ISSN 1392-0340 (Print)
ISSN 2029-0551 (Online)
https://doi.org/10.15823/p.2024.155.9

Pedagogika / Pedagogy
2024, t. 155, Nr. 3, p. 174–194 / Vol. 155, No. 3, pp. 174–194, 2024

VYTAUTO DIDŽIOJO UNIVERSITETO ŠVIETIMO AKADEMIJA

Developing Students' Critical Thinking Skills Through Differentiated Problem-Based Learning

Karunia Puji Hastuti[1], Deasy Arisanty[2], Sunarno Basuki[3], Dharmono[4], Ali Rachman[5]

[1] University of Lambung Mangkurat, Teacher Training and Education Faculty, Department of Geography Education, Jl. Brig Jend., Hasan Basri, IDN-70123 Banjarmasin, South Kalimantan, Indonesia, karuniapuji@ulm.ac.id
[2] University of Lambung Mangkurat, Teacher Training and Education Faculty, Department of Geography Education, Jl. Brig Jend., Hasan Basri, IDN-70123, Banjarmasin, South Kalimantan, Indonesia deasyarisanty@ulm.ac.id
[3] University of Lambung Mangkurat, Teacher Training and Education Faculty, Department of Physical Education, Jl. Brig Jend., Hasan Basri, IDN-70123 Banjarmasin, South Kalimantan, Indonesia, sunarno.basuki@ulm.ac.id
[4] University of Lambung Mangkurat, Teacher Training and Education Faculty, Department of Biology Education, Jl. Brig Jend., Hasan Basri, IDN-70123, Banjarmasin, South Kalimantan, Indonesia, dhar66@ulm.ac.id
[5] University of Lambung Mangkurat, Teacher Training and Education Faculty, Department of Guidance and Counselling, Jl. Brig Jend., Hasan Basri, IDN-70123, Banjarmasin, South Kalimantan, Indonesia, ali.bk@ulm.ac.id

Annotation. This study aims to analyse critical thinking skills through differentiated problem-based learning (PBL). The data analysis methods included descriptive analysis, normality tests, homogeneity tests, independent sample t-tests, N-Gain, and ANOVA. The results of the research explain that PBL with differentiated instruction effectively improves students critical thinking skills and a significant effect of learning models and learning styles on students critical thinking skills.

Keywords: *differentiated instruction, critical thinking, problem-based learning.*

Introduction

Education is essential for nation-building. A developed country has high-quality education. In the Industry 4.0 era, competition and demands in education are getting tighter and higher. Our young generation must face industrial revolution 4.0 with the

following skills: (1) critical thinking and problem solving, (2) collaboration, (3) agility and adaptability, (4) initiative and entrepreneurship, (5) effective oral and written communication, (6) accessing and analyzing information (7) curiosity, and imagination (Doringin et al., 2020; Lase, 2019). In line with this opinion, education in the 4.0 era must focus on areas of expertise, including critical thinking as a skill for various analyses, assessments, evaluations, and reconstruction, as well as the ability to make decisions for rational and logical actions (Asyari et al., 2016; Heong et al., 2020; Seibert, 2021; Silviarza et al., 2020).

Students must master critical thinking, which is crucial for making decisions and determining the best choices, especially in solving problems (Hadi et al., 2022). Critical thinking is a cognitive process to gain knowledge and is included in higher-order thinking activities (Heong et al., 2020; Retnawati et al., 2018; Rijal, 2021). Critical thinking activates the ability to analyze and evaluate evidence, identify questions and logical conclusions, and understand the implications of arguments. Thus, critical thinking is an essential activity to be developed in educational institutions, and educators are expected to be able to realize learning that activates and develops critical thinking skills in students (Mataniari et al., 2020; Seibert, 2021; Sulistyanto, 2021; Umam & Susandi, 2022; Zubaidah et al., 2020).

However, our observations of May 2023 confirmed that many students could not express ideas or opinions well during class discussions. Students only asked for definitions and trivial questions without going deep into the topic with critical and analytical questions. In addition, the evaluation results during the semester's middle and final tests showed that students needed help to answer relevant questions to measure their critical thinking skills. Our experience told us that our students needed a learning atmosphere that encouraged them to think critically to solve problems.

To overcome these problems, an innovative and compelling learning model is needed to encourage and improve students' critical thinking skills, namely the problem-based learning model with differentiated instruction. The Problem-based Learning (PBL) Model leads to critical thinking skills and encourages students to solve problems according to real life. The PBL learning model has been proven to improve students' abilities in various ways, including critical thinking skills and mastery of concepts.

PBL can train students to think critically, analyze, and solve complex problems, be able to work cooperatively in small teams and improve their ability to communicate effectively both verbally and in writing (Kasuga et al., 2022; Loyens et al., 2015; Quinn, 2020; Shamsuddin & Kaur, 2020; Tan, 2021). PBL also helps students develop thinking, and intellectual skills. This provides a broad opportunity for students to explore their potential (Razak et al., 2022). However, the PBL model also needs to improve. If a class has a high level of student diversity, there will be difficulties in dividing tasks. Another weakness is that students often find it difficult to determine the problem according to the level of thinking and the learning style influences the level of thinking (Shamsuddin

& Kaur, 2020). To provide the best way of learning for each individual and learning styles must be determined or known in advance by considering differences such as personality, perception, and students' intelligence/level of thinking.

Learning style is a unique way of learning for students (Alghasham, 2012; Shamsuddin & Kaur, 2020). This distinctive way of learning affects students' ability to understand and absorb lessons (Griffiths, 2022). Thus, it can be said that learning style is one of the factors that influences critical thinking skills and problem-solving skills for students. Learning style is also a driving factor for achieving critical thinking skills. Learning style is the most preferred, dominant way in the learning process in which individuals can receive, absorb, organize, and process the information they get. Teachers must understand students' learning styles before designing lessons to make it easier for teachers to determine the right learning model so students can understand learning materials easier.

Learning style is a form of differentiation (Dariyani et al., 2022; Shamsuddin & Kaur, 2020). An educator, besides having to vary the use of learning models and strategies, must also pay attention to students' learning styles. Differences in learning styles affect to critical-thinking skills of students. Differentiated learning is learning that pays attention to students' characteristics and uses different learning designs. It is designed through three types of differentiation: content differentiation, process differentiation, and product differentiation (Dariyani et al., 2022; Hendel, 2022; Sapan & Mede, 2022). Content differentiation differentiates "what students learn" by developing materials in different forms, such as reading materials, audio recordings, or videos. Process differentiation is based on "how students learn", in which students can choose what activities to do during the learning process. Educators are required to prepare variations in the learning activities. Product differentiation refers to learning that allows students to present their learning outcomes according to their interests and talents.

Differentiated learning is a very important perspective of teaching and learning in the 21st century. Differentiated learning is familiar in the world of education. Several studies have revealed that differentiated learning is widely adopted in motor learning. Previous findings reported that at the learning level, differentiated learning also proved to be better than traditional methods. Differentiated learning appears promising for enhancing critical and creative behavior (Osifo, 2019).

Based on some of the outcomes of previous studies, the researcher intends to elaborate on the PBL model syntax with a differentiation strategy and see its effect on students' critical thinking skills. The objectives of this research are to find out the differences in the application of the differentiated PBL model and conventional learning, determine the effectiveness of differentiated PBL models, and determine the effect of differentiated PBL models and learning styles.

The novelty of this study is the analysis of critical thinking skills in terms of the outcomes of implementing the PBL model which is elaborated with a differentiation

strategy. The research results are expected to provide information to teachers about the latest learning model in the form of a differentiated PBL model in developing the critical thinking abilities of students.

Literature Review

Problem-Based Learning

Problem-based learning (PBL) is called innovative learning because it is considered new and different from the previous conservative, conventional, and teacher-based learning models. PBL sees students not as merely objects in learning but as subjects that can be partners and contributors who can inspire ongoing learning. Therefore, PBL is a learning innovation from a conventional to a democratic one (Dagdag et al., 2021; Heong et al., 2020; Khoiriyah & Husamah, 2018; Muvid et al., 2022; Tan, 2021).

PBL can improve analytical reasoning ability because students are given the freedom to solve problems. PBL aims to make students tough and independent, accustomed to taking the initiative, and skilled at using critical thinking to solve problems. Thus, this model is expected to form the students' independence, allowing them to get accustomed to solving problems and being competitive. Ribeiro is interested in this learning model because students are involved in learning; the teacher gives them various problems, and then students are expected to analyze problems, formulate alternatives or problem-solving, determine and implement problem-solving strategies, and evaluate them (Tan, 2021). Therefore, teachers must be skilled in choosing what problems are important and related to the learning objectives. PBL is a learning model in which students try to solve problems with several scientific stages in which students are expected to learn relevant knowledge related to this problem (Heong et al., 2020; Romanowski & Alkhateeb, 2022; Tan, 2021). PBL seeks to serve students with real-world problems as a context for students to practice how to think critically and gain skills to solve problems.

To achieve learning objectives consistently, the problems created must follow the curriculum, be adapted to existing equipment, and raise realistic problems following empirical facts in the environment. The closer the problem is to the environment, the easier it will be for students to comprehend the problem and get answers more quickly.

Differentiated Learning

Barcelona (2020) introduced differentiated learning, mentioning that differentiated learning accommodates, serves, and recognizes the diversity of students in learning according to their readiness, interests, and learning preferences. The main consideration in differentiated learning is the strengths and needs of students. Differentiated

learning requires educators to pay attention and provide actions to meet the special needs of students. Differentiated learning allows teachers to see learning from various perspectives. Finding out about students and responding to their different learning styles is a cyclical process. When teachers continue to learn about the diversity of their students, then professional, efficient, and effective learning will be realized (Lintangsari & Emaliana, 2020; Magableh & Abdullah, 2022; Pozas et al., 2020). Differentiated learning is based on modifying four elements: content, process, product, and learning environment.

The goal of differentiated learning is to modify the educational program in the classroom to meet the unique needs and skills of each student; each student has their own uniqueness and different ways of understanding learning materials. So, differentiated learning is a series of activities in the form of decisions following common sense prepared by teachers for a pro-student learning model and oriented to the learning needs of students (Hendel, 2022; Magableh & Abdullah, 2022). The decision relates to the following matters: how to create a learning environment for students, define learning objectives, and provide continuous assessment to create an effective class. Knowing learning needs and the environment that facilitates all individuals in educational institutions to improve their competence safely and comfortably is crucial. Based on this, it can be concluded that differentiated learning is an attempt to adjust the learning process in the classroom to meet the individual learning needs of each learner (Barcelona, 2020; Magableh & Abdullah, 2022).

Differentiated learning typically addresses student needs by focusing on their learning interests, levels of readiness, and individual preferences. The primary objectives of differentiated learning are (Magableh & Abdullah, 2022):

1. Facilitating learning for all students by enabling educators to recognize and enhance each student's abilities, ensuring that all students can achieve their learning objectives.
2. Enhancing student motivation and academic performance by providing material that matches the student's ability levels. When instruction is tailored to their capabilities, students are more motivated and achieve better learning outcomes.
3. Fostering a positive and collaborative relationship between teachers and students, thereby enhancing student engagement and enthusiasm for learning.
4. Promoting student independence by encouraging self-directed learning and fostering respect for diversity among students.
5. Increasing teacher satisfaction by challenging educators to develop and refine their teaching skills, which enhances their creativity and professional fulfilment.

The basic principle in differentiated learning is that teachers, as class leaders, must take steps to ensure students learn what they need to achieve curriculum goals (Hendel, 2022). Before the class starts, teachers must know what is expected of students. One of the suggestions offered by many practitioners of differentiated learning is knowing, understanding, and doing. When preparing a lesson, the teacher must specify what students must achieve through knowing, understanding, and doing activities. Teachers determine the learning outcomes they expect from students by developing learning units to meet their needs.

Critical Thinking

Among the essential abilities that must be acquired through education is the ability to think critically. A person's ability to think will affect life's success because it is related to what will be done. "Learning to think emphasizes seeking and finding knowledge through interactions between individuals and the environment" (Silverblatt, 2018). This means that learning to think in the educational process in educational institutions does not only emphasize the accumulation of subject matter knowledge, but the priority is the capacity of students to acquire their knowledge (self-regulated). Someone who has critical thinking skills tends to identify relevant information quickly, separate irrelevant information and use this information to find solutions to problems or make decisions, and if necessary, look for relevant supporting information.

Students with sufficient critical thinking skills have a high probability of studying problems systematically, facing challenges in an organized way, formulating innovative questions, and devising solutions to relatively new problems. One needs to learn critical thinking skills because these skills are very useful for facing life now and in the future (Umam & Susandi, 2022). With critical thinking skills, a person can think rationally and logically to receive information and solve problems systematically. This means that critical thinking can improve analytical skills. Critical thinking skills also increase a person's creativity and innovation ability (Hakim et al., 2021). Someone with critical thinking skills can take advantage of ideas or information and look for additional relevant information so they can evaluate and then modify it to produce the best ideas. Critical thinking skills also function to reflect or self-evaluate the decisions that have been taken (Liu & Pásztor, 2022).

Critical thinking is one of the higher-order thinking skills (HOTS). The ability to think critically can be described as a person's ability to analyse an idea using logical reasoning; critical thinking is a set of skills and tendencies that allow a person to solve issues logically. Critical thinking skills can also be interpreted as a person's decision-making ability (Anggraeni et al., 2023).

Methods

Research Design

This study used the Quasi-Experimental Design method with a non-equivalent control group design (Hastjarjo, 2019). The non-equivalent control group design provides a pre-test before treatment and a post-test after treatment in each group.

Table 1

A Quasi-Experimental Design With the Non-Equivalent Control Group

Sample	Pre-test	Treatment	Post-test
Experimental Group	Y_1	T_1	Y_2
Control group	Y_1	T_2	Y_2

Sample and Data Collection

The subjects of this study were students of the Geography Education Study Program, Faculty of Teacher Training of Education, Lambung Mangkurat University, Banjarmasin, South Kalimantan Province, Indonesia, with homogeneous characteristics. Subjects were taken from classes with relatively the same (equivalent) academic ability based on the average Introduction to Wetlands Environmental Management Course score. Specifically, the students involved in this research were all 2021 Geography Education students who received the Introduction to Wetlands Environmental Management Course. We had 68 students from Batch 2021 divided into two classes (class A and class B). The two classes were then grouped into an experimental class (class A with 34 people) and a control class (class B with 34 people). The teaching material used in this research was the environmental management of wetlands for the entire 2022/2023 academic year semester. Quasi-experimental research uses only two sample groups; one sample group applies as the treatment and the other as the control group. The experimental class is given a special treatment. The control class intended in this research is a class that does not get treatment (conventional approach).

Research Instrument

The instrument used to measure critical thinking ability is displayed as an essay question. The questions are based on 5 indicators of critical thinking skills, namely: elementary clarification, basic support, inference, advanced clarification, strategies, and tactics (Ennis, 1993). Test the validity of the questions using Pearson's Product Moment correlation with a significance of 0.05. In comparison the reliability test of the item instrument uses Cronbach's alpha test with a significance of 0.05. The results test results for the validity of the questions produce a significance value of ≤ 0.05 so that they are declared valid. The reliability test results of the questions yielded a significance of $0.701 \geq 0.6$, so they were declared reliable.

Table 2
Indicators of Critical Thinking Skills

No	Critical Thinking Skills	Indicators
1	Elementary Clarification	Formulating questions leading to the answers
2	Basic Support	Making arguments with suitable or logical reasons Pointing out similarities and differences Complete arguments
3	Inference	Logical deduction Logical interpretation of statements
4	Advanced Clarification	Investigating or collecting data Generalizing data, making tables and figures Providing logical assumptions
5	Strategies and Tactics	Evaluating based on facts, principles, and guidelines Providing alternatives

Data Analysis

The data analysis technique used in this study is aimed at measuring students' critical thinking skills, namely by conducting a prerequisite test including normality and homogeneity tests, after going through the prerequisite tests followed by hypothesis testing. The prerequisite test consists of a normality and homogeneity test carried out to guarantee that the information is dispersed normally and the variance is homogeneous before testing the hypothesis. The normality test uses the Kolmogorov-Smirnov test with a significance level of 5% (0.05) with a probability value ≥ 0.05, if the probability value is high, then the data is regularly distributed is <0.05, then the distribution of the data is not normal. The homogeneity test uses Levene's test for variance equality with a confidence level of 5% with the condition that if the probability value is ≥0.05, then that data has a homogeneous variant, if the probability value is <0.05, then the data does not have a homogeneous variant. Test the hypothesis in this investigation using an independent sample t-test. The hypothesis in the study are:

$\mathbf{H_a}$: There is a significant difference between the use of differentiated problem-based learning models and conventional learning.

$\mathbf{H_o}$: There is no significant difference between the use of differentiated problem-based learning models and conventional learning.

Use the N-Gain test to find out the variation between the experimental class's and the control class's mean critical thinking scores. Furthermore, the ANOVA test was utilized for determining the impact of differentiated PBL models and learning styles. All data analysis was done using SPSS 27.0 for Windows with a significance level of 5%.

Results

Before treatment, the experimental and control classes took a pre-test to determine students' initial abilities, especially in the environmental management of wetlands. Table 3 indicates that the pre-test mean value in the experimental class was 51.71, and the control class was 51.09. These results indicate that students in the experimental and control classes had almost the same critical thinking skills before treatment. After the pre-test, the two classes were given different treatments: the experimental class with a differentiated problem-based learning model and the control class with the conventional model. Then, at the end of the lesson, a post-test was given to determine the critical thinking abilities of students after treatment. Table 3 indicates that the post-test mean the experimental class's value is 74.94, and the post-test mean of the control class is 59.09. This shows significant differences in critical thinking skills in the two classes, with the lower average value within the class of control.

Table 3
Descriptive Analysis

	N	Minimum	Maximum	Mean	Std. Deviation
Pre-Test Experiment	34	37	80	51.71	10.903
Post-Test Experiment	34	57	97	74.94	10.331
Pre-Test Control	34	33	80	51.09	12.672
Post-Test Control	34	37	86	59.09	12.305
Valid N	34				

Normality Test

We used the Kolmogrov-Smirnov method with the help of SPSS 27 for Windows, with the following criteria. If the significance value is >0.05, then the data used in the study has a normal distribution. If the significance value is <0.05, then the information used does not have a normal distribution.

Table 4 shows that the significance level for pre-test data for the experimental class is 0.102, and the control class is 0.200. This proves that the significance level of the experimental and control classes' pre-test data is >0.05, so the pre-test data in the experimental and control classes are normally distributed. The significance level for post-test data for the trial class was 0.130, and for the control class was 0.061. This shows that the significance level of the post-test data for the experimental and control classes is >0.05, so it might be said that the post-test data is normally distributed.

Table 4
Normality Test

		Kolmogorov-Smirnov			Shapiro-Wilk		
Critical Thinking Skill	**Class**	**Statistic**	**Df**	**Sig.**	**Statistic**	**df**	**Sig.**
	Pre-Test Experiment	.138	34	.102	.941	34	.067
	Post-Test Experiment	.134	34	.130	.965	34	.345
	Pre-Test Control	.122	34	.200*	.954	34	.161
	Post-Test Control	.147	34	.061	.966	34	.365

*. This is a lower bound of the true significance
a. Lilliefors Significance Correction

Homogeneity Test

The homogeneity test aims to find out whether the sample data from a population has the same or homogeneous variance. The homogeneity test was done using Levene's test with the help of SPSS 27 for Windows. Data distribution is said to be homogeneous if a significant value is >0.05, and if the significance value is <0.05, then the data distribution is said to be non-homogeneous. Table 5 shows that the data significance value is 0.471, meaning that the data presented is homogeneously distributed because 0.471 > 0.05.

Table 5
Homogenity Test

Critical Thinking		**Levene Statistic**	**df1**	**df2**	**Sig.**
	Mean	.524	1	66	.471
	Median	.624	1	66	.432
	Median and with adjusted df	.624	1	63.162	.433
	Trimmed mean	.533	1	66	.468

Independent Sample T-Test

The t-test results in Table 6 show an important distinction between the gain scores of the experimental and control groups' students' critical thinking abilities. This is evidenced by the results of the t-test calculation, where the value of significance is 0.001 <0.05. Specifically, in the end the increase in the experimental group (differentiated PBL) was higher than in the control group (conventional learning). Thus, it can be

concluded that there is a significant difference between the use of differentiated PBL and conventional learning.

Table 6
Independent Sample T-test

		Levene's Test for Equality of Variances				
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**
Critical Thinking	Equal variances assumed	.526	.471	5.850	66	<.001
	Equal variances not assumed			.580	63.686	<.001

N-Gain Score

The N-Gain score data in Table 7 indicates that the experimental class's mean critical thinking abilities score is 77.26%, and the control class's mean value is 42.34%. The variation in student scores was due to differences in treatment in the two classes. The experimental group received differentiated PBL model and the treatment of the control group with the conventional model (lectures and discussions). Regarding the outcomes of N-Gain, therefore, it may be said that differentiated PBL model effectively improves capacity for critical thinking.

Table 7
N-Gain Results

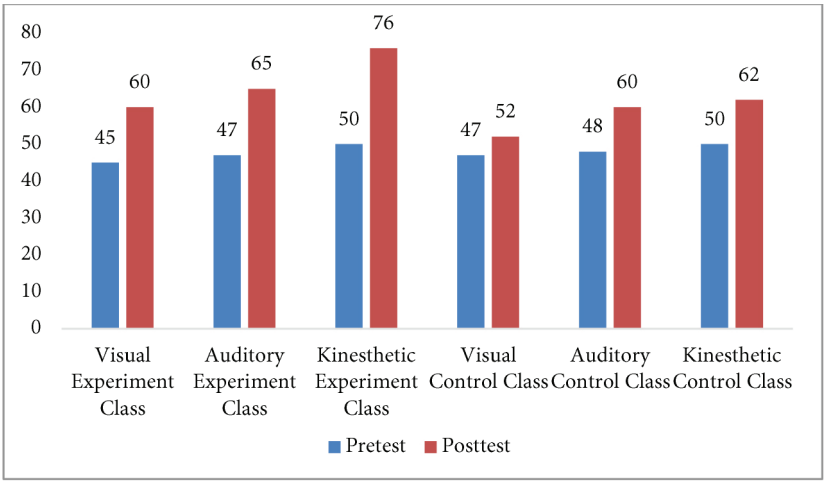
No	Group	N-Gain Score (%)	Remark
1	Experiment Class	77.26	Effective
2	Control Class	42.34	Less Effective

Anova

Before Anova, we first described the average pre-test and post-test results based on learning styles in each class (Figure 1). Based on results, which were based on differences in learning styles in the experimental and control classes, an increase in thinking critically abilities was found in each class with different learning styles; the most dominant increase was in the experimental class.

Figure 1

Pre-Test and Post-Test Results Based on Learning Style



The outcome of the hypothesis testing that investigates the impact of the differentiated PBL model and learning styles are presented in Table 8.

Table 8

Anova Results

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	441.521	2	220.760	7.685	.002[b]
	Residual	890.479	31	28.725		
	Total	1332.000	33			

Dependent Variable: Critical thinking Skills (Y)
Predictors: (Constant), Learning Style (X2), Diff. PBL Models (X1)

Table 8 shows a significance value of 0.002 < 0.05. This indicates that there is a considerable influence between the differentiated PBL model and learning styles.

Discussion

The Wetlands Environmental Management Course is one of the compulsory subjects that students must take in the Geography Education Study Program, Faculty of Teacher Training and Education, Lambung Mangkurat University. Every discussion on the environmental management of wetlands requires students to think critically because of the real conditions in the field, with many problems occurring in the wetland environment in Indonesia, including the decreasing quantity and quality. Students must be able to think critically to address problems and find the best solutions.

Considering the findings of the analysis, it is known that the experimental class's critical thinking assessment with the differentiated PBL model is better than the control class with the conventional model. This can be proven from the findings of the independent samples t test which shows a significance value of 0.001 < 0.05. The differentiated PBL model has characteristics that support learning activities, especially in the environmental management of wetlands. To get good student learning outcomes, dynamic learning activities must be pursued (Hmelo-Silver & Eberbach, 2012; Moust et al., 2021; Muangmee et al., 2021; Savery, 2015). The differentiated PBL model involves active students and trains higher-order thinking, and fosters the ability to think independently in stages or learning processes (Herzon et al., 2018; Loyens et al., 2015; Moust et al., 2021). Students' critical thinking skills increase when learning with the PBL model (Herzon et al., 2018).

PBL is based on contextual problems, which require investigative efforts to solve issues. PBL includes asking questions or problems, focusing on interdisciplinary relationships, authentic investigations, collaboration, and producing work and rewards (Batlolona & Souisa, 2020; Kolmos & Graaff, 2014; Loyens et al., 2015; Quinn, 2020). This provides an opportunity for educators to motivate and facilitate student learning needs. Among the efforts made by teachers in facilitating student learning needs is to do differentiated learning. Differentiated learning provides more opportunities for students to explore their differences to be used as strengths in understanding lessons. The process begins with collecting initial information on students through learning readiness, interests, and learning styles.

PBL combined with differentiated learning and paying attention to learning styles is increasingly able to maximize critical thinking skills. The application of learning with a differentiation strategy increases the level of students' critical thinking (Ernawati et al., 2023; Zubaidah et al., 2017; 2020). This has observed in the PBL model syntax with the differentiated strategy applied to students in this study

The first phase is problem orientation; the lecturer gives problems at this stage, and students are asked to analyse them. Problems that are contextual and meaningful for students will be more interesting, so students will start learning from an awareness. The second phase is organizing students; in this phase, the lecturer forms groups according to students' learning profiles and learning styles based on the initial diagnostic test. The third phase is guiding group investigations. At this stage, the lecturer differentiates content by freeing students to explore and choose learning resources according to their interests. In addition, the lecturer also carries out process differentiation, in which students are free to carry out learning activities according to their preferred learning style. Students who learn with a visual style, learn through videos and PowerPoint. Students with an auditory learning style learn by listening to direct explanations from the lecturer. Students who have a kinaesthetic learning style learn by conducting investigations outside the classroom.

The fourth phase is presenting and developing the work. At this stage, the lecturer performs product differentiation in which students can choose how to present their learning outcomes. Students with a visual learning style may choose to present their learning results through pictures and posters, students with an auditory learning style can present their learning results through stories, and students with a kinaesthetic learning style can present results of investigations outside the classroom (outdoor).

The fifth phase is analysing and evaluating the problem-solving process; at this stage, the lecturer and students conclude the problem-solving results, reflect together on the learning, and evaluate student learning outcomes. At this stage, the lecturer carries out a differentiation strategy by providing opportunities for the visual, auditory, and kinaesthetic groups to convey their opinions on the results of their reflection and evaluation according to their learning style.

The PBL model was very effective and supported differentiated learning. Problem orientation could develop students' critical thinking skills. Content and process differentiation could provide students with meaningful, challenging, and relevant learning experiences. Product differentiation could develop critical thinking skills and collaboration between students.

These findings are in line with previous studies which prove that the PBL model has a positive influence on students' critical thinking skills (Hakan, 2018; Herzon et al., 2018; Loyens et al., 2015; Muangmee et al., 2021; Seibert, 2021; Shamsuddin & Kaur, 2020). Students must do several things, such as accepting challenges from problems, planning problem-solving strategies, implementing strategies, and retesting the solutions in PBL. Learning activities like this raise students' creative ideas and affect their creative thinking abilities.

Differentiated learning strategies have also improved learning outcomes (Hadi et al., 2022; Magableh & Abdullah, 2022; Osifo, 2019; Pozas et al., 2020). This learning accommodates, serves, and recognizes the diversity of students in learning according to their readiness, interests, and preferences. Improving learning outcomes through differentiated learning can be seen in students' increased pleasure, enthusiasm, and motivation in understanding the subject matter. Previous research also shows that the effective use of differentiation strategies has a positive impact on student performance and learning outcomes (Dariyani et al., 2022). Differentiated PBL positively affects students' perceptions. The strategy aims to improve the achievement of all students at low, medium, and high levels in their classes. This allows more students to participate in class learning.

PBL with differentiated instruction challenges students to work together to solve problems to gain knowledge according to their learning style. Students who study according to their learning styles will feel more comfortable and easily follow every learning process. Learning that adapts to student learning styles is a form of differentiated instruction carried out by teachers. This is an advantage of PBL with differentiated

instruction; it has a better effect on students' critical thinking skills than conventional learning models.

This part provides a thorough discussion along with an explanation of the research findings. Results can be presented in figures, graphs, tables, and others that make the reader understand easily (Baier et al., 2019), (Flanagan et al., 2020). The topic can be covered in a number of subsections.

To meet the skills of Critical Thinking and Problem Solving in learning, an appropriate learning method and style is needed to support the demands of 21st century learning. Differentiated Learning emphasizes meeting the learning needs of material that is in accordance with the characteristics of each learner. The Problem-Based Learning (PBL) model is one of learning methods that has been proven effective in improving students' critical thinking and problem-solving skills.

Conclusion

Problem-based Learning (PBL) with differentiated instruction can improve students' critical thinking abilities more than conventional learning models. PBL with differentiated instruction pays attention to the distinctive characteristics of students, i.e., different learning styles. Based on the independent sample t-test, a significance value of $0.001 < 0.05$ was obtained; this marks a significant difference between using a differentiated PBL model and conventional learning on students' critical thinking skills. The N-Gain test showed that the experimental class produced a score of 77.26% while the control class was 42.34%, meaning that the differentiated PBL model effectively increases students' critical thinking skills. The ANOVA test's outcomes show a significance value of $0.002 < 0.05$. This means that there is an influence between the differentiated PBL model and learning styles. This research implies that the problem-based learning model can be elaborated with differentiated instruction by considering students' characteristics (learning styles) so that learning objectives can be better achieved.

References

Aftab, J. (2015). Teachers' beliefs about differentiated instructions in mixed ability classrooms: a case of time limitation. *Journal of Education and Educational Development*, *2*(2), 94–114. https://doi.org/ 10.22555/JOEED.V2I2.441

Alghasham, A. A. (2012). Effect of students' learning styles on classroom performance in problem-based learning. *Medical Teacher*, *34*(1), 14–19. https://www.tandfonline.com/doi/abs/10.3109/0142159X.2012.656744

Anggraeni, D. M., Prahani, B., Suprapto, N., Shofiyah, N., & Jatmiko, B. (2023). Systematic review of problem-based learning research in fostering critical thinking skills. *Thinking Skills and Creativity*, *49*, 101334. https://doi.org/10.1016/j.tsc.2023.101334

Asyari, M., Muhdhar, M. H. I. Al, & Susilo, H. (2016). Improving critical thinking skills through the integration of problembased learning and group investigation. *International Journal for Lesson and Learning Studies*, *5*(1), 36–44. https://doi.org/10.1108/IJLLS-10-2014-0042

Baier, F., Decker, A.-T., Voss, T., Kleickmann, T., Klusmann, U., & Kunter, M. (2019). What makes a good teacher? The relative importance of mathematics teachers' cognitive ability, personality, knowledge, beliefs, and motivation for instructional quality. *British Journal of Educational Psychology*, *89*(4), 767–786. https://doi.org/10.1111/bjep.12256

Balgan, A., Renchin, T., & Ojgoosh, K. (2022). An experiment in applying differentiated instruction in STEAM disciplines. *Eurasian Journal of Educational Research (EJER)*, *98*, 21–37. https://doi.org/10.14689/ejer.2022.98.02

Barcelona, A. B. (2020). An analytic hierarchy process for quality action researches in education. *International Journal of Evaluation and Research in Education*, *9*(3), 517–523. https://doi.org/10.11591/ijere.v9i3.2062

Batlolona, J. R., & Souisa, H. F. (2020). Problem based learning: students' mental models on water conductivity concept. *International Journal of Evaluation and Research in Education*, *9*(2), 269–277. http://doi.org/10.11591/ijere.v9i2.20468

Bondie, R. S., Dahnke, C., & Zusho, A. (2019). How does changing "one-size-fits-all" to differentiated instruction affect teaching? *Review of Research in Education*, *43*(1), 336–362. https://doi.org/10.3102/0091732X18821130

Bouguerne, A., & Keskes, S. (2022). Exploring Algerian EFL students' perceptions about learning styles and learning development in higher education. *Revue Académique Des Études Sociales et Humaines*, *14*(4), 78–88.

Dagdag, J. D., Palapuz, N. A., & Calimag, N. A. (2021). Predictive ability of problem-solving efficacy sources on mathematics achievement. *International Journal of Evaluation and Research in Education*, *10*(4), 1185–1191. http://doi.org/10.11591/ijere.v10i4.21416

Dariyani, N., Marlina, L., Sriyanti, I., Sudirman, S., & Meilinda, M. (2022). Learning style analysis for differentiated new paradigm learning in public senior high school 1 semendawai suku III east oku. *Jurnal IPA & Pembelajaran IPA*, *6*(3), 247–258. https://doi.org/ 10.24815/jipi.v6i3.25704

Doringin, F., Tarigan, N. M., & Prihanto, J. N. (2020). The existence of education in the industrial revolution 4.0 era. *Jurnal Teknologi Industri dan Rekayasa (JTIR)*, *1*(1), 43–48. https://doi.org/10.53091/jtir.v1i1.17

Ediansyah, E., Kurniawan, D. A., Perdana, R., & Salamah, S. (2019). Using problem-based learning in college: mastery concepts subject statistical research and motivation. *International Journal of Evaluation and Research in Education*, *8*(3), 446–454. http://doi.org/10.11591/ijere.v8i3.20243

Ennis, R. H. (1993). Critical thinking assessment. *Theory into Practice*, *32*(3), 179–186. https://doi.org/10.1080/00405849309543594

Ernawati, M. D. W., Yusnidar, Y., Haryanto, H., Rini, E. F. S., Aldila, F. tia, & Perdana, R. (2023). Do creative thinking skills in problem-based learning benefit from scaffolding? *Journal of Turkish Science Education*, *20*(3), 1–19. https://doi.org/10.36681/tused.2023.023

Flanagan, A. M., Cormier, D. C., & Bulut, O. (2020). Achievement may be rooted in teacher expectations: examining the differential influences of ethnicity, years of teaching, and classroom behaviour. *Social Psychology of Education*, *23*, 1429–1448. https://doi.org/10.1007/s11218-020-09590-y

Griffiths, C. (2022). Learning styles and strategies. In Li, S., Hiver, P., & Papi, M. (Eds.), *The Routledge Handbook of Second Language Acquisition and Individual Differences* (1st ed., pp. 82–94). Routledge. https://doi.org/10.4324/9781003270546

Hadi, W., Wuriyani, E. P., Yuhdi, A., & Agustina, R. (2022). Differentiated learning design with problem-based learning supports students' critical thinking skills in the new normal era after the COVID-19 pandemic. *Basastra*, *11*(1), 56–68. https://doi.org/10.24114/bss.v11i1.33852

Hakan, K. O. Ç. (2018). Teaching geography in higher education: A case study of problem-based learning. *Review of International Geographical Education Online*, *8*(2), 311–337.

Hakim, L. N., Rachmawati, E., & Purwaningsih, S. (2021). Teachers' strategies in developing students' critical thinking and critical reading. *Pedagogia: Jurnal Pendidikan*, *10*(1), 11–19. https://doi.org/10.21070/pedagogia.v10i1.1036

Hastjarjo, T. D. (2019). Quasi-experimental design. *Buletin Psikologi*, *27*(2), 187–203. https://doi.org/ 10.22146/buletinpsikologi.38619

Hendel, R. J. (2022). A transdisciplinary approach to differentiated instruction. *Journal of Systemics, Cybernetics and Informatics*, *20*(1), 65–85. https://doi.org/10.54808/JSCI.20.01.65

Heong, Y. M., Hamdan, N., Ching, K., Kiong, T., & Azid, N. (2020). Development of integrated creative and critical thinking module in problem-based learning to solve problems. *International Journal of Scientific and Technology Research*, *9*(3), 6567–6571.

Herzon, H. H., Budijanto, B., & Utomo, D. H. (2018). The influence of problem-based learning on critical thinking skills. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan*, *3*(1), 42–46. https://doi.org/ 10.17977/jptpp.v3i1.10446

Kasuga, W., Maro, W., & Pangani, I. (2022). Effect of problem-based learning approach on developing students' science process skills on the topic of safety in our environment. *Journal of Turkish Science Education*, *19*(3), 872–886. https://doi.org/10.36681/

Khoiriyah, A. J., & Husamah, H. (2018). Problem-based learning: Creative thinking skills, problem-solving skills, and learning outcome of seventh grade students. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *4*(2), 151–160. https://doi.org/10.22219/jpbi.v4i2.5804

Kolmos, A., & Graaff, E. de. (2014). Problem-based and project-based learning in engineering education Merging Models. In A. Johri (Eds.), *Cambridge Handbook of Engineering Education Research* (1st ed., pp. 141–160). Cambridge University Press. https://doi.org/10.1017/CBO9781139013451.012

Lase, D. (2019). Education in the industrial revolution 4.0 era. *SUNDERMANN: Jurnal Ilmiah Teologi, Pendidikan, Sains, Humaniora Dan Kebudayaan*, *12*(2), 28–43. https://doi.org/10.36588/sundermann.v1i1.18

Lintangsari, A. P., & Emaliana, I. (2020). Inclusive education services for the blind: values, roles, and challenges of university EFL teachers. *International Journal of Evaluation and Research in Education*, *9*(2), 439–447. https://doi.org/10.11591/ijere.v9i2.20436

Liu, Y., & Pásztor, A. (2022). Effects of problem-based learning instructional intervention on critical thinking in higher education: A meta-analysis. *Thinking Skills and Creativity*, *45*, 101069. https://doi.org/10.1016/j.tsc.2022.101069

Loyens, S. M. M., Jones, S. H., Mikkers, J., & Gog, T. van. (2015). Problem-based learning as a facilitator of conceptual change. *Learning and Instruction*, *38*, 34–42. https://doi.org/10.1016/j.learninstruc.2015.03.002

Magableh, I. S., & Abdullah, A. (2022). Differentiated instruction effectiveness on the secondary stage students' reading comprehension proficiency level in Jordan. *International Journal of Evaluation and Research in Education*, *11*(1), 459–466. https://doi.org/10.36681/

Manurung, A. S., Halim, A., & Rosyid, A. (2023). The role of problem-based learning learning in improving student character education. *Jurnal Basicedu*, *7*(1), 169–170. https://doi.org/10.5430/wjel.v12n7p319

Marni, S., Aliman, M., & Harsiati, T. (2020). Students' critical thinking skills based on gender and knowledge group. *Journal of Turkish Science Education*, *17*(4), 544–560.

Mataniari, R., Willison, J., HASIBUAN, M. H. E., Sulistiyo, U., & Fatria, D. (2020). Portraying students' critical thinking skills through research skill development (RSD) framework: A case of a biology course in an Indonesian University. *Journal of Turkish Science Education*, *17*(2), 302–314. https://doi.org/10.36681/

Moust, J., Bouhuijs, P., & Schmidt, H. (2021). *Introduction to problem-based learning: A guide for students.* Routledge.

Muangmee, C., Kot, S., Meekaewkunchorn, N., Kassakorn, N., Tiranawatananun, S., & Khalid, B. (2021). Students' use behavior towards e-learning tools during Covid-19 pandemics: case study of higher educational institutions of Thailand. *International Journal of Evaluation and Research in Education*, *10*(4), 1166–1175. http://doi.org/10.11591/ijere.v10i4.21821

Muvid, M. B., Septiawan, Y., Lubis, M. A., & Zainiyati, H. S. (2022). Shaping socio-critical thinking of junior students using problem-based learning and inquiry strategy. *International Journal of Evaluation and Research in Education*, *11*(2), 780–789. http://doi.org/10.11591/ijere.v11i2.21954

Negoro, R. A., Rusilowati, A., & Aji, M. P. (2023). Scratch-assisted waves teaching materials: ict literacy and students' critical thinking skills. *Journal of Turkish Science Education*, *20*(1), 189–210. https://doi.org/10.36681/

Osifo, A. (2019). Improving collaboration in blended learning environments through differentiated activities and mobile-assisted language learning tools. *International*

Association for Development of the Information Society, 3–10 https://doi.org/10.33965/ml2019_201903L001

Pozas, M., Letzel, V., & Schneider, C. (2020). Teachers and differentiated instruction: exploring differentiation practices to address student diversity. *Journal of Research in Special Educational Needs*, *20*(3), 217–230. https://doi.org/10.1111/1471-3802.12481

Quinn, A. (2020). Incorporating problem-based learning skills into graduate and professional student classes. *Journal of Problem Based Learning in Higher Education*, *8*(2), 115–128. https://doi.org/10.5278/ojs.jpblhe.v8i2.3595

Raleiras, M., Nabizadeh, A. H., & Costa, F. A. (2022). Automatic learning styles prediction: A survey of the State-of-the-Art (2006–2021). *Journal of Computers in Education*, *9*(4), 587–679. https://doi.org/10.1007/s40692-021-00215-7

Razak, A. A., Ramdan, M. R., Mahjom, N., Zabit, M. N. M., Muhammad, F., Hussin, M. Y. M., & Abdullah, N. L. (2022). Improving critical thinking skills in teaching through problem-based learning for students: A scoping review. *International Journal of Learning, Teaching and Educational Research*, *21*(2), 342–362. https://doi.org/10.26803/ijlter.21.2.19

Retnawati, H., Djidu, H., Kartianom, A., & Anazifa, R. D. (2018). Teachers' knowledge about higher-order thinking skills and its learning strategy. *Problems of Education in the 21st Century*, *76*(2), 215.

Rijal, M. (2021). Differences in learners' critical thinking by ability level in conventional, NHT, PBL, and integrated NHT-PBL classrooms. *International Journal of Evaluation and Research in Education (IJERE)*, *10*(4), 1133–1139. https://doi.org/10.11591/ijere.v10i4.21408

Romanowski, M. H., & Alkhateeb, H. (2022). Problematizing accreditation for teacher education. *Higher Education Policy*, 1–21. https://doi.org/10.1057/s41307-022-00264-2

Sapan, M., & Mede, E. (2022). The effects of differentiated instruction (di) on achievement, motivation, and autonomy among English learners. *Iranian Journal of Language Teaching Research*, *10*(1), 127–144. https://doi.org/10.30466/ijltr.2022.121125

Savery, J. R. (2015). Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-Based Learning*, *1*(1), 9–20. https://doi.org/10.7771/1541-5015.1002

Seibert, S. A. (2021). Problem-based learning: A strategy to foster generation Z's critical thinking and perseverance. *Teaching and Learning in Nursing*, *16*(1), 85–88. https://doi.org/10.1016/j.teln.2020.09.002

Shamsuddin, N., & Kaur, J. (2020). Students' learning style and its effect on blended learning, does it matter? *International Journal of Evaluation and Research in Education*, *9*(1), 195–202. http://doi.org/10.11591/ijere.v9i1.20422

Silverblatt, A. (2018). Media literacy and critical thinking. *International Journal of Media and Information Literacy*, *3*(2), 66–71. https://doi.org/10.13187/ijmil.2018.2.66

Silviarza, W., Sumarmi, S., & Handoyo, B. (2020). Using of Spatial Problem Based Learning (SPBL) model in geography education for developing critical thinking skills. *Journal for the Education of Gifted Young Scientists*, *8*(3), 1045–1060. https://doi.org/10.17478/jegys.737219

Sulistyanto, H. (2021). The potential of hybrid learning models in improving students' critical thinking ability. *Urecol Journal. Part A: Education and Training*, *1*(1), 1–8. https://doi.org/10.53017/ujet.15

Tan, O.-S. (2021). *Problem-based learning innovation: Using problems to power learning in the 21st century*. Gale Cengage Learning.

Umam, K., & Susandi, A. D. (2022). Critical thinking skills: error identifications on students' with APOS Theory. *International Journal of Evaluation and Research in Education*, *11*(1), 182–192. 10.11591/ijere.v11i1.21171

Utaminingsih, M., Widjanarko, M., & Ismaya, E. A. (2022). The effect of problem-based learning assisted by peer tutoring on student's critical thinking ability. *ANP Journal of Social Science and Humanities*, *3*, 101–106. https://doi.org/10.53797/anp.jssh.v3sp2.14.2022

Zabit, M. N. M. (2010). Problem-based learning on students critical thinking skills in teaching business education in Malaysia: A literature review. *American Journal of Business Education (AJBE)*, *3*(6), 19–32. https://doi.org/EJ1058610

Zubaidah, S., Fuad, N. M., Mahanal, S., & Suarsini, E. (2017). Improving creative thinking skills of students through differentiated science inquiry integrated with mind map. *Journal of Turkish Science Education*, *14*(4), 77–91. https://doi.org/10.36681/

Zubaidah, S., Mahanal, S., & Fauzi, A. (2020). Critical thinking embedded essay test. *International Conference on Biology, Sciences and Education (ICoBioSE 2019)*, 171–177.

Studentų kritinio mąstymo įgūdžių lavinimas taikant diferencijuotą probleminį mokymąsi

Karunia Puji Hastuti[1], Deasy Arisanty[2], Sunarno Basuki[3], Dharmono[4], Ali Rachman[5]

[1] Lambung Mangkurat universitetas, Mokytojų rengimo ir švietimo fakultetas, Geografijos edukologijos katedra, Jl. Brig Jend. Hasan Basri, IDN-70123 Bandžarmasinas, Pietų Kalimantanas, Indonezija, karuniapuji@ulm.ac.id

[2] Lambung Mangkurat universitetas, Mokytojų rengimo ir švietimo fakultetas, Geografijos edukologijos katedra, Jl, Brig Jend. Hasan Basri, IDN-70123 Bandžarmasinas, Pietų Kalimantanas, Indonezija, deasyarisanty@ulm.ac.id

[3] Lambung Mangkurat universitetas, Mokytojų rengimo ir švietimo fakultetas, Kūno kultūros katedra. Jl, Brig Jend. Hasan Basri, IDN-7012 Bandžarmasinas, Pietų Kalimantanas, Indonezija, sunarno.basuki@ulm.ac.id

[4] Lambung Mangkurat universitetas, Mokytojų rengimo ir švietimo fakultetas, Biologijos mokymo katedra, Jl. Brig Jend. Hasan Basri, IDN-70123 Bandžarmasinas, Pietų Kalimantanas, Indonezija, dhar66@ulm.ac.id

[5] Lambung Mangkurat universitetas, Mokytojų rengimo ir švietimo fakultetas, Profesinio orientavimo ir konsultavimo katedra, Jl. Brig Jend. Hasan Basri, IDN 70123 Bandžarmasinas, Pietų Kalimantanas, Indonezija, ali.bk@ulm.ac.id

Santrauka

Šio tyrimo tikslas – išanalizuoti studentų kritinio mąstymo įgūdžius taikant diferencijuoto probleminio mokymosi modelį. Šiame tyrime dalyvavo 68 Indonezijos Lambung Mangkurat universiteto Mokytojų rengimo ir švietimo fakulteto Geografijos edukologijos katedros studentai.

Renkant duomenis respondentams buvo pateikti klausimai, apimantys kritinio mąstymo įgūdžius. Šiame tyrime naudotas kvazieksperimentinio dizaino metodas ir buvo išskirtos eksperimentinės ir kontrolinės grupės. Kiekvienai grupei buvo pateikti klausimai prieš testą, testo metu ir po testo. Šiame tyrime naudoti šie duomenų analizės metodai: aprašomoji analizė, normalumo testas, homogeniškumo testas, nepriklausomos imties t-testas, N-Gain, ir ANOVA. Tyrimo rezultatai rodo: 1) reikšmingą studentų kritinio mąstymo įgūdžių skirtumą diferencijuoto probleminio mokymosi ir įprastinio mokymosi taikymo metu; 2) probleminio mokymosi taikant diferencijuotą mokymą efektyvumą lavinant mokinių kritinio mąstymo įgūdžius; 3) reikšmingą mokymosi modelių ir mokymosi stilių poveikį mokinių kritinio mąstymo įgūdžiams.

Esminiai žodžiai: *diferencijuotas mokymas, kritinis mąstymas, probleminis mokymasis.*

Gauta 2024 02 16 / Received 16 02 2024
Priimta 2024 10 02 / Accepted 02 10 2024