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Improving Students Skills in Assembling Electronic Circuits Through an Experiment-Based Problem-Solving Learning Model

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Abstract

Vocational education is the main key to improving student competencies that are in accordance with the needs of the workplace. However, learning activities in the subject of Basic Electronics require effective learning strategies that engage students in solving real-world problems. Therefore, this study aims to improve student learning outcomes through the implementation of a problem-solving learning model in the subject of Basic Electronics at SMK Negeri 5 Banda Aceh. This study used a Classroom Action Research design consisting of two cycles. The research participants were 15 students of grade XI with a test sheet instrument, which was used to measure student learning outcomes after the implementation of the treatment in learning. The results showed that there was an increase in student learning outcomes with the percentage of students achieving the Minimum Mastery Criteria (KKM) with an average score of 79% in Cycle I and increasing to 87.6% in Cycle II. The results of the study showed a significant change in student performance. This indicates that the application of the problem-solving learning model can be an effective alternative to increase active student participation and encourage the achievement of better learning outcomes in learning Basic Electronics and other productive subjects.

Keywords: *Basic Electronics, Learning Outcomes, Problem Solving.*

Abstrak

Pendidikan vokasi merupakan kunci utama meningkatkan kompetensi siswa yang sesuai dengan kebutuhan dunia kerja. Namun, kegiatan pembelajaran dalam mata pelajaran Elektronika Dasar membutuhkan strategi pembelajaran yang efektif melibatkan siswa dalam memecahkan masalah dunia nyata. Oleh karena itu, penelitian ini bertujuan untuk meningkatkan hasil belajar siswa melalui implementasi model pembelajaran pemecahan masalah dalam mata pelajaran Elektronika Dasar di SMK Negeri 5 Banda Aceh. Penelitian ini menggunakan desain Penelitian Tindakan Kelas yang terdiri dari dua siklus. Partisipan penelitian adalah 15 siswa kelas XI dengan instrumen lembar tes, yang digunakan untuk mengukur hasil belajar siswa setelah penerapan perlakuan dalam pembelajaran. Hasil penelitian menunjukkan bahwa terdapat peningkatan hasil belajar siswa dengan persentase siswa yang mencapai Kriteria Penguasaan Minimum (KKM) dengan nilai rata-rata 79% pada Siklus I dan meningkat menjadi 87,6% pada Siklus II. Hasil penelitian menunjukkan perubahan yang signifikan dalam kinerja siswa. Hal ini menunjukkan bahwa penerapan model pembelajaran pemecahan masalah dapat menjadi alternatif yang efektif untuk meningkatkan partisipasi aktif siswa serta mendorong pencapaian hasil belajar yang lebih baik dalam pembelajaran Elektronika Dasar maupun mata pelajaran produktif lainnya.

Kata Kunci: Elektronika Dasar, Hasil Belajar, Problem Solving,

Introduction

The learning process approach has shifted from being initially teacher-centered to being student-centered, positioning learners as the primary subjects of learning. According to Namkatu, the main objective of this approach is to encourage students active engagement in the learning process, enable them to understand learning materials in relation to real-life contexts, and develop their ability to identify and solve problems they encounter[1]. Through this approach, students not only gain deeper understanding but also contribute to the overall improvement of learning quality.

Vocational education particularly in the field of electronics plays a crucial role in producing individuals with the competencies required in the current digital era[2]. Competence in assembling electronic circuits is a key skill that determines the quality of graduates from vocational high schools (SMK) in the field of electronics[3]. According to Di and Negeri, learning in Vocational High Schools (SMK) places a strong emphasis on the development of knowledge, skills, attitudes, and values that are relevant to the world of work. This approach aims to produce graduates who are competent in performing tasks in accordance with the competencies acquired, as well as capable of adapting to workplace environments and developing professionally. However, empirical conditions in the field indicate the presence of various significant challenges in the implementation of practical electronics learning[4].

According to Syahraini, rapid technological advancement necessitates improvements in the quality of education, particularly in the fields of engineering and electronics[3]. Furthermore, the crucial competencies that students in this sector must master is the ability to assemble electronic circuits. This competency requires not only a solid theoretical understanding but also well-developed practical skills. Nevertheless, many students continue to encounter difficulties in assembling electronic circuits accurately and efficiently[5].

These difficulties are caused by several factors, including ineffective teaching methods and the limited opportunities for students to participate directly in practical activities. According to Mustika, in the problem-solving approach, teachers function primarily as motivators and facilitators who assist students in resolving problems. Conventional instructional methods that emphasize lectures and task assignments often fail to optimally develop students' practical skills. Therefore, an instructional approach is required that can enhance students' practical competencies while simultaneously fostering their thinking abilities[6][7].

A problem-based learning approach is a method that can be employed as a solution to this issue. This approach emphasizes systematic stages of problem solving, which actively engage learners in identifying problems, analyzing situations, formulating tentative hypotheses, collecting relevant information, and testing these hypotheses in order to obtain optimal solutions. Through this approach, learners do not merely receive information passively but actively participate in the learning process[8].

With reference to the background described above, the researcher is motivated to conduct a study entitled "Enhancing Students' Skills in Assembling Electronic Circuits through an Experiment-Based Problem-Solving Learning Model at SMKN 5 Banda

Aceh. Problem-solving learning is a systematic approach in which learners are presented with problems and subsequently required to solve them using appropriate strategies. This approach also enables learners to communicate and provide oral feedback regarding the analysis of the problems and the solutions proposed[9][10]. Problem solving can also be defined as a set of learning tasks that emphasize problem-solving strategies through a scientific approach. Problem solving has three main characteristics. Problem solving in learning represents a series of teaching and learning processes in which students are required to perform a number of tasks. Learning activities are directed toward problem resolution, where the presence of a problem becomes the central element in the learning process. Problem-solving steps are carried out by applying logical thinking methods. This approach integrates both inductive and deductive reasoning patterns[11].

However, this approach has several advantages that make it effective in enhancing students' abilities, particularly in the context of assembling electronic circuits[12]. The main advantages of this model include the following:

1. Enhancing critical and innovative thinking capacity.
2. Improving problem-solving skills.
3. Encouraging active participation and learners' motivation.
4. Strengthening collaborative skills.
5. Enhancing conceptual understanding.
6. Promoting learner autonomy.
7. Ensuring relevance to real-life contexts.

Method

This study was designed using a Classroom Action Research (CAR) approach. Classroom Action Research is a reflective process that involves systematically reviewing and evaluating teaching and learning activities in the classroom. This approach is carried out through deliberately planned and implemented actions conducted concurrently within the classroom setting [13]. This method aims to address various challenges in the teaching and learning process and to improve the overall quality of education[14]. The flow of this classroom action research can be seen in Figure 1 below.

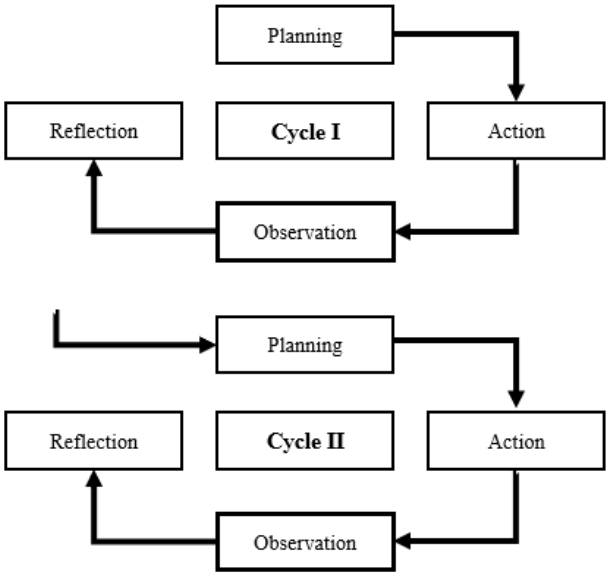


Figure 1: Miniature Research Flowchart[15]

The description of the research stages in Figure 1 is as follows:

1. Planning
   Planning involves identifying the learning problems being encountered, defining clear objectives, and formulating detailed action strategies[13]. This stage also includes the selection of appropriate instructional methods. At this stage, researchers prepare a Learning Plan (RPP) based on the syntax of the problem-solving learning model, determine learning objectives to be achieved by students, develop observation sheets, and prepare experiment-based Student Worksheets (LKPD) to support learning activities.
2. Action
   The action refers to the execution of the planned actions, such as applying innovative teaching approaches in the classroom and actively engaging students in the learning process[16]. At this stage, the researcher delivers the learning material to the students and allocates time to conduct experiments under the researcher's direct guidance. The experiment process is carried out by providing students with pre-test sheets. After the experimental activities and discussions are complete, the teacher administers a final cycle test to measure students' understanding, abilities, and skills.
3. Observation
   Observation involves the systematic collection of data to monitor the implementation and progression of the intervention being carried out. The researcher used a student activity observation sheet to record the level of students' activeness and engagement at each stage of the learning activities[17]. The observation process was conducted with a basic electronics teacher. This observation was conducted to observe the progress of students' learning in the classroom before and after the researcher provided the material.
4. Reflection
   Reflection is the process of evaluating the collected data to assess the effectiveness of the intervention[18]. This stage includes examining whether the intended objectives have been achieved, identifying aspects that require adjustment, and formulating strategies for subsequent cycles. The results of this reflection serve as the basis for formulating the action plan for Cycle II, with the aim of addressing the weaknesses identified in Cycle I and enhancing the effectiveness of implementing the experiment-based Problem-Solving learning model.

Cycle I was designed to be implemented in one meeting for action implementation and one meeting for test administration. The time allocation for each meeting was 4 x 45 minutes. The difference between cycle I and cycle II was that in cycle I, students had not yet received complete learning materials, while in cycle II, students had received complete materials from the researcher. This became one of the benchmarks for the researcher to see the differences between the two cycles. The data collection techniques used in this study were practical tests and observations. The instruments used in this study included student worksheets (LKPD) and questionnaires. The LKPD sheets in this study were used to view student test results. Data analysis in this study was conducted using percentage-based calculations. This study was considered successful when students

achieved individual learning mastery with a minimum score of 75%. The percentage of suitability of teaching aids can be seen using the following equation[19]:

$$P = \frac{F}{N} x100\% \quad \text{.....(1)}$$

Description:
P = Presentation/Learning Outcomes
F = The number of students who achieved mastery
N= The total number of students

Result and Discussion

The results of the research conducted in Class XI TJA-1 SMK Negeri 5 Telkom in the 2025-2026 Academic Year. A total of 2 cycles, namely 1 meeting in Cycle 1 and 1 meeting in Cycle 2. At the beginning of the learning process, the students were not yet active and did not understand the lesson well. However, when given material in the form of teaching materials, the students began to be interested and began to be active in learning.

a. Student Worksheets (LKPD) Results

In this study, the Student Worksheet (LKPD) was used to assess students' abilities across two instructional cycles. The assessment indicators employed in this research included knowledge, skills, and character. Prior to the implementation of the LKPD, students were provided with instructional material on the fundamental functions of each electronic component. Subsequently, students were required to independently assemble electronic circuits based on the circuit designs provided in the LKPD.

Based on the findings from Cycle I, the assessment results indicated that the majority of students had begun to understand the basic assembly procedures. However, several errors were still observed, particularly in interpreting circuit diagrams and connecting the pathways on the breadboard. The average student learning outcome in Cycle I was categorized as fair, with some students not yet achieving the Minimum Mastery Criteria (KKM). Students' suboptimal learning to support problem-solving learning is due to several factors, including low motivation, underdeveloped critical thinking skills, and inadequate mastery of basic concepts. Furthermore, students tend to be accustomed to conventional, teacher-centered learning, thus lacking the skills to analyze problems and find solutions independently. The graphical representation of the Cycle I result is presented in Table 1 below.

Table 1. Cycle I Assessment Results

No	Name	Knowledge	Skill	Average	Description
1	MZ	70	70	70	Complete
2	FZ	85	70	77,5	Complete
3	HK	70	71	70,5	Complete
4	AJ	30	50	40	Incomplete
5	AS	45	50	47,5	Incomplete
6	TS	30	65	47,5	Incomplete
7	FD	70	85	77,5	Complete
8	NO	55	70	62,5	Incomplete
9	MR	30	67	48,5	Incomplete

10	NS	70	89	79,5	Complete
11	AN	70	87	78,5	Complete
12	HT	30	98	64	Incomplete
13	MD	45	60	52,5	Incomplete
14	TR	30	78	54	Incomplete
15	RS	55	90	72,5	Complete

Based on the table above, it can be observed that only four students met the minimum mastery criteria (MMC) and were categorized as passing, while the remaining eleven students scored below the required MMC. Furthermore, Table 1 shows the students' average scores, which are presented graphically in the figure below.

Among the two aspects assessed, skills achieved the highest score of 73, indicating that this aspect showed the most significant development. Meanwhile, knowledge ranked second with a score of 52, suggesting that this aspect still requires further attention and improvement. Overall, Cycle I illustrate that the knowledge aspect needs to be further enhanced in order to achieve more balanced learning outcomes. The results of Cycle II based on the assessment of students' LKPD (Student Worksheets) are presented in Table 2 below.

Table 2. Cycle II Assessment Results

No	Name	Knowledge	Skill	Average	Description
1	MZ	95	95	95	Complete
2	FZ	95	90	92,5	Complete
3	HK	100	95	97,5	Complete
4	AJ	100	95	97,5	Complete
5	AS	100	95	97,5	Complete
6	TS	100	95	97,5	Complete
7	FD	100	90	95	Complete
8	NO	100	95	97,5	Complete
9	MR	60	75	67,5	Incomplete
10	NS	75	90	82,5	Complete
11	AN	75	90	82,5	Complete
12	HT	75	90	82,5	Complete
13	MD	100	95	97,5	Complete
14	TR	95	95	95	Complete
15	RS	100	95	97,5	Complete

Based on the table above, it can be observed that the number of students who met the required Minimum Mastery Criterion (MMC) increased compared to Cycle I, with 14 students categorized as passing, while one student remained below the required mastery threshold. Furthermore, as shown in Table 2, the students' average scores are presented in graphical form in the figure below.

A comparison between the graphs of Cycle I and Cycle II indicate a significant improvement in both measured aspects, namely knowledge and skills. In Cycle I, the knowledge score was 52; however, in Cycle II, this score increased substantially to 91. A similar improvement was also observed in the skills aspect, which rose from 73 to 92. This occurs because problem-solving learning guides students through systematic stages, from identifying problems, analyzing causes, designing solutions, and evaluating results. Through these stages, students become more active, develop critical thinking skills, and

become accustomed to connecting concepts to real-world situations. Thus, the application of problem-solving learning has been proven to address weaknesses in the previous cycle and produce more stable and equitable performance improvements across knowledge and skills.

b. Observation Results

Observations in this study involved the subject teacher and students, aiming to examine the learning process experienced by students during classroom instruction. The results of the teacher observation indicated that the instructional methods used were still limited in innovation and tended to be conventional, primarily employing lecturing and note-taking. This approach was chosen to meet curriculum targets; however, it led to student boredom and low learning engagement, which consequently affected students' learning outcomes.

Student observations further revealed that learners at SMKN 5 Banda Aceh demonstrated low mastery of the learning material, particularly in the Basic Electronics subject. This condition was reflected in the evaluation results, where many students had not yet achieved learning mastery and only a few attained satisfactory scores. Based on these findings, an experimental problem-solving-based learning model was implemented to encourage active student participation and enhance students' curiosity toward the learning material. This model shifts the learning process from a teacher centered approach to a student centered one, in which all students are actively involved in the learning activities.

In delivering the learning process using an experiment-based problem-solving learning model, the researcher employed an instructional medium in the form of a teaching module. The findings indicate that students demonstrated a high level of interest in this learning model, as evidenced by improvements in learning outcomes across the knowledge, skills, and character domains. The knowledge score increased to 91 which was obtained from the average score in Cycle II, indicating that this learning model is effective not only in enhancing cognitive achievement but also in fostering positive attitudes and collaborative skills among students. Overall, the experiment-based problem-solving learning model successfully attracted students' interest and significantly improved learning outcomes in the Basic Electronics subject. This is supported by the results of the student interest questionnaire, which showed an average score of 79.0% in Cycle I and 87.6% in Cycle II, both categorized as highly interesting.

The implementation of the experiment-based problem-solving learning model has positive pedagogical implications for the process and outcomes of Basic Electronics learning. This model encourages a shift from teacher-centered learning to student-centered learning. Through problem-solving stages, from problem identification, analysis, solution design, experiment implementation, and evaluation, students are trained to think critically, actively, and independently in solving practical problems. The pedagogical implications not only improve learning outcomes but also foster practical skills, collaboration, and a sense of responsibility throughout the learning process[20][21].

Teacher reflections on Cycle I indicated that students still experienced difficulty understanding basic concepts and applying them to practical electronic circuit assembly. This was evident in low scores on the knowledge aspect and persistent errors in reading circuit diagrams and using breadboards. Furthermore, teachers recognized that the material delivery in Cycle I was not fully optimal, both in terms of comprehensiveness and time management. Based on these reflections, teachers made improvements in Cycle II by providing more comprehensive material, more structured explanations, and more intensive guidance during the experiments.

The changes made in Cycle II significantly improved student learning outcomes. The knowledge aspect score increased from 52 in Cycle I to 91 in Cycle II, while the skills aspect score increased from 73 to 92. In addition, the number of students who achieved the Minimum Completion Criteria (KKM) increased drastically from 4 in Cycle I to 14 in Cycle II. These changes indicate that improvements in learning strategies and consistent implementation of problem-solving stages were able to overcome weaknesses in the previous cycle and produce more effective and equitable learning. These improvements indicate that the experiment-based Problem Solving learning model has a positive impact on students' practical abilities in assembling electronic circuits because it directs them to direct learning experiences and solve problems independently[22].

This learning model is considered effective because the Problem-Solving approach encourages students to think actively, express their ideas, solve real-world problems, and collaborate in groups. This approach also overcomes the limitations of conventional teaching methods, such as lecture-based teaching, which often makes students passive and less engaged in the learning process[23]. Student responses to the implementation of the experiment-based Problem-Solving learning model also showed very positive results. Students appeared more enthusiastic, actively engaged in discussions, and directly involved in the learning process. The questionnaire results showed an increase in student learning interest from 79% in Cycle I to 87.6% in Cycle II, with the category of interesting. Students felt that learning became more meaningful because they could connect theory with practice directly. This shows that the problem-solving learning model not only improves academic achievement but also increases student motivation and engagement in Basic Electronics learning.

This discussion is strengthened by previous studies. Problem Solving learning is an approach that can enhance students' logical thinking skills and active participation, as it requires learners to understand problems and seek scientific solutions[8]. Furthermore, Problem Solving-based learning is effective in improving communication skills, analytical abilities, and practical skills[24][25], as students are required to express ideas and solve problems through systematic steps. These findings are consistent with the results of the present study, which demonstrate an improvement in students' practical abilities in assembling electronic circuits[9].

Conclusion

Based on the results of the research that has been carried out, it can be concluded that In Cycle I, the average student learning outcomes were categorized as moderate, with some students not yet meeting the Minimum Competency Criteria. In addition, students

still made errors in reading circuit diagrams and connecting pathways on the breadboard. Student interest in the learning model reached 79.0%, which fell into the interesting category. In Cycle II, a significant improvement was observed across knowledge, skills, and character. These results indicate that students had a better understanding of assembly procedures, were able to apply theoretical concepts to practical activities, and demonstrated positive attitudes and collaboration. Student interest also increased to 87.6%. Overall, the experiment-based problem-solving learning model proved effective in improving student learning outcomes comprehensively, enhancing student interest, and overcoming the limitations of conventional teaching methods. Therefore, this model is recommended for sustained implementation by teachers to improve students' mastery of content and skills in the Basic Electronics subject.

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