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The Effectiveness of PBL-Based Electronic Modules in Improving Students' Critical Thinking and Problem-Solving Skills at SMK Negeri 4 Pariaman

Nadila Septia*, Ika Parma Dewi, Muhammad Anwar, Hendra Hidayat

Electronic Engineering Department, Faculty of Engineering, Universitas Negeri Padang, Padang, Indonesia

*Corresponding Author: nadilaspt02@gmail.com

Abstract - The problem in the learning process is that many students lack focus and motivation to learn when teachers deliver material. The cause is a learning model that is not interactive enough, where teachers often use a one-way learning approach. In addition, teachers have not mastered or utilized interactive learning media beyond the use of PowerPoint. This condition not only reduces the effectiveness of learning but also has a negative impact on students' critical thinking and problem-solving abilities. The purpose of this study is to look at how using a Problem-Based Learning method with electronic module media affects students' ability to think critically and solve problems in the subject of Electronics Basics at State Vocational High School 4 Pariaman. This research is a quantitative study that uses an experimental approach, specifically a Quasi-Experimental Design called the Non-Equivalent Control Group Design. The students involved were all from class X TEI during the 2022/2023 school year. The data analysis showed that using the Problem-Based Learning method with Augmented Reality media had a significant effect on the critical thinking and problem-solving skills of Industrial Electronics Engineering students. The control group saw an average improvement of 24.81%, while the experimental group had an average improvement of 22.13%.

Keywords: e-Modul, Problem Based Learning, Critical Thinking, Problem Solving.

I. INTRODUCTION

Human resources with the ability to collaborate, communicate, think critically, and solve problems creatively are expected to be produced via 21st century education [1]. The Partnership for 21st Century Skills states that critical thinking skills are one of the essential skills needed in the 21st century [2]. 21st century learning is adaptable to technological changes in competencies, learning objectives, media, and learning methodologies [3], [4]. Thus, there are a number of challenges and opportunities, especially for the world of education in Indonesia.

Digital-based learning, such as the use of interactive e-modules as learning assistance, is one way to adapt learning trends and best practices to get 21st century skills. The development of learning models and tactics, as well as the improvement of the caliber of teachers and learning materials, are all part of ongoing efforts to raise students' HOTS [5], [6].

In this modern era, critical thinking and problem-solving skills are very important for every individual, even though these two skills have been developed for a long time [7]. The improvement of learners' critical thinking skills is paralleled by the improvement of problem solving ability. When someone's ability to think critically improves, their problem solving ability also gets better. On the other hand, if critical thinking skills go down, problem solving skills also tend to decline [8].

Based on observations during the Educational Field Experience Program (PLK) conducted by researchers from July to December 2022 at SMK 4 Negeri Pariaman, researchers found problems, particularly in class X TEI in the subject of Electronics Basics (DDE), where educators still use conventional models or one-way methods where educators explain and students only listen. Therefore, students tended to be less active and still lacked critical thinking skills during the learning process [9]. In addition to the ineffective learning model, the teaching materials used were only in print form and were not distributed evenly, making it difficult for students to absorb the material in the DDE subject. The results of the odd semester midterm exam for grade X TEI students in the subject of Fundamentals of Electronics show that the Learning Objective Achievement Criteria (KKTP) for the subject of Fundamentals of Electronics is 75.

Educators have not fully utilized educational technology that is relevant to the needs of generation Z, which tends to be more responsive to digital media [10], [11]. Dependence on teaching materials in the form of printed books, whose distribution is uneven, causes students to feel less interested and tend to be passive, so that the learning process feels monotonous and not interactive [12]. Learners must be required to understand the material, then do the practice questions given by the educator. Therefore, educators are required to be able to present more interesting learning media so that students are more active and able to apply critical thinking skills in learning [13], [14].

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Media is one of the supports for effectiveness and efficiency in learning. One of the innovations in information and communication technology in education is interactive electronic modules [15], [16]. This is because interactive modules are designed in a way that makes the material easier for students to grasp and they are simple to use, and can be accessed from any location [17]. Related to the technology-based innovative media discussed above, one example is the flipbook e-module [18]. This e-module flipbook is an editing software that is able to add hyperlinks, images, videos, and text or even other supporting materials. It can also be likened to an actual book [19]. Thus, the features presented in this e-module flipbook can increase understanding of the material because there is interactive media that is interesting and not monotonous [20]. So, this e-module flipbook is a media that should be a reference for teachers and educational practitioners to support and fulfill 21st century skills [21]. This is none other than because flipbooks are interesting, interactive and effective according to the character of the material and learning style. Flipbooks also train students' metacognitive and self-regulation skills [22], [23].

II. METHOD

This study is a quantitative study that uses an experimental method. The experimental method is used to find out how different variables affect each other. In experimental research, we look at how a treatment influences other variables in a controlled and organized way. The study uses a Quasy Experimental Design with a Non-Equivalent Control Group model. In this setup, there are two groups that take a pretest to check their starting conditions and to see if there are any differences between the experimental group and the control group. The pretest results are considered good if the experimental group's scores do not show a significant difference from the control group. This research was conducted at State Vocational School 4 Pariaman. This study involved two groups, the experimental group and the control group. The experimental group will be given treatment using Media, problem-based e-modules, while the control group will follow the conventional learning model. The following is a description of the Non-Equivalent Control Group Design research design.

O_1 X O_2
O_3 O_4

Fig 1. Non-Equivalent Control Group Design

Information :
O1: Pretest for the Experimental Group
O3: Pretest for the Control Group
X: Treatment using e-modules
O2: Posttest for the Experimental Group
O4: Posttest for the Control Group

In this study, two classes were selected, one class using problem-based e-Modules and one class using conventional learning methods. Before the treatment was administered, both the experimental and control classes were given pre-tests to determine the initial abilities of students in both classes. After the treatment was administered, both classes were given post-tests to determine students' critical thinking and problem-solving abilities.

Data collection instruments are used to obtain the necessary data. The data collection instrument used was a test. The data collected were then analyzed quantitatively using descriptive statistics and t-test. The test instrument was used to measure critical thinking ability and problem solving ability. The tests in this study consisted of an initial test (pretest) and a final test (posttest). The initial test was used to measure students' initial abilities, while the final test was used to measure the improvement of students' critical thinking and problem solving abilities.

III. RESULTS AND DISCUSSION

This study involved students of group X TEI SMK Negeri 4 Pariaman, as research samples, consisting of an experimental class and a control class. In this study, X TEI I was selected as the experimental class with 25 students, and X TEI II was selected as the control class with 25 students. The experimental class was taught using PBL-based e-modules as learning media, while the control class used the conventional learning model. Furthermore, the researcher set a measurement scale to measure critical thinking skills adopted from which has categorized student performance into four categories, namely excellent, good, fair, poor, and very poor.

Table 1
Ctps Score Description

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
Pretest	Control	25	51.60	11.431	2.286
	Experiment	25	57.80	8.549	1.710
Posttest	Control	25	64.40	8.078	1.616
	Experiment	25	72.80	8.549	1.710

For both the experimental and control groups, the pretest's lowest score on the problem-solving ability was 35. The experimental class scored 95 on the posttest, while the control class scored 75. The control and experimental classes had average pretest scores of 51.6 and 57.8, respectively, and posttest scores of 64.8 and 72.8. The analysis's findings demonstrated that both classes' scores on problem-solving skills increased, with the experimental class's average score which was higher than the control class's and in the good category using PBL-based e-modules.

A. Hypothesis Test Results

Prerequisite test analysis was carried out before conducting hypothesis testing: First, the normality test uses SPSS 25 with the Kolmogorov-Smirnov test. Data is considered normally distributed if the Asymp.Sig value. > 0.05, and abnormal if the value of Asymp.Sig. < 0,05.

Table 2
Pretest Posttest Normality Test Results

Tests of Normality

	Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Pretest	Control	.156	25	.121	.929	25	.083

Tests of Normality

	Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Posttest	Experiment	.162	25	.091	.970	25	.642
	Control	.170	25	.062	.933	25	.099
	Experiment	.148	25	.162	.940	25	.145

a. Lilliefors Significance Correction

Pretest Posttest Normality Test. The significance values of the pretest and posttest for the control class are 0.121 and 0.062, which indicates the data is normally distributed because it is greater than 0.05. Likewise, the significance value of the pretest in the experimental class is 0.091 and 0.162, indicating the data is also normally distributed.

Table 3
Variation Homogeneity Test Results

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Pretest	Based on Mean	2.926	1	48	.094
	Based on Median	2.169	1	48	.147
	Based on Median and with adjusted df	2.169	1	46.811	.148
	Based on trimmed mean	2.869	1	48	.097
Posttest	Based on Mean	.160	1	48	.691
	Based on Median	.153	1	48	.697
	Based on Median and with adjusted df	.153	1	47.228	.697
	Based on trimmed mean	.139	1	48	.711

The third result of the Test of Homogeneity of Variance analysis showed a significance value of 0.781 for the pretest and 0.499 for the posttest. The significance value which is greater than 0.05 in both tests indicates that the pretest and posttest data come from a homogeneous population.

Hypothesis Test Results: The t-test to compare two means was conducted using the SPSS 25 program with the Paired Sample Test method, assuming homogeneous variance and a significance level of 0.05. The following is a hypothesis statement for the test of learning outcomes between the experimental class and the control class:

H0: There is no significant difference in CTPS results between students who use PBL-based e-modules and students who follow conventional learning.

Ha: There is a significant difference in the results of CTPS between students who use PBL-based e-modules and students who follow conventional learning.

The decision-making criteria for this test are as follows if the significance value is <0.05, then Ho is rejected and if the significance value > 0.05, then Ha is accepted. The results of the t-test calculation show that the t-statistic for the experimental class is 10.023 with a significance value of 0.000, and for the control class is 2.705 with a significance value of 0.000. Since the significance value for both classes is smaller than 0.05, Ho is rejected in both classes. This means there is a significant difference in the CTPS test results between students using the PBL-based e-module and those using the conventional method. Overall, the analysis showed that there was a significant difference between the mean CTPS results in the experimental and control classes.

B. Implementation PBL in K3LH

The majority of opinions fall into the good category, according to the findings of testing the usage of e-modules based on Problem-Based Learning (PBL)-based e-modules in fundamental electronics training, particularly HSE elements. This suggests that K3LH learning is successfully implementing PBL-based e-modules.

PBL with e-modules is an approach that focuses on problem solving using electronic modules. The learning process starts with the introduction of a complex problem through an e-module, which can be a text, video or simulation. It aims to arouse students' curiosity and help them understand what they already know as well as what needs to be learned further. Once the problem is introduced, students do independent exploration using the e-module, which provides various resources such as articles, videos and quizzes. They then discuss in small groups to share information and discuss potential solutions.

Next, teachers utilize digital technology to guide students in investigations, both individually and in groups, with the e-module as a learning tool. After the discussion, groups present their solutions using the digital tools from the e-modules, which are then assessed by the class or other groups for feedback. Finally, students and teachers evaluate the effectiveness of the proposed solutions with the criteria provided by the e-modules, as well as reflect on the learning process to assess their achievements.

C. Experimental Class and Control Class CTPS

Descriptive analysis showed an increase in students' CTPS scores in both classes. The control class increased by 24.81%, from 51.6 and 57.8, while the experimental class increased by 22.13%, from 64.8 to 72.8, and reached the complete category with an average of ≥ 70. Thus, the average CTPS results of students in the experimental class who used problem-based e-modules were higher than those of the control class.

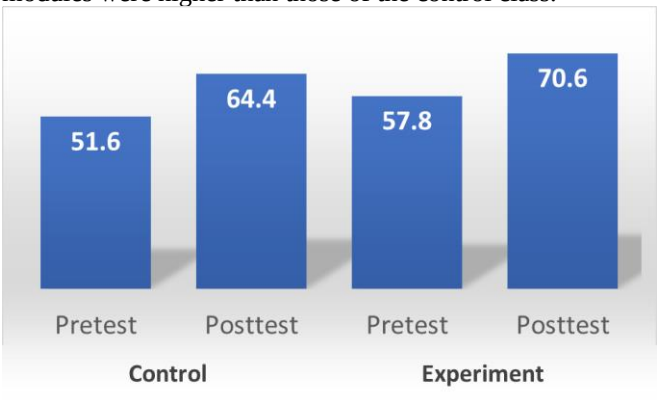

Fig 2. Diagram Average CTPS

According to Figure 2, The average scores for critical thinking and problem-solving abilities improved in both the experimental and control groups. Students in both classrooms had equal starting abilities, according to the pretest results. Nonetheless, the experimental class, which employed PBL-

based e-modules, had a higher average CTPS score on the posttest than the control group. The PBL-based e-module learning that taught students the steps of problem solving understanding the problem, formulating a solution, carrying out the plan, and assessing the outcome was the reason for the experimental class's higher test scores. This learning strengthens students' conceptual and procedural knowledge, which improves their ability in tests that require problem solving. Hypothesis testing results with a significance of 0.000 showed that the PBL-based e-module had a significant effect on students' CTPS outcomes, thanks to the integration of complementary PBL methods in the learning process

IV. CONCLUSIONS

Data analysis revealed that after utilizing the PBL-based e-module on element 5 of K3LH, the SMK Negeri 4 Pariaman class X TEI students' critical thinking and problem-solving abilities increased. Between 51.6 and 57.8, the experimental class's average CTPS score improved by 24.81%, and between 64.8 and 72.8, it increased by 22.13%. The experimental class outperformed the control class in terms of average score, reaching the full category (≥ 70).

The increase in scores in the experimental class occurred because when participating in PBL-based e-module learning, students were trained to solve problems through the problem-solving stages of understanding the problem, planning the solution, implementing the plan, and reviewing the steps taken to solve the problem. The T-test results showed a significance level of 0.001, which is less than 0.05. This means the PBL-based e-module used in the experimental class made a difference in students' CTPS scores.

The T-test results of this study are in line with the research conducted by Gili Pratama (2018) entitled "The Effect of E-Modules Based on the Problem-Based Learning Method in Database Subjects on Student Learning Outcomes and Motivation". The T-test in this study obtained a significance level of 0.000. This value indicates that there is a difference between learning using e-modules and conventional methods.

V. REFERENCES

[1] Y. Andrian and R. Rusman, "Implementasi pembelajaran abad 21 dalam kurikulum 2013," *J. Penelit. Ilmu Pendidik.*, vol. 12, no. 1, pp. 14–23, 2019, doi: 10.21831/jpipfip.v12i1.20116.

[2] D. Yulia, M. Permata, and M. Anwar, "Analysis of Critical Thinking Skills on the Use of Augmented Reality with the TAM Approach," *J. Eng. Collab. Learn.*, pp. 18–24, 2024.

[3] N. Jalinus *et al.*, "Developing Blended Learning Model in Vocational Education Based On 21st Century Integrated Learning and Industrial Revolution 4.0," *Turkish J. Comput. Math. Educ.*, vol. 12, no. 9, pp. 1276–1291, 2021.

[4] A. Huda *et al.*, "Augmented Reality Technology as a Complement on Graphic Design to Face Revolution Industry 4.0 Learning and Competence: The Development and Validity," *Int. J. Interact. Mob. Technol.*, vol. 15, no. 5, pp. 116–126, 2021, doi: 10.3991/ijim.v15i05.20905.

[5] M. Anwar, T. Taali, H. Hidayat, and E. Sabrina, "Exploring Trait Thinking in Predicting Students' Higher-Order Thinking Skills (HOTS) Using ANFIS: A Study on Electronics Engineering Education Students," *TEM J.*, vol. 13, no. 4, pp. 3103–3111, 2024, doi: 10.18421/TEM134-45.

[6] A. Huda *et al.*, *Media Animasi Digital Berbasis Hots (Higher Order Thinking Skill)*. Padang: UNP PRESS, 2020.

[7] J. Jose M Ocampo, "Effecting Change on Students?? Critical Thinking in Problem Solving," *Educare*, vol. 10, no. 2, pp. 109–118, 2018, doi: https://doi.org/10.2121/edu-ijes.v10i2.949.g857.

[8] V. Puspita and I. P. Dewi, "Efektifitas E-LKPD berbasis Pendekatan Investigasi terhadap Kemampuan Berfikir Kritis Siswa Sekolah Dasar," *J. Cendekia J. Pendidik. Mat.*, vol. 5, no. 1, pp. 86–96, 2021, doi: 10.31004/cendekia.v5i1.456.

[9] J. Sembiring, Ambyar, A. Mubai, O. Dakhi, and F. Edi, "Project-Oriented Self-directed Learning as a Learning Model to Improve Learning Outcomes Jakaria," in *9th International Conference on Technical and Vocational Education and Training (ICTVET 2022)*, 2023, vol. 1, pp. 116–121, doi: 10.2991/978-2-38476-050-3.

[10] F. Reza, F. L. Tinggogoy, and K. Kunci, "Konflik Generasi Z Di Bidang Pendidikan Di Era Revolusi Industri 4.0 Tantangan dan Solusinya," *Paradig. J. Adm. Publik*, vol. 1, no. 2, pp. 142–155, 2022, [Online]. Available: http://jurnal.stiapembangunanpalu.ac.id/index.php/PARADIGMA/article/view/51.

[11] I. P. Dewi *et al.*, "Improving the Competence of MGMP Informatics Teachers in Preparing Gamification-Based IBT in the Era of Education 5.0," *GUYUB J. Community Engagem.*, vol. 6, no. 1, pp. 130–151, Mar. 2025, doi: 10.33650/guyub.v6i1.9906.

[12] L. S. Putri, Y. Setiani, and C. A. H. F. Santosa, "E-Modul Matematika Berbasis Problem Based Learning Bermuatan Pengetahuan Budaya Lokal untuk Meningkatkan Kemampuan Pemecahan Masalah," *J. Educ. FKIP UNMA*, vol. 9, no. 2, pp. 880–890, 2023, doi: 10.31949/educatio.v9i2.5002.

[13] B. Cahyono, "Korelasi Pemecahan Masalah dan Indikator Berfikir Kritis," *Phenom. J. Pendidik. MIPA*, vol. 5, no. 1, pp. 15–24, 2016, doi: 10.21580/phen.2015.5.1.87.

[14] D. Irfan, L. Mursyida, and A. Mubai, "Implementation of Mobile Learning Design in the Flipped Direct Instruction Model to Increase Student Competency Using a Constructivist Approach," *J. Educ. Technol.*, vol. 7, no. 4, pp. 752–762, 2023, doi: 10.23887/jet.v7i4.69768.

[15] Madroji, F. Zulaiha, and Faizah, "Pengembangan Modul Fisika Berbasis Problem Based Learning Pada Materi Fluida Dinamis Untuk Meningkatkan Kemampuan Berpikir Kritis Siswa Kelas XI SMAN 1 Astanajapura," *J. Pendidik. Fis. dan Sains*, vol. 2,

no. 1, pp. 17–23, 2019, doi: 10.52188/jpfs.v2i1.65.

[16] L. Asnur, N. Jalinus, A. Faridah, D. Irfan, A. Mubai, and F. Utami, "Empowering Project-Based Learning Model With Video Blog," *TEM J.*, vol. 14, no. 1, pp. 707–715, Feb. 2025, doi: 10.18421/TEM141-63.

[17] I. P. Dewi, R. Sofya, and T. Sriwahyuni, "Pengembangan Media Pembelajaran Multimedia Interaktif Menggunakan Adobe Flash CS3 Pada Matakuliah media Pembelajaran EkonomiYang Menerapkan Metode Project Based Learning," *J. Teknol. Inf. dan Pendidik.*, vol. 11, no. 2, pp. 72–79, 2018.

[18] I. P. Dewi, R. Sofya, and A. Huda, *Membuat Media Pembelajaran Inovatif dengan Aplikasi Articulate Storyline 3*. 2021.

[19] K. Sa'diyah, "Pengembangan E-Modul Berbasis Digital Flipbook Untuk Mempermudah Pembelajaran Jarak Jauh Di SMA," *Edukatif J. Ilmu Pendidik.*, vol. 3, no. 4, pp. 1298–1308, 2021.

[20] E. Wibowo and D. D. Pratiwi, "Pengembangan Bahan Ajar Menggunakan Aplikasi Kvisoft Flipbook Maker Materi Himpunan," *Desimal J. Mat.*, vol. 1, no. 2, p. 147, 2018, doi: 10.24042/djm.v1i2.2279.

[21] P. E. A. Purnomo, K. Agustini, and I. G. W. Sudatha, "Peran Flipbook Sebagai Media Pembelajaran Inovatif Dalam Pembelajaran Abad 21," *J. Ris. dan Inov. Pembelajaran*, vol. 4, no. 3, pp. 2001–2015, 2024, doi: 10.51574/jrip.v4i3.2286.

[22] E. Susantini, R. P. Puspitawati, Raharjo, and H. L. Suaidah, "E-book of metacognitive learning strategies: design and implementation to activate student's self-regulation," *Res. Pract. Technol. Enhanc. Learn.*, vol. 16, no. 1, 2021, doi: 10.1186/s41039-021-00161-z.

[23] A. Mubai, A. Ambiyar, F. Fadhilah, and U. Usmeldi, "Meta analisis: Efektivitas model pembelajaran flipped classroom di pendidikan kejuruan," *J. Pembang. Pendidik. Fondasi dan Apl.*, vol. 8, no. 1, pp. 25–32, Dec. 2020, doi: 10.21831/jppfa.v8i1.36542.