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Differentiated Project Based Learning Model: An Effective Strategy in Ecoliteracy Education for Elementary School Students

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Abstract: Increasingly complex environmental problems demand strategic efforts in shaping ecological awareness and behavior from an early age. In this context, basic education has a strategic role in internalizing ecoliteracy values through appropriate learning approaches. This study aims to analyze the effect of the Differentiated Project Based Learning (PjBL) Model on improving the ecoliteracy skills of fifth grade elementary school students. The study used an experimental design with control and experimental groups totaling 31 students each. The pretest results showed that the average ecoliteracy ability of the experimental group was 64.03, while the control group was 66.68. After the application of Differentiated PjBL, the posttest showed that the average ecoliteracy ability of the experimental group increased to 75.32, while the control group was 70.35. The independent sample t test showed a significant difference in the posttest between the two groups ($p = 0.039 < 0.05$), and the paired t test in the experimental group also showed a significant improvement ($p = 0.000 < 0.05$). Thus, it can be concluded that the application of the Differentiated PjBL Model can significantly improve the ecoliteracy skills of fifth grade elementary school students and is more effective than conventional learning methods.

Keywords: Project based learning (PjBL); Differentiated; Ecoliteracy; Elementary school

Introduction

Learning about the environment is one of the important aspects that needs to be instilled at every level of education, in line with the fourth goal of the Sustainable Development Goals (SDGs), namely education for sustainable development (ESD). This learning aims to motivate students to improve ecoliteracy, which is the ability to understand how nature works and live in harmony with its principles to maintain the balance of life (Maulana et al., 2021; McBride et al., 2013; Setyaningrum, 2020). With ecoliteracy, students are expected to be able to develop concern for the environment and contribute to nature conservation, natural resource management, and sustainable development(Rudiana et al., 2022; Sucia et al., 2018).The urgency of mastering ecoliteracy is also emphasized in the PISA 2025 Science Framework, where the OECD emphasizes the importance of students not only understanding scientific concepts, but also being able to act as "Agents in the Anthropocene" in maintaining ecosystems and environmental sustainability (OECD, 2023). This is becoming increasingly relevant given global challenges such as climate change, pollution and environmental degradation that require appropriate knowledge, skills and attitudes (Lasaiba, 2023). Indonesia itself still faces serious challenges in this regard, as evidenced by its position in the bottom 20 out of 180 countries in the Environmental Performance Index (EPI) 2022, so

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concrete efforts are needed to increase environmental awareness and literacy since basic education.

At the primary school level, ecoliteracy plays an important role in shaping students' ability to understand, adapt, empathize and act for environmental sustainability(Perez et al., 2025; Rutledge & Manegre, 2024). However, its implementation is still not optimal. PISA 2022 results show a decrease in students' environmental literacy compared to 2018 (OECD, 2023). in line with the findings of low environmentally friendly behavior in various elementary schools Purnami (2021). Observations at elementary schools in Kapanewon Kalasan and the complexity of waste management in Yogyakarta after the closure of the Piyungan landfill reinforce the importance of contextualized environmental education. The low ecoliteracy of students is influenced by the lack of integration of environment-based learning, limited teacher knowledge, minimal utilization of local wisdom, and weak social support (Hidayati et al., 2023; Kurniasih, 2022). The lack of real experience-based learning also makes students less involved in understanding the relationship between humans and the environment (Ismawati et al., 2024). Therefore, contextualized and meaningful learning strategies are needed to improve early ecoliteracy.

This study aims to improve the ecoliteracy of elementary school students through the application of the Differentiated Project Based Learning (PjBL) Model in IPAS learning with the topic "Love my Earth". This research also aims to provide students with authentic experiences in solving environmental problems around them. Hopefully, this research can contribute to the development of more effective learning methods to improve students' ecoliteracy. The Differentiated PjBL approach provides flexibility for teachers in tailoring learning to student needs, which in turn can improve student engagement and learning outcomes (W. Azizah et al., 2024; Yusro & Ardania, 2023). This research also contributes to the enrichment of literature related to the implementation of PjBL in the context of continuing education.

This research contributes to the development of project-based learning through the integration of differentiated learning in the Project Based Learning (PjBL) model on the topic "Sayangi Bumiku". This approach not only conveys theoretical concepts, but also provides direct experience for students to play an active role in environmental conservation (Fajrina et al., 2024). with a specialty in local focus and strategies tailored to individual needs. Teachers play a strategic role in fostering environmental awareness through adaptive learning (Rosela & Gunansyah, 2022). The Differentiated PjBL model has been proven effective in improving students' ecoliteracy (S. Azizah et al., 2024) as shown by Mutiara Putri & Rezania (2022) who recorded an increase in achievement from 52.33% to 82%. This model encourages students' active involvement in environmental projects as well as the development of sustainable knowledge, attitudes and skills..

In addition, innovation through differentiated learning allows flexibility in tailoring learning to students' needs, interests and learning styles (Fajrina et al., 2024; Ramila, 2023). This approach can improve science literacy through students' active involvement in solving real problems and applying science in a real-world context (Rahmawati et al., 2023; Wahyuni et al., 2024). With Differentiated PjBL, students can produce projects related to waste management in the school environment, which aims to increase knowledge, attitudes, skills, and awareness of environmental sustainability (Maryanti & Sartono, 2024; Yuliawati et al., 2024). This approach provides authentic experiences, so students are more environmentally friendly and able to find effective solutions to environmental challenges.

The application of Differentiated PjBL on the topic "Sayangi Bumiku" in IPAS learning can improve students' ecoliteracy. Through this approach, students not only learn theory, but are also directly involved in environmental conservation efforts, such as sorting waste, saving energy, and managing environmental projects. This is expected to form a young generation that cares about the environment, is responsible, and is ready to face global challenges related to sustainability.

Method

This study used a quantitative approach with a quasi-experimental design of the Pretest-Posttest Nonequivalent Control Group Design type (Hastjarjo, 2019). The experimental group was treated with the Differentiated Project Based Learning (PjBL) Model, while the control group used the direct instruction learning model. The independent variable is the PjBL Model, and the dependent variable is the ability of ecoliteracy. The population of this study was fifth grade students in Gugus III SD Kapanewon Kalasan, Sleman, Yogyakarta, with a sample of 62 students (31 experimental students and 31 control students). The sampling technique used purposive sampling by considering 1) heterogeneous student abilities, 2) diversity of cultural, social, and economic backgrounds of students, and 3) teacher teaching experience and infrastructure.

The learning stage integrates PjBL syntax with differentiated learning principles, including: 1) determining fundamental questions, 2) designing a waste management project plan, 3) developing a schedule, 4) monitoring project progress, 5) testing project results, and 6) evaluating the learning experience

(Nurhidayah et al., 2021). The project includes solving waste problems in the school environment. Data were collected using tests and questionnaires. The instrument was designed based on four aspects of ecoliteracy from the Center for Ecoliteracy (Tyas et al., 2022): cognitive (head), emotional (heart), psychomotor (hands), and connectional (spirit). The test was used to assess the ecoliteracy ability of cognitive aspects through 16 multiple choice questions, while the questionnaire measured attitudes, skills, and environmental awareness with 20 statements using a Likert scale. The pretest measured students' abilities before the application of the Differentiated Project Based Learning (PjBL) Model, while the posttest was used to measure abilities after treatment. Instrument validity was tested using content and construct validity.

This research uses data analysis with descriptive and inferential statistics. Descriptive statistics were used to describe the mean, standard deviation, maximum and minimum values of students' ecoliteracy skills. Inferential statistics were conducted through paired sample t-test to determine differences in ecoliteracy skills before and after treatment in each group, as well as independent sample t-test to compare differences in ecoliteracy skills between experimental and control groups. Prior to the inferential test, the data were first analyzed through normality and homogeneity tests as a prerequisite for parametric tests. The analysis was conducted with the help of SPSS software. In addition, effect size calculation was used to determine the effect of the treatment given.

The following aspects assessed in ecoliteracy skills are presented as follows.

Table 1. Aspects of Student's Ecoliteracy Skills

Aspect	Indicator	Sub Indicator
Head/ Cognitive	1) Understand the principles of ecology.	a) Identify and analyze waste problems.
	2) Understand environmental and ecosystem issues.	b) Manage and recycle waste.
	3) Think critically and creatively in solving problems.	c) Make decisions that support nature conservation.
Heart/ Afectif	1) Have empathy for living things.	a) Caring for living things and respecting ecosystems.
	2) Appreciate different points of view.	b) Respect the opinions of others and actively protect the environment.
Hands/ Psikomotor	1) Establish procedures for sustainability.	a) Reduce the use of plastic and encourage others to manage waste.
	2) Turning beliefs into actions.	b) Making a habit of sorting waste and planning for efficient waste management.
Spirit/ Connectional	1) Feeling respect for the earth.	a) Maintain habitat and encourage others to care about responsible waste management.
	2) Closeness to nature	b) Creating a habit of sorting waste and encouraging others to participate.

This research uses data analysis with descriptive and inferential statistics (Martias, 2021). Descriptive statistics summarized the research variables to describe the sample, while parametric inferential statistics were used for hypothesis testing. The independent sample t-test compares students' ecoliteracy skills between groups that apply the Differentiated Project Based Learning (PjBL) Model and those that use the direct instruction method. The paired sample t-test was used to see the difference in students' ecoliteracy skills before and after learning with the Differentiated PjBL Model.

Result and Discussion

Result

Descriptive Test

This study aims to analyze the effect of the Differentiated Project Based Learning (PjBL) Model on improving the ecoliteracy skills of fifth grade elementary school students. To achieve this goal, a description of students' ecoliteracy skills before and after the application of the model is needed.

Table 2. Statistical Description of Control Group and Experimental Group

Inquiry	Class Group	Mean	Std. Deviation	N
Pretest	Control	57.5484	8.78195	31
Questionnaire	Experiment	56.6452	8.30080	31
PjBL	Total	57.0968	8.48665	62
Differentiation				
Posttest	Control	60.0323	8.87875	31
Questionnaire	Experiment	64.5161	7.80970	31
PjBL	Total	62.2742	8.59502	62
Differentiation				
PjBL	Control	66.6774	9.00143	31
Deferentiation	Experiment	64.0323	11.64613	31
Pretest Test	Total	65.3548	10.40822	62
	Control	70.3548	7.89746	31
	Experiment	75.3226	10.83632	31

Inquiry	Class Group	Mean	Std. Deviation	N
PjBL Deferentiation Posttest	Total	72.8387	9.73113	62

Pretest was given to measure students' ecoliteracy skills before the application of Differentiated PjBL, while posttest to measure the ability after its application. Descriptive analysis was conducted using the IBM SPSS Statistics version 27 program, with data that included pretest and posttest results of students' ecoliteracy skills from the experimental and control groups. The following is presented descriptive analysis data of ecoliteracy skills.

Based on the pretest data presented in Table 2, it can be seen that the ecoliteracy skills of experimental group students before learning are in the lower category compared to the control group. However, after learning, the posttest results of the experimental group students' ecoliteracy skills showed a higher category compared to the control group. There is a significant difference, with the average value of the experimental group higher than the control group.

Prerequisite Test

Normality

The normality test aims to ascertain whether the data is normally distributed as a condition of hypothesis testing. This test was carried out on the pretest and posttest results of the ecoliteracy skills of the experimental and control groups using IBM SPSS Statistics version 27. Data is considered normally distributed if the Asymp. Sig. (2-tailed) is greater than 0.05. The results of the normality test for the experimental and control classes can be seen in Table 3.

Table 3. Normality Test of Control Group and Experimental Group

Questionnaires and Tests	Class Group	Shapiro-Wilk			Explanation
		Statistic	df	Sig.	Asymp.Sig (2-tailed)
Pretest Questionnaire	Control	.946	31	.123	.123.> .05 = normal
PjBL Differentiation	Experiment	.949	31	.144	.144.> .05 = normal
Posttest Questionnaire	Control	.945	31	.114	.114 > .05 = normal
PjBL Deferentiation	Experiment	.947	31	.132	.132> .05 = normal
Pretest Test PjBL	Control	.945	31	.111	.111.> .05 = normal
Differentiation	Experiment	.944	31	.107	.107.> .05 = normal
PjBL Deferentiation	Control	.948	31	.136	.136 > .05 = normal
Pretest Test	Experiment	.950	31	.153	.153.> .05 = normal

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

a. Lilliefors Significance Correction

Based on the normality test data in Table 3, the pretest and posttest of the experimental and control groups showed a normal distribution. This is indicated by the Asymp. Sig. (2-tailed) which is more than 0.05. Thus, it can be concluded that the data in the experimental and control classes are normally distributed.

Homogeneity

The homogeneity test aims to ascertain whether the data has a homogeneous variance as a condition of hypothesis testing. This test was carried out on the pretest and posttest results of the ecoliteracy skills of the experimental and control groups using IBM SPSS Statistics version 27. Data is considered homogeneous if the Asymp. Sig. (2-tailed) value is more than 0.05. The results of the homogeneity test for the experimental and control classes can be seen in Table 4.

Table 4. Homogeneity Test Results

		Levene Statistic	df1	df2	Sig.	Analysis
Pretest Questionnaire PjBL Differentiation	Based on Mean	.040	1	60	.843	.843 > .05 = homogeneos
Angket Posttest PjBL Deferensiasi	Based on Mean	.843	1	60	.362	.362 > .05 = homogeneous
Tes Pretest PjBL Deferensiasi	Based on Mean	1.570	1	60	.350	.350 > .05 = homogeneous
Posttest Questionnaire PjBL Differentiation	Based on Mean	1.026	1	60	.279	.279 > .05 = homogeneous

Based on the homogeneity test data in Table 4, the pretest and posttest of the experimental and control groups show homogeneous variance. This is indicated by the value of Asymp. Sig. (2-tailed) which is more than 0.05. Thus, the data qualify to continue the analysis in the next test.

Hypothesis Test

Hypothesis testing was conducted to determine significant differences in student characteristics through the application of the Differentiated Project Based Learning (PjBL) Model. Based on the results of the assumption test, the data from the experimental and control groups were normally distributed and homogeneous. Therefore, hypothesis testing was carried out using parametric tests, namely the independent sample t-test and paired sample t-test.

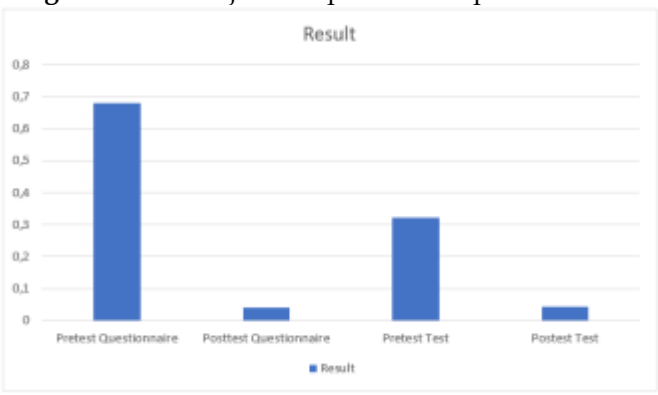
Independent Sample t-Test

Independent Sample t-Test is used to test two samples that are not interconnected. This test aims to measure the difference in ecoliteracy skills between the experimental and control groups before treatment. The analysis was conducted on the pretest results of both groups using IBM SPSS Statistics version 27. If the Sig. <0.05, then there is a significant difference between groups. The following are the results of the independent sample t test.

Table.5 Independent Sample T Test Results

			t	df	Sig. (2-tailed)	Analysis
Pretest Questionnaire PjBL Differentiation	Equal assumed	variances	.416	60	.679	.679 > .05 = no average difference
Angket Posttest PjBL Deferensiasi	Equal assumed	variances	-2.111	60	.039	.039 < .05 = there is an average difference
Tes Pretest PjBL Deferensiasi	Equal assumed	variances	1.001	60	.321	.321 > .05 = no average difference
Posttest Questionnaire PjBL Differentiation	Equal assumed	variances	-2.063	60	.043	.043 < .05 = there is an average difference

Diagram 1. Hasil Uji T Independen Sampel



Based on diagrams 1, the pretest showed no significant average difference in ecoliteracy skills between the control and experimental groups before treatment, with an Asymp. Sig. (2-tailed) > 0.05. This shows that the initial ability of both groups is at the same level. In contrast, the posttest results showed a significant average difference in ecoliteracy skills after the Differentiated Project Based Learning (PjBL) Model learning was applied, with an Asymp. Sig. (2-tailed) < 0.05. In conclusion, the application of Differentiated PjBL successfully improves students' ecoliteracy skills.

Paired Samples t-test

This analysis aims to measure differences in students' ecoliteracy skills before and after learning using the Differentiated Project Based Learning (PjBL) Model in the experimental group. This test was conducted with the help of IBM SPSS Statistics version 27, with significant criteria if the Sig value. (2-tailed) <0.05. The following are the results of the Paired Sample t-Test test between pretest and posttest in the experimental group.

Table 6. Paired T Test Results Sample

		N	Correlation	Sig.	Analysis
Pair 1	PjBL Differentiation Pretest Questionnaire & PjBL Differentiation Posttest Questionnaire	62	.896	.000	If the Sig. (2-tailed) <0.05, then HO is rejected and Ha is accepted.
Pair 2	PjBL Differentiation Pretest Test & PjBL Differentiation Posttest Test	62	.875	.000	If the Sig. (2-tailed) <0.05, then HO is rejected and Ha is accepted.

Based on Table 6, the pretest and posttest results of the experimental group show a significant average difference in students' ecoliteracy skills before and after the application of Differentiated Project Based Learning (PjBL) Model learning. This is evidenced by the value of Asymp. Sig. (2-tailed) value on the pretest and posttest of the experimental group which is smaller than 0.05. These results strengthen the conclusion that the Differentiated Project Based Learning (PjBL) Model learning effectively improves students' ecoliteracy skills.

Discuccion

This study aims to analyze the effect of the Differentiated Project Based Learning (PjBL) Model on the ecoliteracy skills of elementary school students, which is assessed through the four main aspects of ecoliteracy formulated by the Center for Ecoliteracy: head (knowledge), heart (attitude), hands (skills), and spirit (connectional).

Based on the results of the data analysis conducted, the application of the Differentiated Project Based Learning (PjBL) model regarding waste management projects can improve the ecoliteracy of grade V students in elementary schools. This is also reinforced by the results of research showing that the Project Based Learning (PjBL) learning model is appropriate for use in implementing the ecoliteracy development of elementary school students by instilling the character values of environmental love (Mufidah et al., 2021; Mughni & Sari, 2024; I. Sakti et al., 2021). In addition, these results are supported by Fernanda et al., (2024) which states that a differentiated learning approach can improve ecoliteracy in social studies learning through developing students' skills, attitudes, and awareness of the environment.

The implementation of Differentiated PjBL is proven to improve students' ecoliteracy knowledge aspects on environmental issues, including ecological principles and waste management. This learning model provides space for students to analyze waste problems in depth and develop solutions based on scientific knowledge. This finding is in line with Permata & Agung Wibowo's research (2023) which revealed that PjBL provides space for students to analyze environmental problems in depth, design solutions based on scientific knowledge, and evaluate the results of their work. This model also supports the development of learning strategies centered on the individual needs of students, as stated by Saleh et al., (2024).

The Differentiated Project Based Learning (PjBL) model is proven to be effective in building students' empathy and concern for the environment. Through students' involvement in projects related to waste issues, their awareness of environmental impacts increases, accompanied by a growing sense of responsibility for the surrounding community. This finding is in line with the research of Thohiroh et al., (2024), which shows that students' participation in environmentally relevant projects can increase their understanding of social-ecological issues, as well as encourage changes in attitudes to become more active and care for the environment.

In the skills aspect, students actively participate in practical activities such as sorting waste, making recycled products, and designing waste management systems in schools. The Differentiated PjBL approach allows students to put their ideas into action, thus developing practical skills while strengthening the connection between theory and practice (Andika et al., 2024; Lema et al., 2023). This learning process also helps students feel more connected to nature. Projects that involve direct observation of the impact of waste on the environment provide experiences that deepen students' connection with nature, as well as foster a deeper sense of responsibility to preserve it. The implementation of Differentiated PjBL also sensitizes students to environmental issues and motivates them to find solutions to the problems they face. This model offers an effective approach to address learning challenges for students with diverse interests, because it focuses on critical questions and complex tasks that encourage students to design, solve problems, organize work, and produce real products (N. C. Sakti & Ainiyah, 2024).

Learning with the Project Based Learning (PjBL) model combined with a differentiation approach provides opportunities for students to develop according to their respective potential. Students are given the freedom to choose independent learning methods, projects or research that suit their interests and strengths (Estiono et al., 2023). This approach strengthens students' confidence in completing their tasks, as project-based learning does not only focus on knowledge content, but also on skill development and confidence in their own abilities (Made et al., 2022). This research confirms that Differentiated PjBL can be an innovative solution to meet cross-interest learning needs, while supporting the implementation of the national curriculum that emphasizes 21st century competencies.

Conclusion

This study shows that the application of the Differentiated Project-Based Learning (PjBL) Model has a positive effect on improving the ecoliteracy skills of grade V elementary school students. This model allows project customization based on students' needs, interests and abilities, thus creating a holistic and meaningful learning experience. The results support the goal of improving four aspects of ecoliteracy, namely knowledge (head), attitude (heart), skills (hands), and connectional (spirit), which focuses on the formation of environmental love character. The data obtained shows that Differentiated PjBL is effective in improving students' understanding of environmental issues, critical thinking skills, and real actions in waste management and nature conservation.

Based on these findings, it is recommended that future research expand the sample coverage and cover more diverse learning materials, with a longer duration of implementation to provide more intensive assistance.

This approach will increase the reliability of the data as well as help students become more familiar with the applied learning strategies. In addition, it is recommended to involve qualitative data, such as interviews with students and teachers, to enrich and deepen the results of quantitative data analysis. Overall, the implementation of Differentiated PjBL not only supports the achievement of academic goals, but also contributes to the formation of students who are more concerned about the environment and able to face future ecological challenges.

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