0.317 [31]. All 31 instrument items indicated a Pearson value of more than 0.317, so they were declared valid. These results show that all instrument items can already be used for due diligence. Furthermore, reliability testing is carried out so that the instrument can be trusted (reliable). The reliability calculation obtained is:

$$r_i = \left(\frac{25}{25-1}\right)\cdot\left(1-\frac{9.802}{131.3}\right) = 0.96$$

The instrument reliability test for 28 respondents obtained a r_i result of 0.96. Based on the reliability coefficient category table, the test is included in the very high reliability (0.8–1.00). The validity and reliability tests showed that the instrument was ready to be used to evaluate training kits on a large scale.

H. Expert Judgment

Expert judgment is carried out by subject matter experts and media experts. The aspects validated by subject matter experts were learning and content, while media experts were operation and appearance. The instrument data collection model used a questionnaire with a Likert scale 5. Data on the summary of expert judgment can be seen in Table 7.

Table 7. Expert Judgement Result

Expert	Aspect	Amount Score	Mean	Percentage
Subject Matter	Learning	38	4.22	84.44%
	Content	54	4.15	83.08%
	Total	92	4.18	83.64%
Media	Operation	51	4.25	85%
	Appearance	53	4.42	88.33%
	Total	104	4.33	86.67%

The subject matter expert's judgment concluded aspect of learning had 84.44%, and the content aspect had 83.08%, so the total percentage had 83.64%. The Media expert's judgment of the operation aspect is 85.00%, and the display aspect is 88.33%. Media expert's average percentage is 86.67%. According to the rating scale described in the research method, the results of subject matter experts and media experts are included in the Very Feasible category.

I. Feasibility Testing

Subjects who tried this media were students majoring in electronics and informatics engineering education at FT-

UNY who had/are taking intelligent systems practice engineering courses. A total of 38 respondents filled out this assessment questionnaire. These respondents came from classes A1 and A3 of the 2021 Electronics Engineering Education Study Program. Students filled out an assessment form with four aspects: learning, subject matter content, operation, and the appearance of the training kit. The summary of the user test is obtained, as shown in Table 8.

Table 8. Feasibility testing result

No	Aspect	Total Score	Percentage	Category
1	Learning	359	84.81%	Very feasible
2	Content	423	83.46%	Very feasible
3	Operation	429	81.88%	Very feasible
4	Appearance	574	83.26%	Very feasible
	Overall Score	1785	83.35%	Very feasible

The test results of the respondents above show that the percentage of feasibility in the learning aspect is 84.81% which is the greatest value, the content aspect is 83.46%, the operation is 81.88%, and the display is 83.26%. So, it was concluded that the mean percentage was 83.35%. According to the rating scale on the research method, the training kit from the test results of the respondents is included in the Very Feasible category.

J. Effectivities Testing

Test the effectiveness of the artificial intelligence training kit using multiple choice questions whose stages consist of a pre-test, treatment for the experimental class (artificial intelligence training kit), and post-test. The tested classes were A1 as the experimental class and A3 as the control class in the 2021 Electronic Engineering Education Study Program, FT UNY. Table 9 shows the results of the pre-test and post-test for the experimental class and the control class.

Table 9. Pre-test and post-test result

Experiment Class			Control Class		
Student	Pre-Test	Post-Test	Student	Pre-Test	Post-Test
1	38.89	94.44	1	38.39	72.22
2	27.78	88.89	2	33.34	72.22
3	38.89	94.44	3	27.78	83.33
4	11.11	77.78	4	16.67	83.33
5	38.89	83.33	5	33.34	83.33
6	22.22	88.89	6	27.78	61.11
7	16.67	88.89	7	22.22	77.78
8	16.67	100	8	38.89	77.78
9	11.11	77.78	9	27.78	77.78
10	38.89	100	10	44.44	72.22
11	55.56	100	11	33.34	55.56
12	16.67	94.44	12	22.22	83.33
13	27.78	77.78	13	44.44	83.33
14	38.89	100	14	22.22	66.67
15	22.22	72.22	15	38.89	83.33
16	22.22	94.44	16	33.34	88.89
Total	444.46	1433.3	Total	505.08	1222.2
Mean	27.78	89.58	Mean	31.57	76.39

There were 32 respondents to the effectiveness test, with 16 students in each class. The total pre-test score for the experimental class was 444.46, with an average of 27.78, and a post-test of 1433.32, with an average of 89.58. The total pre-test value for the control class was 505.08, with an average of 31.57, and the post-test was 1222.2, with an average of 76.39. From these results with the t-test, there was an increase in students' abilities and knowledge in both classes in terms of increasing test results. The mean difference in the experimental class was 61.80, and the difference in the control class was 44.82, so the results of the experimental class were more effective than the control class.

V. CONCLUSIONS AND RECOMMENDATIONS

Research that has been done produces an artificial intelligence training kit based on embedded systems with dimensions of 35cm × 25cm × 7 cm. Performance test shows results that follow the theory marked by the acquisition of accurate experimental data. Performance results by testing the functionality show that the average component successfully works according to competence. Even though some didn't work, it was resolved by replacing the appropriate components. The performance testing results of the training kit menu also provide a display that matches the indicators and is legible regarding objectives, materials, circuit schematics, and the simulation process.

The feasibility level of the artificial intelligence training kit based on an embedded system is categorized as very feasible by the validation results of subject experts, media experts, and users. Subject matter experts provide validation based on learning aspects and content with a percentage of 83.64%. Media experts provide validation by evaluating aspects of the operation and appearance of the media resulting in a percentage of 86.67%. User test results which include learning aspects, content, operation, and display, obtain a feasibility percentage of 83.345%.

Results of the parametric t-test (paired sample t-test and independent sample t-test) indicate an increase in learning outcomes between the experimental and control classes. The difference using paired sample t-test in the experimental class was 61.80, and in the control class was 44.82. The paired sample t-values for the pre-test and post-test of the experimental class are higher, so the experimental class is more effective than the control class. The mean value using an independent sample t-test (post-test) for the experimental class was 89.58 and 76.39 for the control class. Based on the t-test, it can be concluded that the artificial intelligence training kit is more effectively applied to the practicum process.

The Artificial intelligence training kit based on embedded systems needs to be further developed to adapt to technological developments. Training kits can be more tailored to the needs of the electronics or artificial intelligence industry. Electronic components such as sensors, displays, and actuators can also be added. This addition is adjusted to the worksheet which wants to use during the practicum process.

CONFLICT OF INTEREST

The author declares no conflict of interest.

AUTHOR CONTRIBUTIONS

Wahyu Ramadhani Gusti conducted the research, designed the system, collected and analyzed the data, and wrote the paper. Fatchul Arifin validated the system design, the instruments needed for needs analysis, and assessment questionnaires. All authors had approved the final version.

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