



Original Article

Comparison Analysis of the Effectiveness of Three Microcontroller Practicum Media (Trainer-Box, Simulation Software, and Breadboard Hands-On) at SMK Negeri 1 Sentani

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Abstract:

Microcontroller practicum learning in Vocational High Schools (SMK) requires effective media to help students understand both concepts and practical skills optimally. This study aims to analyze the comparison of the effectiveness of three microcontroller practicum media, namely trainer-box, simulation software, and breadboard hands-on, in improving student learning outcomes. The research was conducted using a quasi-experimental method on 14 students from class XI at SMK Negeri 1 Sentani, majoring in Industrial Electronics. The instruments used were a pretest and posttest consisting of 20 multiple-choice questions, along with a student satisfaction questionnaire with 12 Likert scale questions. The analysis results show that the average pretest score of 52.143 increased to 71.786 in the posttest. The N-Gain calculation resulted in a value of 0.41, which falls into the moderate category, indicating that the use of all three media was effective in improving student learning outcomes. Based on the questionnaire results, student responses to the practicum media varied. The trainer-box received the highest average score (4.43, categorized as very high), followed by the breadboard hands-on (4.14, categorized as high), and lastly, the simulation software (3.36, categorized as moderate).

Keywords: microcontroller, trainer-box, simulation software, breadboard hands-on.

Introduction

SMK Negeri 1 Sentani is a vocational school established in 1999 and has been accredited with a B grade. The school implements the Merdeka curriculum, focusing on technology and engineering fields. As of 2024, SMK Negeri 1 Sentani employs 58 teachers and has a total of 830 students. The school also provides 30 classrooms and 10 laboratories. Furthermore, various practicum devices are available to support the learning process (Kemdikbud, 2024).



<https://jurnal.usk.ac.id/riwayat>

One of the vocational programs at SMK Negeri 1 Sentani is industrial electronics. Students' competencies in this field heavily rely on the development of microcontroller control systems. As a result, the school plans to enhance these competencies by acquiring practicum devices. There are three available practicum media options: training-box, simulation software, and breadboard hands-on.

The development of microcontroller-related learning at SMK Negeri 1 Sentani is still a relatively new concept; however, the teaching staff lacks sufficient foundational knowledge. Therefore, the selected practicum media must be easy to learn, apply, and teach to students. Additionally, by 2024, student proficiency in using microcontrollers will be evaluated as part of graduation requirements.

Based on the background above, this research aims to determine the most effective practicum media based on the needs and challenges faced by SMK Negeri 1 Sentani. This goal will produce research outputs such as the final research report, related practicum devices, and a national journal publication.

B. Research Objectives and Benefits

a. Research Objectives

The objectives of this research are:

1. To develop the three microcontroller practicum media—training-box, simulation software, and breadboard hands-on—according to the needs of the industrial electronics vocational program at SMK Negeri 1 Sentani.
2. To determine the most effective practicum media based on the fulfillment of microcontroller competencies by both teachers and students at SMK Negeri 1 Sentani.

b. Research Benefits

The benefits of this research are:

1. This research can be used as an evaluation tool for teachers at SMK Negeri 1 Sentani to determine the most effective practicum media to use.
2. This research can serve as a study for teaching, particularly in the courses of Microcontroller Systems and Human-Computer Interaction in the field of Electrical Engineering.

Methods

This study employs a qualitative research design, specifically utilizing a library research approach to explore the role of andragogical strategies in enhancing lifelong learning within community education settings. Qualitative research is well-suited for this study as it allows for an in-depth understanding of complex, context-specific educational phenomena and provides rich, detailed insights into adult learning processes (Creswell & Poth, 2018). Library research, as a specific type of qualitative research, focuses on collecting and analyzing existing literature, including academic journal articles, books, reports, and other scholarly documents, to build a comprehensive understanding of the chosen topic (George, 2008). This approach is particularly appropriate for synthesizing theoretical frameworks and empirical findings related to andragogy and lifelong learning.

Data Sources

A. Research Location and Time

The research (data collection) was conducted from August to September 2025 at SMK Negeri 1 Sentani.

B. Research Sample

The study involved 14 students from class XI of the Industrial Electronics program as research subjects. All of these students were selected as respondents due to their relatively small number, which allows for a comprehensive analysis. Therefore, the sampling technique used was saturated sampling (total sampling), where the entire population is considered as the research sample (Sugiyono, 2019).

Data Collection Methods

Type of Research

This research was conducted using a quasi-experimental method. The choice of this method was based on the consideration that it would be carried out in a real classroom situation, where the researcher divided students into two large groups. All students participated in learning using the three media (trainer-box, simulation software, and breadboard hands-on). The quasi-experimental method was chosen because it still allows the researcher to compare conditions before and after the study through pretests and posttests, making it possible to measure the effectiveness of the learning objectively.

Data Analysis Techniques

The data analysis techniques used are as follows:

1. Test Data Analysis (Pretest and Posttest)
 - Calculate the average pretest and posttest scores.
 - Calculate the N-Gain for each student using the formula.
 - Determine the improvement category.
2. Questionnaire Data Analysis
 - Calculate the average score for each item in the questionnaire.
 - Convert the results into categories.

Results

The research was conducted at SMK Negeri 1 Technology and Engineering Sentani, class XI of Industrial Electronics Department. The research was conducted in stages. In August, interviews were conducted with teachers about the students' conditions and backgrounds, as well as the learning methods that had been implemented, especially in terms of microcontroller learning. Furthermore, on September 10, 2025, learning activities were carried out with the research team and data collection was carried out from 14 students, in the form of pretest, posttest, and questionnaire results.

A. Pretest and Posttest Results

1. Initial Data Presentation (Pretest-Posttest)

In the initial phase of the research, students were given a pretest to assess their abilities before using the learning media. After the learning activities and practical work, students were given a posttest to measure improvements in learning outcomes.

A comparison graph of the pretest and posttest results for each student can be seen in Figure 4.1.

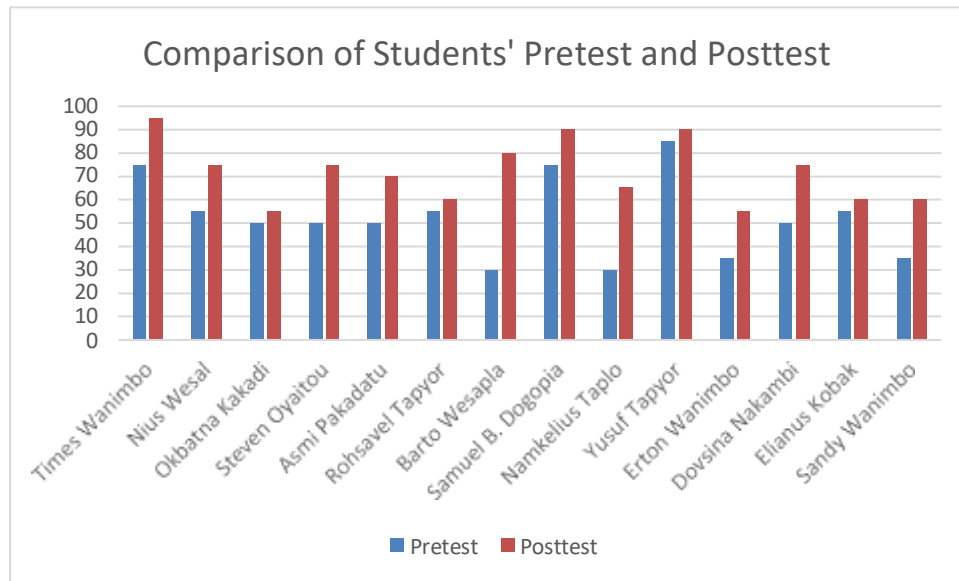


Figure 4.1 Comparison Graph of Students' Pretest and Posttest Results

2. Average of Pretest and Posttest

The calculation results showed an average pretest score of 52.143 and an average posttest score of 71.786. This showed an average increase of 19.643 after treatment.

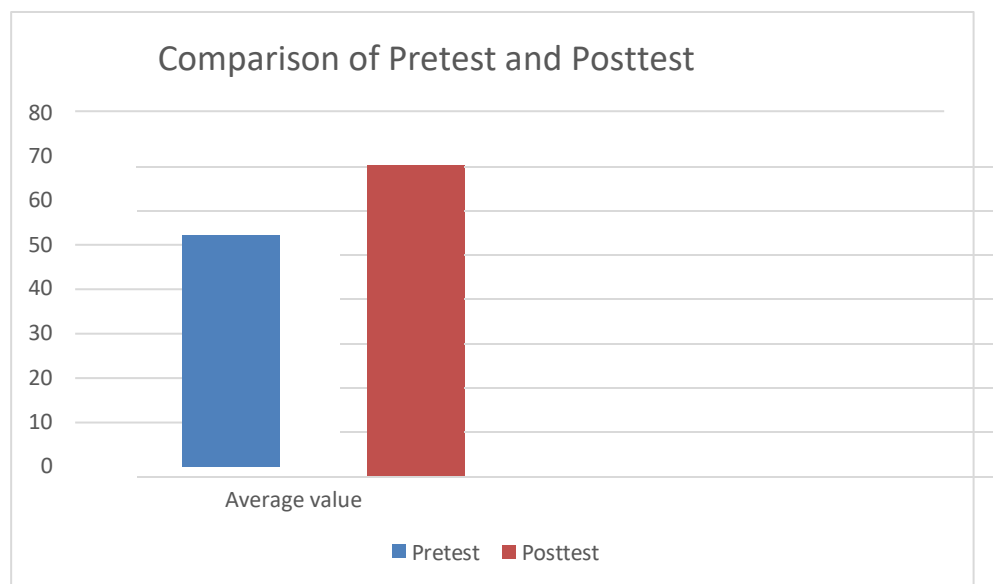


Figure 4.2 Comparison Graph of Pretest and Posttest Averages

3. Calculation of N-Gain per Student

To determine the extent of improvement in learning outcomes more objectively, the N-Gain formula is used. The N-Gain value is calculated based on each student's score using formula 2.1.

The results of the N-Gain calculation per student can be seen in Table 4.1. Table 4.1 Results of the pretest, posttest, N-Gain and categories per student

Student	Pretest	Posttest	Post-Pre	Max-Pre	N-Gain	Category
1	75	95	20	25	0.8	Tall
2	55	75	20	45	0.44	Currently
3	50	55	5	50	0.1	Low
4	50	75	25	50	0.5	Currently
5	50	70	20	50	0.4	Currently
6	55	60	5	45	0.11	Low
7	30	80	50	70	0.71	Tall
8	75	90	15	25	0.6	Currently
9	30	65	35	70	0.5	Currently
10	85	90	5	15	0.33	Currently
11	35	55	20	65	0.31	Currently
12	50	75	25	50	0.5	Currently
13	55	60	5	45	0.11	Low
14	35	60	25	65	0.38	Currently
Average	52,143	71,786	19,643	47,857	0.410	Currently

The table shows that all students experienced an increase in scores from the pretest to the posttest. Two students fell into the high category ($g > 0.7$), nine into the medium category ($0.3 \leq g \leq 0.7$), and three into the low category ($g < 0.3$).

4. Average N-Gain Result

After calculating the N-Gain for each student, the average N-Gain value was 0.41, which, according to Hake's (1999) criteria, falls into the moderate category. This indicates that the use of the learning media implemented in the study was able to improve student learning outcomes after participating in the lesson, although it did not reach the high category. Factors such as limited time for the practicum, the availability of facilities, and differences in students' initial abilities could contribute to the less than optimal improvement in learning outcomes.

B. Questionnaire Data Analysis

A questionnaire was administered to determine students' responses to the practicum media. The instrument consisted of 12 questions with a Likert scale of 1-5, grouped into four main aspects: media and learning (items 1-3), practicum media (items 4-7), practicum process (items 8-10), and general satisfaction (items 11-12). The results of the entire questionnaire can be seen in Table 4.2.

Table 4.2. Table of each student's answers to each questionnaire question

Student	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
1	3	5	5	4	2	5	4	4	4	5	5	5
2	5	4	3	5	1	4	4	3	4	3	4	4
3	5	5	5	5	5	5	5	4	5	5	5	5
4	4	3	4	5	5	5	4	3	4	5	5	5

5	5	5	5	5	5	5	5	5	5	5	5	5
6	5	4	4	4	5	3	4	5	3	4	4	5
7	5	5	3	5	3	5	5	5	4	4	5	5
8	3	4	4	5	4	4	4	3	4	5	4	5
9	1	3	2	3	3	2	2	3	2	4	3	4
10	5	5	4	4	3	5	4	3	5	3	5	5
11	5	3	1	3	1	1	5	2	2	4	1	4
12	1	5	3	4	3	5	5	5	5	3	5	4
13	4	5	4	5	3	4	4	5	5	4	4	4
14	5	5	5	5	4	5	5	5	5	5	5	5
Average	4	4.36	3.71	4.33	3.36	4.1	4.29	3.93	4.07	4.2	4.3	4.64

From the table, we can see that the answers vary from each student and from the answer choices (scale 1 – 5).

Based on the overall answers to the questionnaire, an average score for each question can be calculated. The average student response to the use of practical media can be seen in Table 4.3.

Table 4.3. Average value per question item and its category

No	Statement	Average	Category
1	Easy to understand material	4.00	Tall
2	The practical assignment is clear	4.36	Very high
3	Easy to follow work instructions	3.71	Tall
4	Trainer-box makes it easier to understand the circuit	4.43	Very high
5	Simulation software helps visualize	3.36	Currently
6	Breadboards hands-on skills training	4.14	Tall
7	Equipment in good condition	4.29	Very high
8	Sufficient practical time	3.93	Tall
9	The teacher's explanation helps	4.07	Tall
10	The practicum went smoothly	4.21	Very high
11	I am satisfied with the results of the practicum	4.29	Very high
12	Recommend this method	4.64	Very high

Based on the results of the student satisfaction questionnaire, the average scores were generally in the high to very high category. This indicates that students responded positively to the microcontroller practicum.

If viewed from the practical media aspect, it can be made into a graph like Figure 4.3.

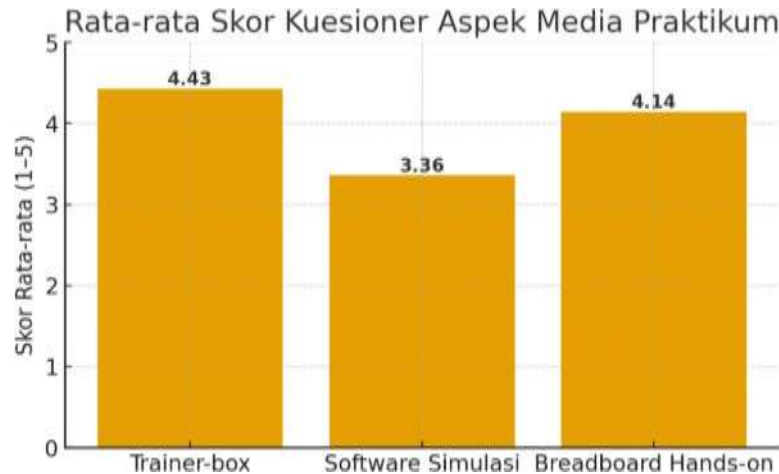


Figure 4.3 Graph of the average scores of the questionnaire for the practical media aspect. Based on this graph, it can be explained as follows:

- Trainer-box achieved an average score of 4.43, which is considered very high. This indicates that most students felt that Trainer-box was very helpful in directly understanding microcontroller circuit concepts. The real-world interaction with the hardware made this medium the most effective, according to students.
- The hands-on breadboard achieved an average score of 4.14, in the high category. This tool was deemed effective in developing students' technical skills in assembling circuits, although some students encountered technical difficulties, such as the circuit coming apart easily or requiring more time to assemble.
- The simulation software received an average score of 3.36, which is in the moderate category. While simulations make it easier to visualize circuit operation and reduce the risk of technical errors, students considered this tool to be less hands-on, thus lowering its effectiveness compared to trainer-boxes and breadboards.

By combining the test and questionnaire results, it can be concluded that learning microcontroller practicum using a combination of the three media can improve student learning outcomes (moderate category based on N-Gain). From the perspective of student perception, trainer-box is the most effective media, followed by breadboard hands-on, while simulation software is seen as the least effective compared to the other two media.

When compared with previous research, these results align with Syahputra's (2020) findings, which showed that using a microcontroller trainer box was more effective in improving learning outcomes than learning without media. Research by Mangesa et al. (2023) also supports this finding, where the use of trainer media in practical learning was shown to significantly improve student skills. This confirms that students value real-device-based media (trainer boxes) more because they provide hands-on experience.

However, the effectiveness of learning in this study was still influenced by several factors. Limited time for the practicum prevented students from having sufficient opportunity to explore all media in depth. The limited number of practicum tools forced some students to share, thus reducing the intensity of the practical experience. Students' preference for real-world practice over computer simulations also influenced the questionnaire results, where trainer-box and breadboard hands-on were rated more positively than simulation software. These findings indicate that direct experience with

real devices is preferred by students, although simulations still function as a supporting medium for understanding basic concepts.

Conclusion

From the research results, the following conclusions can be drawn:

1. There was an increase in student learning outcomes after using the three media (N-Gain= 0.41 medium category).
2. Based on the questionnaire, the most effective trainer-box (4.43 falls into the very high category), breadboard hands-on (1.44 falls into the high category), and simulation software (3.36 falls into the medium category).
3. Overall, the combination of the three media is effective, but the trainer-box is more recommended for practical learning of microcontrollers in vocational schools.

Suggestion

From the research results, the following suggestions can be made:

1. Teachers can use trainer-box as the main media, simulation as support, and breadboard as skill reinforcement.
2. Further research could involve a larger number of students, other media variations, and statistical significance tests.

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