Journal of Primary Education
14 (1) (2025) :16 – 27

https://journal.unnes.ac.id/sju/index.php/jpe

Cognitive Learning Outcomes of Elementary School Students Through Differentiated Problem-Based Learning

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Article Info

History Articles
Received:
15 April 2025
Accepted:
18 Mei 2025
Published:
30 Juni 2025

Keywords:
Cognitive Learning Outcomes; Differentiated Learning; Problem-Based Learning

Abstract

Learning that focuses solely on one-way knowledge transmission without integrating students into the learning process is one factor contributing to students' low cognitive learning outcomes. Conventional learning encompasses this kind of learning. Since every student learns differently, the current application of the Merdeka Curriculum's tenets is not in line with the use of conventional teaching methods. The purpose of this study is to investigate how the use of a differentiated Problem-Based Learning paradigm can improve students' cognitive learning outcomes in science. This study uses Nonequivalent Control Group Design and is quantitative in nature. The study's sample comprised 28 fourth-grade children from SDN Ngemplak Simongan 01 and 28 students from SDN Manyaran 03. The N-Gain test findings, which show that the experimental group received an average score of 0.71 while the control group received an average score of 0.55, provide evidence of this. Furthermore, the independent sample t-test used for hypothesis testing produced a significant value of 0.000<0.05, which resulted in the rejection of H_0. This suggests that, in comparison to children who received conventional instruction, the cognitive learning outcomes of students taught utilizing the differentiated PBL paradigm demonstrated a high degree of progress and a significant difference

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p-ISSN 2252-6404
e-ISSN 2502-4515

INTRODUCTION

Education is a life process that aims to help people reach their full potential within individuals so that they are able to live their lives fully as well-educated human beings in terms of cognitive, affective, and psychomotor aspects (Aprima & Sari, 2022). Moreover, it can create quality future generations who are capable of competing, possess good morals and noble character, and can adapt in line with the times (Ramadha & Zuhaida, 2021). To date, the administration is still working to raise educational standards. through enhancing curriculum quality, developing more modern learning strategies, and implementing innovative teaching tools to evaluate students' learning levels (Himmah & Nugraheni, 2023).

Indonesian education now uses the Merdeka Curriculum, which emphasizes humanizing humans and giving students freedom in learning. IPAS is one of the disciplines in the Merdeka Curriculum, as per the Decree of the Minister of Education, Culture, Research, and Technology of the Republic of Indonesia Number 262/M/2022. The natural and social sciences are combined to form IPAS. Science encompasses the process of discovery as well as the mastery of information expressed in the form of facts, concepts, or principles (Wahyu et al., 2020). Elementary school science instruction can give kids the chance to organically foster their curiosity, hone their questioning abilities, look for evidence-based explanations for natural events, and cultivate scientific thinking (Astiti et al., 2021).

The findings of the observations made at Semarang's SDN Ngemplak Simongan 01 indicate that the implementation of learning still uses conventional methods. Learning is delivered in a one-way manner, also known as teacher-centered. As a result, students are unable to explore their abilities, feel bored, and lack enthusiasm in following the lessons. The subject matter being investigated is not well understood because the teacher only instructs students to memorize the material without involving them or allowing them to directly witness the process of new knowledge being formed. Therefore, the knowledge provided does not last long in students' memories and leads to low cognitive learning outcomes. The scores that students receive after completing the learning process through achievement assessments represent these cognitive learning outcomes. (Ilma et al., 2022; Wahab et al., 2021). Cognitive learning outcomes in Science learning play a role in conveying character messages and in training students to be skilled thinkers (Hasanah & Fitria, 2021).

Since every student learns differently, the current Independent Curriculum's tenets are not supported by the employment of conventional teaching methods while teaching. Diagnostic tests are not used to ascertain students' skills, interests, or learning preferences before instruction. Standardizing the way materials are delivered and assignments are given to all students is an action that does not align with students who have different learning needs. This problem arises because learning has not been conducted according to the students' needs. Every student is different, which motivates teachers to adapt their instruction to the traits of the students they work with. Ideally, teachers should respond to students' uniqueness by providing learning through appropriate strategies or methods to facilitate students in absorbing knowledge optimally. Differentiated instruction is one of the teaching methods that can meet the demands of the students.

By giving students the chance to acquire material, process concepts, and enhance their individual learning outcomes, differentiated learning fosters a diverse learning environment in the classroom, thereby enhancing learning effectiveness (Faiz et al., 2022; Kahmann et al., 2022). Additionally, by identifying and tailoring instruction to each student's unique learning preferences and talents, differentiated learning is one tactic that teachers can use to address the distinct features of their students. (Ayu Sri Wahyuni, 2022; Djatmika & Astutik, 2023). Differentiated learning has characteristics such as a learning environment that invites students to learn, continuous assessment, a curriculum with specific learning goals, teachers who are quick to

respond to students' needs, and efficient classroom management (Sarie, 2022).

When students focus, process, internalize, and retain new and challenging knowledge or abilities, they develop learning habits that shape their learning styles (Arono et al., 2022). Three categories of learning styles have been identified: kinesthetic (through motor activities), auditory (through hearing), and visual (through visualization) (Adawiyah et al., 2020). The secret to students' learning success is having a suitable learning style (Nuralan et al., 2022). Therefore, in order to maximize learning results, students must be guided and aided in identifying the learning styles that work best for them during learning activities.

Differentiated learning can be approached in three ways: content, procedure, and product (Nawati et al., 2023). What kids learn in relation to the curriculum and instructional resources is referred to as content differentiation. Students' handling of concepts and information is known as process differentiation, including how they choose learning methods. Product differentiation is how students demonstrate the work they have learned.

The Problem-Based Learning model is one of the suggested learning models for implementing the Merdeka curriculum.. One type of learning model is the Problem-Based Learning (PBL) model is a learning model that directs students to solve problems by seeking information based on real-world situations and then resolving them (Sari et al., 2021; Tawfik et al., 2021). PBL makes learning student-centered through problem-solving experiences and activates skills such as questioning, researching, decision-making, communication, negotiation, and problem-solving (Bayram & Deveci, 2022; Chaidam & Poonputta, 2022).

The Problem Based Learning (PBL) model has characteristics, including: 1) student-centered; 2) students are encouraged to take responsibility for acquiring knowledge in their learning; 3) the problems used as a starting point for learning are real-world problems that are ill-structured, integrated with various disciplines, and require investigation; 4) teachers act as facilitators; 5) collaboration and communication are important for building student cooperation in problem-solving; 6) reviewing students' understanding of concepts in problem-solving; 7) assessment in the form of self-assessment and peer assessment; 8) and assessing to determine progress in knowledge (Zainal, 2022).

According to the statement, the goal of this research is to investigate how a differentiated problem-based learning model might be used to enhance the cognitive learning outcomes of science classes in elementary schools. This research is expected to provide benefits to teachers as a reference in selecting approaches and learning models that are appropriate for the teaching material, thereby improving students' cognitive learning outcomes. In addition, it can serve as a reference for relevant parties for further research.

METHOD

This study is a quantitative experimental research that uses the "Nonequivalent Control Group Design." Purposive Sampling technique is one of the Nonprobability Sampling techniques in which the sample is determined based on certain considerations (Sugiyono, 2020: 152). The design is illustrated in the following Table 1.

Table 1. Research Design Scheme

Group	*Pretest*	Treatment	*Posttest*
A	O_1	X	O_2
B	O_3		O_4

Description: X= differentiated Problem-Based Learning Model; O1= pretest of cognitive learning outcomes in the control group; O2 = pretest of cognitive learning outcomes in the experimental group; O3= posttest of critical thinking skills in the experimental group; O4 = posttest of cognitive learning outcomes in the control group

The population consists of all subjects to be measured, having certain quantities and characteristics as determined by the researcher. Meanwhile, a sample is a part of the population (Sugiyono, 2020: 145). Fourth-grade students make up the study's population. from elementary schools in the Sinta cluster, West Semarang District, Semarang City, totaling 10 schools, including: SD Negeri Ngemplak Simongan 01, SD Negeri Manyaran 03, SD Negeri Manyaran 01, SD Negeri Kalibanteng Kidul 02, SD Alqolan, and SD Maranatha. Students in the fourth grade from SD Negeri Ngemplak Simongan 01, of which 28 are in the experimental class, and SD Negeri Manyaran 03, of which 28 are in the control class, make up the study's sample.

The sample selection used a Purposive Sampling technique. Purposive Sampling is a technique of Nonprobability Sampling in which the sample is determined based on certain considerations (Sugiyono, 2020: 152). The considerations used as a reference in determining the research sample are as follows: 1) the school independently implements the Merdeka Curriculum; 2) students are in classes with heterogeneous abilities, not special or advanced classes; 3) both schools, particularly in grade IV, have never received differentiated Problem-Based Learning.

This study included questionnaires, tests, observations, interviews, and documentation as data gathering methods. The instruments for the questionnaire and tests, in the form of pretests and posttests, were analyzed for validity and reliability before being used. Furthermore, the data from the pretests and posttests were processed using normality tests, homogeneity tests, n-gain tests, and hypothesis tests. The study hypothesizes that fourth-grade elementary school students who were taught using a differentiated Problem-Based Learning model versus a conventional model had different cognitive learning results.

RESULTS AND DISCUSSION

The normality and homogeneity of the research data, which consisted of pretest and posttest outcomes of students' cognitive learning from the experimental class and the control class, were initially examined. The purpose of this test is to ascertain whether or not each variable that will be evaluated is normally distributed, as well as whether or not the subjects are drawn from a homogeneous variance. Tables 2 and 3 display the findings of the homogeneity and normalcy tests.

Table 2. Normality Test Results Data

	Class	Kolmogorov-Smirnov[a]		
		Statistic	df	Sig.
Cognitive Learning Outcomes	Pretest A (Control)	.145	28	.137
	Posttest A (Control)	.158	28	.073
	Pretest B (Experiment)	.151	28	.103
	Posttest B (Experiment)	.150	28	.107

The data are known to be regularly distributed based on the preceding table. The significance values of the pretest in class A at 0.137, the pretest in class B at 0.103, the posttest in class A at 0.073, and the posttest in class B at 0.107 demonstrate this. The fact that all of these significant values are higher than 0.05 indicates that students' cognitive learning outcomes pretest and posttest scores in the PBL class are differentiated, whereas in the conventional class, they are normally distributed.

Table 3. Homogeneity Test Result Data

			Levene Statistic	df1	df2	Sig.
Cognitive Learning Outcomes	Pretest	Based on Mean	1.301	1	54	.259
	Posttest	Based on Mean	.153	1	54	.697

The output results from the homogeneity test above show that the pretest significance value is 0.259 and the posttest significance value is 0.697. Both data have a significance value > 0.05. This indicates that the cognitive learning results of students as measured by the pretest and posttest in both classes are considered homogeneous or have the same variance. In the experimental class at SDN Ngemplak Simongan 01, before the learning was conducted, students were given a learning style questionnaire. Table 4 displays the findings from the learning style survey

.

Table 4. Student Learning Style Results Data

No	Learning Style	Total	Percentage
1	Visual	14	50%
2	Auditorial	9	32%
3	Kinesthetic	5	18%
Total		28	100%

According to Table 4, there are three different learning styles among the fourth-graders at SDN Ngemplak Simongan 01: 50%, or 14 kids, have a visual learning style, 32%, or 9 students, have an auditory learning style, and 18%, or 5 students, have a kinesthetic learning style. This suggests that visual learning is preferred by students.

Figure 1 below displays the pretest and posttest results for students utilizing both the conventional and differentiated PBL models.

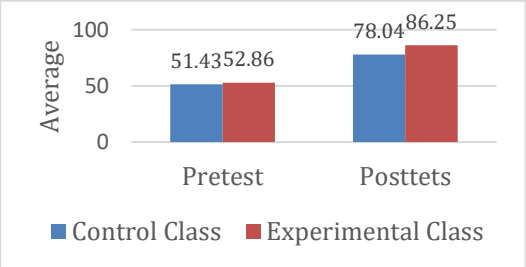

Figure 1. Increase in Average Pretest and Posttest Scores of Cognitive Learning Outcomes

With an average pretest score of 52.86 and a posttest score of 86.25, the experimental class's learning outcomes employing a differentiated PBL model were examined in grade IV at SDN Ngemplak Simongan 01 with 28 students. The data analysis is displayed in Figure 1. On the other hand, the control class's data analysis of learning outcomes utilizing the lecture technique, which involved 28 students in grade IV at SDN Manyaran 03, yielded an average pretest score of 51.43 and a posttest score of 78.04. The average pretest and posttest scores of students' learning outcomes in differentiated PBL learning and conventional learning differ significantly, according to this research.

The N-Gain test can be used to examine the progress in student learning outcomes in

addition to comparing the pretest and posttest averages. By comparing the rise in scores between the pretest and posttest, the N-Gain test also functions as a gauge of how well students are learning. Table 5 below explains the N-Gain test results on students' cognitive learning outcomes.

Table 5. N-Gain Test Result Data

Individual Gain				
Improvement Category	Differentiated PBL Class		Conventional Class	
	Number of Respondents	Percentage	Number of Respondents	Percentage
Hight	14	50%	2	7%
Medium	14	50%	26	93%
Low	0	0%	0	0%
Total	28	100%	28	100%

The N-Gain test of students' cognitive learning outcomes in both classes—the experimental class at SDN Ngemplak Simongan 01 with differentiated PBL learning and the control class at SDN Manyaran 03 with conventional learning—is summarized in Table 5. There were 28 students in each of the two classes who responded. There was a 50% increase in cognitive learning outcomes in the differentiated PBL class, with 14 respondents falling into the high group, 14 respondents falling into the medium category, and 0% of respondents falling into the low category. In contrast, just 7% of respondents, or 2 respondents, fell into the high increase category for kids' learning outcomes in the conventional class, while the remaining 26 respondents, or 93%, fell into the poor category.

A t-test for independent samples was then performed. This test was used to determine whether the cognitive learning outcomes of the class receiving differentiated PBL learning and the class receiving conventional learning differed in a way that was statistically significant. Table 6 displays the findings of the independent sample t-test.

Table 6. Hypothesis Test Results using the Independent Samples Test

		t-test for Equality of Means						
		t	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
							Lower	**Upper**
Cognitive Learning Outcomes	Equal variances assumed	-4.160	54	.000	-8.214	1.975	-12.173	-4.255
	Equal variances not assumed	-4.160	53.716	.000	-8.214	1.975	-12.174	-4.255

Using SPSS 25 and a significance threshold of 5%, Table 6 presents the findings of the independent sample t-test from the cognitive learning outcome data of students in the conventional class (control class) and the differentiated PBL class (experimental class). Since the test's significance value of 0.000 is less than the significance level of 0.05, the hypothesis states that H0 is rejected and H1 is accepted. This indicates that there is a substantial difference between the cognitive learning outcome data of students who received differentiated PBL and conventional learning.

The N-Gain test results in the experimental class indicated an increase classified as high, whereas the control class showed an increase

classified as moderate, based on the pretest and posttest scores. This suggests that while students in both classrooms made substantial progress, the class that received PBL (Problem-Based Learning) instruction saw a greater rise than the class that received conventional education. H0 is rejected based on the findings of the independent sample t-test or the difference test of the mean cognitive learning outcomes of the pretest and posttest for both classes, which had a significant value of 0.000 < 0.05. This suggests that when compared to students who received conventional instruction, the cognitive learning outcomes of students taught using the differentiated PBL methodology differ significantly. Higher cognitive learning outcomes were attained by students who were taught using the differentiated PBL paradigm; all of these outcomes exceeded the minimum competency requirements (KKM). Thus, it can be inferred from the comparison of the mean scores on the pretest and posttest, the results of the N-Gain test, and the results of the difference test that differentiated problem-based learning is more successful than conventional learning at enhancing cognitive learning outcomes.

By addressing students' needs and teaching them to solve problems using knowledge from the real world, the differentiated PBL learning paradigm promotes student participation in the learning process. (Bosica et al., 2021; Deniş-Çeliker & Dere, 2022; Nabilah et al., 2022). PBL students who engage in differentiated instruction seem excited about learning, highly curious, and actively work to solve the teacher's challenges. As a result, educators are crucial to establishing a purposeful and joyful learning environment(Sari et al., 2021). Using the differentiated PBL learning paradigm in the experimental class and conventional learning in the control class, this study was carried out over the course of three meetings. The steps of the differentiated PBL learning paradigm were used in the experimental class during the course of three meetings, while the control class received conventional instruction.

To determine the learning styles of the fourth-grade students at SDN Ngemplak Simongan 01, a diagnostic assessment in the form of a questionnaire was given at the start of the experimental class's learning process. Three student learning styles—visual, auditory, and kinesthetic—are examined in this study. Students prefer learning with a visual approach, according to the findings of the study on their learning preferences. The findings of this investigation served as guidance for group formation in differentiated problem-based learning (PBL). One strategy to address students' learning needs is to group them according to their preferred methods of learning. Students received instruction using the differentiated Problem-Based Learning paradigm over the course of the next three days. Using this approach, learning occurs in the following five phases.

Orienting kids to the problem is the first phase. The teacher (researcher) provides students with an introduction by showing pictures and questions about the energy present in the surrounding environment. In this phase, students actively give their opinions about the pictures based on experiences they have previously had. After that, students have the chance to ask questions about the images, which will be turned into group issues to be resolved. The second phase is organizing students for learning. The researcher helps students direct and define the questions that will be investigated for solutions. The teacher also explains the tasks for gathering information about the problems from various sources. Students are then divided into groups according to how they study best. The first group is the visual group, who prefer writing and receiving information more quickly through reading rather than listening. Students who learn best visually tend to process information related to visual perception, and they prefer reading over listening. The second group, known as the auditory group, prefers speaking over writing and receives information more quickly through listening than reading. Students with an auditory learning style tend to absorb information related to the sense of hearing, and they find it easier to memorize and recall information obtained through listening. The third group, known as the kinesthetic group, prefers performing practical

demonstrations over writing and quickly absorbs information through body movements such as touch or actions. Students with a kinesthetic learning style prioritize body movements to remember information. Instructions for each group are given to ensure that the investigation or discussion process runs smoothly.

The next phase is the third phase, which involves guiding student investigations individually or in groups. The researcher guides and facilitates the information search according to the group's learning style. For the visual group, the researcher provides reading materials, images, and visually appealing posters. The teacher provides instructional videos for the auditory group. Meanwhile, for the kinesthetic group, the researcher provides card media and experiments that can be conducted directly. Each group is given a student worksheet (LKPD) with different instructions according to their learning style. Student enthusiasm is highly noticeable during the process of gathering information through different learning methods. This differentiated PBL learning directly involves students in discovering problem-solving concepts, making them more active and creative in seeking solutions to problems (Thurrodliyah et al., 2023). At this phase, learning styles play an important role in helping students understand the learning material (Restianim et al., 2020). The fourth phase is to develop and present the work results according to the students' creativity. The activities carried out by students include recording investigation results in the student worksheet (LKPD) and answering the questions in the LKPD. Each group presents different work results according to their creativity based on their learning style, in the form of mind mapping, posters, songs, and experiment reports. These third and fourth phases help students become more independent in solving existing problems (Qondias et al., 2022; Yustina et al., 2022).

The last, analyzing and assessing the problem-solving procedure, is the fifth phase. Once the participants are ready with their work, in this phase, students can present it. Then, each group provides feedback. Groups that have presented are given rewards. Next, students, together with the teacher, critically examine and assess the students' approach to problem-solving as well as the content they have studied. Students are then given a posttest at the last meeting. Differentiated PBL learning can also train students' critical thinking abilities in each phase, including: the first phase trains critical thinking in giving basic opinions or explanations during the problem orientation process, the second phase trains students to think critically in determining the basis for decision-making during discussions, the third phase trains critical thinking in concluding the discussion results, the fourth phase trains critical thinking in providing further explanations during the presentation of work results, and the fifth phase trains critical thinking in estimating and combining assumptions during the evaluation process (Inggil Rejeki et al., 2022; Sintya Devi & Wira Bayu, 2020).

In the control class conducted at SDN Manyaran 03, students were given conventional learning, which is teacher-centered instruction. This learning uses lectures as a method to explain the material. Similar to the experimental class, before the learning began, students were asked to complete a pretest, and students were given a posttest following the lesson, specifically during the last meeting. Students' responses during the conventional learning process were clearly different from those of students who were given differentiated PBL learning.

Several pertinent earlier investigations support this research. Differentiated instruction based on learning styles is more effective in increasing students' willingness to learn science, according to a study by Demir (2021). Differentiated learning employing the PBL approach has a favorable association and a very good impact on students' learning outcomes, according to Siagian et al. (2022). Additionally, a study by Dalila et al. (2022) shows that, when compared to conventional teaching techniques, students' cognitive learning outcomes increased through differentiated learning using the Problem-Based Learning model. Furthermore, a differentiated PBL approach based on students' learning styles in biology classes affected students' behavior modifications, according to studies by

Shafira et al. (2023) and Minasari & Susanti (2023). Astuti & Prayito (2023) research indicates that learning outcomes improved following the use of the PBL approach for differentiated instruction. Based on the overall data analysis and several findings from previous researchers, in comparison to conventional learning, differentiated learning using the PBL paradigm has a favorable impact and improves fourth-grade students' cognitive learning results.

CONCLUSION

According to the findings of the study that has been done, the application of differentiated problem-based learning is more successful than conventional learning in enhancing cognitive learning outcomes. The experimental class's N-Gain test results, which indicated an increase classified as high, while the control class's showed an increase classified as moderate, provide evidence of this. Additionally, the cognitive learning outcomes of students taught using the differentiated PBL model were significantly different from those of students who received conventional instruction, according to the independent sample t-test or the difference test of the mean pretest and posttest cognitive learning outcomes of both classes. In addition to enhancing students' cognitive learning results, this strategy teaches them how to think critically and look for answers to challenges they may encounter in daily life. It is intended that future research would look at other talents or abilities that can be developed through this diversified PBL learning methodology, as this study primarily focuses on enhancing students' cognitive learning results.

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