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The Effect of Blended PBL Assisted with Advance Organizer and Thinking Style on Understanding and Application of Digital Electronics Concepts

Godlief Erwin Semuel Mige[1(*)], Punaji Setyosari[2], Saida Ulfa[3], Henry Praherdiono[4]
[1]Nusa Cendana University, Kupang, Indonesia
[1,2,3,4] State University of Malang, Malang, Indonesia

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Abstract
This study aims to see the effect of Blended Problem-Based Learning assisted with Advance Organizer (BPBL AO) model in the experimental class and Direct Learning in the control class, the moderator variable of Thinking Style (Internal and External), on the dependent variable Digital Electronics Concept Understanding and Digital Electronics Concept Application and the interaction effect of the independent variable and moderator variable on the dependent variable. This research is quantitative research with a quasi-experimental approach with a 2x2 factorial design, Multivariate Analysis of Variance (MANOVA) is used to analyze research data. The results of the study are (1) there are differences in learning outcomes between students taught with BPBL AO and students taught with direct learning on Digital Electronics Concept Understanding and Digital Electronics Concept Application, (2) there are differences in higher order thinking skills between students who have internal thinking styles and external thinking styles in the Digital Electronics Concept Understanding dimension and while they tend to be the same or there is no difference in Digital Electronics Concept Application, and (3) between the learning strategies applied and the thinking styles possessed by students on the learning outcomes of Digital Electronics Concept Understanding and Digital Electronics Concept Application, there is no interaction effect. The application of BPBL AO can improve critical thinking skills for problem solving without depending on their thinking style. This research shows that BPBL AO can stimulate students to think more critically, analyze information, link digital electronics concepts with the real world, and produce creative solutions in problem solving.

Keywords: Advance Organizer, Blended,Digital Electronic, Thinking Style, Internal, External, Problem Based Learning.

(*) Corresponding Author: godlief@gmail.com

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INTRODUCTION

Students in the 21st century must have the ability to think (critical thinking, proble-solving, creativity, and metacognition), act (communication, collaboration, and digital and technological literacy),) and life skills (citizenship, global understanding, leadership, and college and career readiness) (Greenstein, 2012). In its implementation, students are required to have 4 kinds of skills, namely being able to think critically for problem solving, communicating, working together and creatively and can be achieved with guidance from teachers through changes in teaching methods (Bialik & Fadel, 2015). Teachers as facilitators must be able to adjust the method of delivering teaching materials using ICT technology. Students must also be willing to learn independently and develop their insights by accessing information online. Each student differs in cultural background, learning styles and interests, social and economic class, and abilities and limitations. Learning style can be defined as a person's way of receiving the most information in learning compared to using other methods. Everyone has their own learning style. If students learn casually and without pressure and according to their level of understanding and interest, they will produce high creativity (Willis, 2011). To achieve a certain competency, students can utilize various learning media that are in accordance with their learning style.

According to Dasilva & Suparno, 2019, learning and innovation skills, life and career skills, information, media, and technology skills are 21st century learning paradigms that students must have to work and live successfully. Badan Pusat Statistik Indonesia released data on the unemployment rate in Indonesia which is still relatively high and dominated by vocational education graduates, even though vocational education is designed to prepare graduates who are ready to work. The findings of this study indicate a substantial mismatch between TVET and the needs of business and industry, especially in the field of electrical engineering. Most TVET institutions in Indonesia have limitations in terms of the quality of human resources, facilities and infrastructure that meet standards, lack of cooperation with industry, curriculum that suits work needs, and weak modern work culture (Ali et al., 2020). In addition to the mismatch between the competencies of vocational school graduates and industry needs, there are also differences in competencies among students or graduates of SMK, which is one of the contributing factors to unemployment among SMK graduates (Bruri Triyono et al., 2018).

The education system, which is always changing due to new policies adapted to the times, makes the duties and responsibilities of teachers heavier so that direct teaching methods must be abandoned immediately (Eslami & Ahmadi, 2019). The use of the lecture method or teacher-centered method still dominates the learning process because of its practicality. Behind the various advantages of the lecture method, if applied to subjects that require active interaction between teachers and students, the results will not be effective and will produce graduates who are not in accordance with the demands of today's competitive market (Ali et al., 2020; Bruri Triyono et al., 2018; Kakepoto et al., 2012). The direct learning method does not support the diversity of student learning styles, does not foster the ability to collaborate among students, engage in active problem solving, and think critically (Strobel & van Barneveld, 2009). In addition to hard skills, soft skills such as creativity, communication, conflict resolution, teamwork, and leadership must also be developed during the learning process. One of the skills required in the 21st century is creativity and is formed based on personality, environment, and cognition that cannot be effectively learned through traditional lecture-based instruction (Hung, 2015).

21st century learning is no longer teacher-centered but student-centered, and learning resources are unlimited for students to obtain information that can be used as optimal learning resources so that they can hone their thinking skills (Farida et al., 2021). In the context of 21st century learning, student-centered learning is much more relevant as it promotes students' active engagement, development of 21st century skills such as critical thinking, collaboration, communication, creativity, and interpersonal skills. Student-centered learning also encourages students to take responsibility for their own learning, which is in line with the demands of a changing world and rapidly evolving technology. Thus, student-centered learning is more suitable for creating a relevant learning environment and preparing students to become lifelong learners, facing the ever-evolving challenges and opportunities in the 21st century. For this reason, education must improve the collaborative learning system with the digital world to modernize and integrate classical learning with technology-based learning. One of the concrete steps is to integrate offline and online learning in the form of Blended Learning (BL) that allows students to learn face-to-face in the classroom and online. The flexibility of BL can be combined with the type of learning that can shape students to have the abilities needed in the world of work, namely communication skills, teamwork, critical thinking and creative in solving problems.

The combination of communication skills, collaboration and critical and creative thinking to solve problems can be applied to the learning process in the classroom in the form of Problem-Based Learning (PBL). PBL is a form of student-centered learning. This approach places students as the center of their own learning process and actively engage in problem solving and investigation oriented to real context. In the implementation of PBL, students are given complex challenges or problems, which require solving by applying the knowledge they have and seeking additional information as needed. Students work in groups to explore and solve these problems, with support from the teacher as a facilitator. PBL helps develop a range of cognitive and social skills, such as critical thinking, teamwork, communication and problem-solving skills. By focusing on deep understanding and application of knowledge in real contexts, PBL creates relevant and meaningful learning experiences for students, in accordance with the principle of student-centered learning. PBL is an instructional method that can foster student creativity. The characteristics of PBL provide aligned learning by not only encouraging student development to develop the abilities, knowledge and skills necessary for creativity to occur, but also providing a learning environment that supports the development process (Hung, 2015).

Many research results prove that PBL has a positive effect on student learning outcomes, some of which are : An article examining the effect of PBL on student learning outcomes found that students in the PBL group showed greater improvements in conceptual understanding and problem-solving skills compared to students in traditional lecture-based teaching. The findings of these studies reveal that PBL method is more effective compared to conventional teaching in improving students' learning ability and science process skills (Kartal Taşoğlu & Bakaç, 2014). In addition, PBL improves students' skills in accessing and using knowledge, working in groups and cooperating, autonomous learning, and problem-solving skills (Paristiowati et al., 2019). PBL also has a positive influence on student behavior and learning outcomes (Dochy et al., 2003; Suciana et al., 2023). Other findings also prove that in addition to other learning instruction approaches, PBL has been widely used and succeeded in effectively improving critical thinking skills for problem solving, increasing creativity, communicating and collaborating (Razak et al., 2022).

Microprocessor and Microcontroller subject for Digital Electronics topic is a difficult section for students. Learning Digital Electronics presents several challenges due to the complex nature of the subject matter and requires a high degree of rigor. Teachers apply learning instructions that are less suited to the characteristics of the material topics studied as well as students' lack of basic knowledge and unfocusedness in learning digital electronics are also obstacles (Bhuyan et al., 2023; Kocijancic, 2018). To overcome these challenges, a comprehensive and diverse approach to teaching and learning digital electronics is needed, including hands-on laboratory experiences, interactive simulations, collaborative projects, and opportunities for real-world applications. In addition, providing adequate support, resources and guidance to students can help them overcome barriers and successfully master the complexities of digital electronics. To learn Digital Electronics, a strong mastery of basic knowledge is required, such as electrical and electronic circuits, mathematical logic and Boolean algebra as well as the ability to analyze, think critically and solve problems. The more prior knowledge required makes the cognitive load heavier and hampers the student learning process (de Jong, 2010). Students may find it difficult to grasp abstract concepts and need additional resources or support to develop the necessary math skills (Wang & Zhao, 2023).

Seeing this phenomenon in the learning process, new models must be developed to encourage students to develop critical thinking/problem solving skills, communication, teamwork and creative thinking. Critical thinking can be trained through the learning process, because no one is born with a fixed ability, but through the learning process. Due to the dominant use of direct learning which is less effective in improving students' creative, critical, and problem-solving abilities, schools currently need a type of learning that can stimulate the growth of these skills (Maknun, 2019). Vocational education graduates must have an adaptive attitude towards the various types of jobs available in the 21st century with all its rapid developments, due to changes in the composition and required work competencies. The dynamics of this change must be responded seriously by vocational education, one of which is through the application of Blended Problem-Based Learning assisted with Advance Organizer (BPBL AO) because all stages of learning will build the skills needed in the 21st century, namely critical thinking for problem solving, creative thinking, communication, and collaboration. BPBL is PBL run in a BL environment. BL is combined with PBL to overcome the large amount of time spent in all stages of PBL and to provide flexibility for students to continue learning outside the classroom, while AO is needed to activate students' prior knowledge so that they are more adaptable to new knowledge and more active in group discussions (Ausubel, 1960). In the implementation of BPBL, students' thinking styles also have an impact on the successful achievement of learning objectives(Kusmiyati et al., 2019). BPBL is implemented in Microprocessor and Microcontroller subjects for Digital Electronics material in SMK with the aim of improving concept understanding and application of Digital Electronics concepts and moderated by students' own internal and external thinking styles.

METHODS

This research method is a quasi-experiment with the design type Nonequivalent Control Group Design. Experimental participants/subjects or study groups were determined in class XI in the Electrical Engineering Expertise Program with Industrial Electronics Engineering (EI) Expertise Competency. Class XI EI 1 is the experimental class with 34 students and 32 students in the control class, class XI EI 2. This research is quantitative research with a quasi-experimental approach with a 2x2 factorial design, Multivariate Analysis of Variance (MANOVA) is used to analyze research data.

BPBL AO was applied to the experimental class, XI EI 1 class to learn Digital Electronics Concepts and Applications which was compared with conventional learning, namely Direct Learning and moderated by external and internal thinking styles. The research was located at SMK Negeri 2 Kupang in Industrial Electronics Class 1 and Industrial Electronics Class 2. Learning styles at the internal and external levels were also seen as moderator variables.

The research design, study materials and test questions were validated before being applied in the experimental class. Pretest was given to the experimental class and control class to ensure homogeneous research subjects and normally distributed data. Advance organizer was only given to students in the experimental class at the beginning of each learning topic. The PBL used is the Seven Jump model and is run in a Blended Learning environment. Group discussions were conducted in the classroom and outside the classroom using various communication media. Research data obtained from research instruments in the form of questionnaires, observation sheets, pretests and post tests and processed with SPSS software.

RESULTS & DISCUSSION

The cross-sectional distribution of research subjects for all groups between learning types and thinking styles can be seen in Table 1.

Table 1. Distribution of Research Subjects Based on Learning Type and ThinkingStyle

		Type of Learning		**Total**
		BPBL AO	**Direct Learning**	
Thinking Style	**Internal**	15	13	28
		22,73%	19,69%	42,42%
	Eksternal	19	19	38
		28,79%	28,79%	57,58%
Total		34	32	66
		51,52%	48,48%	100%

Of the two classes, 28 students had an internal thinking style and 38 students had an external thinking style.

The data presented in Table 2. from both groups of research subjects show different values. Students in the experimental group taught with the BPBL AO learning type achieved a mean of 42.21 with a standard deviation of 6.34, while students in the control group with Direct Learning achieved a mean of 43.19 with a standard deviation of 6.61. The values of the two groups seem to differ from the mean or average, but to find out if there is a significant difference, it must be statistically analyzed for a t-test of two independent samples.

Tabel 2. Pre-test Data

Group Statistics

Pre-Test Class	N	Mean	Std. Deviation	Std. Error Mean
Experiment Class	34	42.21	6.343	1.088
Control Class	32	43.19	6.616	1.170

Before starting the t test, a classical assumption test for normality and homogeneity must be performed. The significance value (Sig) of the Kolmogrov-Smirnov test presented in Table 2 is used to test the normality of the data, with the assumption that if the sig value > 0.05 then the data is considered normally distributed. The test results show that the data is normally distributed because the Sig value of the experimental class is 0.200 > 0.05 and the Sig value of the control class is 0.122 > 0.05. Sot

Table 3. Normality Test of Pretest data

Tests of Normality

Kolmogorov-Smirnov[a]			Shapiro-Wilk			
Statistic	Df	Sig.	Statistic	Df	Sig.	
.107	34	.200*	.941	34	.066	Kelas Eksperimen
.139	32	.122	.970	32	.486	Kelas Kontrol

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The results of the Homogeneity Test for pretest data can be carried out in conjunction with the t test of two independent samples. By looking at the Levane Test value on the analysis results can determine whether the data is homogeneous. The significance value (Sig) > 0.05 is required to fulfill homogeneity. From the test conducted, the Sig value = 0.540> 0.05 is obtained, which means that the data has a homogeneous variance (Table 4).

Table 4. Data from the Pretest Two Independent Samples t Test Results
Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
asil Pre Test	Equal variances assumed	.090	.765	-.615	64	.540	-.982	1.595	-4.168	2.205
	Equal variances not assumed			-.615	63.320	.541	-.982	1.597	-4.173	2.210

The results of the two independent samples t test are shown in Table 4 To conclude whether or not there is a significant difference between the experimental class and the control class, namely by looking at the significance value (Sig) in the sig column (2-tailed) t-test equality of Means. The decision-making guideline is if the sig value is <0.05, then there is a significant difference between the two groups of research subjects. Likewise, if the Sig value> 0.05, then there is no significant difference between the two groups of research subjects.

The results of the two independent samples t-test showed no significant difference from the pretest between the experimental class and the control class. Significance value (Sig) is 0.540 > 0.05, it can be concluded that the initial ability of the two groups is almost the same or equal, so the experiment can be carried out.

Concept understanding and concept application were assessed in the BPBL AO and direct learning groups. Kolmogrov-Smirnov test results in Table 4 shows that the learning outcomes of concept understanding are 0.066 for BPBL AO and 0.200 for direct learning, while the significance value of concept application is 0.200 and 0.095 for each learning group. The research data is considered normally distributed because all sig values are greater than 0.05.

Table 5. Normality Test Results

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
Jenis pembelajaran	Statistic	df	Sig.	Statistic	df	Sig.
BPBL AO Understanding	.145	34	.066	.934	34	.040
BPBL AO Application	.109	34	.200*	.966	34	.369
PL Understanding	.106	32	.200*	.958	32	.247

Variance homogeneity testing was conducted on the learning outcome scores of Digital Electronics Concept Understanding and Digital Electronics Concept Application for both learning groups, BPBL AO and direct learning.

Table 6. Box's Test of Equality of Covariance Matrices

Box's Test of Equality of Covariance Matrices[a]

Box's M	9.735
F	1.016
df1	9
df2	29248.534
Sig.	.424

Tests the null hypothesis that the observed covariance matrices of the dependent variables are equal across groups.

a. Design: Intercept + Metode + GayaPikir + Metode * GayaPikir

The Box's M statistical value in Table 6 is 9.735, with F 1.016, and a significance of 0.424 which is greater than the 0.05 significance level so it can be said that the variance matrix for the concept understanding learning outcome variable and the concept application learning outcome are homogeneous for the learning method or thinking style group. As indicated by Box's M, homogeneity testing for each variable can be done using the Levene test. Levene's test is used to compare variances specifically for each variable, and the results in Table 7 show a significance value of 0.102 and 0.141. Similar to the Box's M test which produces a significance value above 0.05, which means that the variance matrix in the two variables is individually homogeneous.

Table 7. Homogeneity Test Lavene's Test

Levene's Test of Equality of Error Variances[a]

		Levene Statistic	df1	df2	Sig.
HB Pemahaman Konsep	Based on Mean	2.159	3	62	.102
	Based on Median	1.232	3	62	.306
	Based on Median and with adjusted df	1.232	3	56.551	.307
	Based on trimmed mean	2.079	3	62	.112
HB Aplikasi Konsep	Based on Mean	1.885	3	62	.141
	Based on Median	1.529	3	62	.216
	Based on Median and with adjusted df	1.529	3	54.848	.217
	Based on trimmed mean	1.825	3	62	.152

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Metode + GayaPikir + Metode * GayaPikir

The description of the research data obtained shows the average value for the learning outcomes of Digital Electronics Concept Understanding and Digital Electronics Concept Application between the experimental group and the control group. For concept understanding, the average value of the experimental class student group is 79.83, higher than the average value of students in the control class which is 73.30. The average value for concept application learning outcomes of the experimental class student group was 79.43, higher than the value of the student group in the control class which amounted to 72.78. The learning outcomes of both classes exceeded the 70.00 KKM set by the school.

Table 8 .Statistical Description of Research Data

Descriptive Statistics

	Model Pembelajaran	Gaya Berpikir	Mean	Std. Deviation	N
HB Pemahaman Konsep	BPBL AO	GP Internal	75.4287	9.30942	15
		GP External	83.3079	10.42044	19
		Total	79.8318	10.57190	34
	P Langsung	GP Internal	70.4400	12.39802	13
		GP External	75.2632	8.68523	19
		Total	73.3038	10.44477	32
	Total	GP Internal	73.1125	10.93950	28
		GP External	79.2855	10.30239	38
		Total	76.6667	10.93522	66
HB Aplikasi Konsep	BPBL AO	GP Internal	77.0567	8.65501	15
		GP External	81.3163	10.22336	19
		Total	79.4371	9.66426	34
	P Langsung	GP Internal	70.8969	6.47690	13
		GP External	74.0784	12.75324	19
		Total	72.7859	10.63947	32
	Total	GP Internal	74.1968	8.20202	28
		GP External	77.6974	11.97587	38
		Total	76.2123	10.61242	66

The results of multivariate testing using MANOVA are shown in Table 9 and Table 10. The results of existing data processing are used to answer the hypothesis in this study.

Table 4. 9 MANOVA (Multivariate Analysis Variance) Analysis Results

Multivariate Tests[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.989	2752.892[b]	2.000	61.000	.000
	Wilks' Lambda	.011	2752.892[b]	2.000	61.000	.000
	Hotelling's Trace	90.259	2752.892[b]	2.000	61.000	.000
	Roy's Largest Root	90.259	2752.892[b]	2.000	61.000	.000
Metode	Pillai's Trace	.146	5.208[b]	2.000	61.000	.008
	Wilks' Lambda	.854	5.208[b]	2.000	61.000	.008
	Hotelling's Trace	.171	5.208[b]	2.000	61.000	.008
	Roy's Largest Root	.171	5.208[b]	2.000	61.000	.008
GayaPikir	Pillai's Trace	.100	3.399[b]	2.000	61.000	.040
	Wilks' Lambda	.900	3.399[b]	2.000	61.000	.040
	Hotelling's Trace	.111	3.399[b]	2.000	61.000	.040
	Roy's Largest Root	.111	3.399[b]	2.000	61.000	.040
Metode * GayaPikir	Pillai's Trace	.006	.180[b]	2.000	61.000	.835
	Wilks' Lambda	.994	.180[b]	2.000	61.000	.835
	Hotelling's Trace	.006	.180[b]	2.000	61.000	.835
	Roy's Largest Root	.006	.180[b]	2.000	61.000	.835

a. Design: Intercept + Metode + GayaPikir + Metode * GayaPikir

b. Exact statistic

Table 10. MANOVA Pervariable Analysis Results (Test of Between-Subjects Effects)

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	HB Pemahaman Konsep	1402.457[a]	3	467.486	4.550	.006
	HB Aplikasi Konsep	959.470[b]	3	319.823	3.117	.032
Intercept	HB Pemahaman Konsep	372443.086	1	372443.086	3624.932	.000
	HB Aplikasi Konsep	369777.514	1	369777.514	3604.153	.000
Metode	HB Pemahaman Konsep	682.611	1	682.611	6.644	.012
	HB Aplikasi Konsep	721.296	1	721.296	7.030	.010
GayaPikir	HB Pemahaman Konsep	648.377	1	648.377	6.311	.015
	HB Aplikasi Konsep	222.504	1	222.504	2.169	.146
Metode * GayaPikir	HB Pemahaman Konsep	37.530	1	37.530	.365	.548
	HB Aplikasi Konsep	4.671	1	4.671	.046	.832
Error	HB Pemahaman Konsep	6370.180	62	102.745		
	HB Aplikasi Konsep	6361.053	62	102.598		
Total	HB Pemahaman Konsep	395705.970	66			
	HB Aplikasi Konsep	390669.017	66			
Corrected Total	HB Pemahaman Konsep	7772.636	65			
	HB Aplikasi Konsep	7320.523	65			

a. R Squared = .180 (Adjusted R Squared = .141)

b. R Squared = .131 (Adjusted R Squared = .089)

The following is an explanation of hypothesis testing based on the data analysis obtained.

The values of Pillai's Trace, Wilk's Lamda, Hotelling's Trace and Roy's Largest Root based on the results of MANOVA analysis for learning methods in Table 9 are 0.146; 0.854; 0.171; and 0.171 respectively. The calculated F value is 5.208 with a significance probability of 0.008. The criterion for making a decision is if the sig value <0.05 then H0 is rejected. The results of simultaneous testing obtained a significance value of 0.008 <0.05, so it can be interpreted that there is a significant difference in understanding the concept of Digital Electronics between students who take BPBL AO and students who take direct learning simultaneously or together.

Table 10 contains the results of the MANOVA test for each variable which shows that the value of F = 6.644 with a significance probability of less than 0.05 or 0.012 < 0.05. Therefore, H0 is rejected and it can be interpreted that there is a significant difference in Digital Electronics Concept Understanding between students who follow BPBL AO and students who follow direct learning. The results of the analysis based on table 9 and table 10 respectively are:

There is a significant difference in Understanding the Concept of Digital Electronics between students who have an internal thinking style and those who have an external thinking style simultaneously or together. There is a significant difference in Digital Electronics Concept Understanding between students who have an internal thinking style and those who have an external thinking style.

There is no interaction effect between learning and thinking style on Digital Electronics Concept Understanding. There is no interaction effect between BPBL AO and thinking style on students' Digital Electronics Concept Understanding.

There is a significant difference in Digital Electronics Concept Application between students who follow BPBL AO and students who follow direct learning simultaneously or together. There is a significant difference in Digital Electronics Concept Application between students who follow BPBL AO and students who follow direct learning.

There is a significant difference in Digital Electronics Concept Application between students who have an internal thinking style and those who have an external thinking style simultaneously or together. There is no significant difference in Digital Electronics Concept Application between students who have an internal thinking style and those who have an external thinking style. There is no interaction effect between learning and thinking style on students' Digital Electronics Concept Application.

CONCLUSION

The use of AO at the beginning of each new material discussion is proven to make students who have internal and external thinking styles more confident and active in the BPBL learning process with AO so as to make the learning outcomes of Understanding Digital Electronics Concepts and Application of Digital Electronics Concepts higher than the learning outcomes in the direct learning model.

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