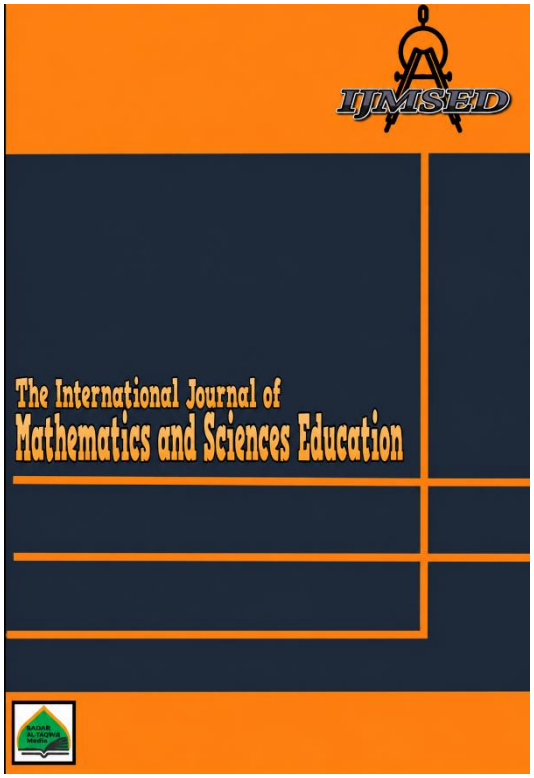
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Environmental awareness in two grade X classes using problem-based and project-based learning

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Environmental awareness in two grade X classes using problem-based and project-based learning

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Abstract
Comparative studies of problem-based learning (PBL) and project-based learning (PJBL) in Indonesian secondary schools have focused mainly on academic achievement, leaving limited evidence on how students' environmental awareness changes under the two approaches. This study compared changes in environmental awareness during an environmental change unit taught in two Grade X classes at an Indonesian madrasah. Using a quasi-experimental pretest–posttest design, the study analyzed matched questionnaire scores from 28 students, with 14 in each class. Classroom observations provided descriptive evidence of students' environmental behaviors during instruction. Mean questionnaire scores increased from 61.21 to 62.14 in the PBL class and from 63.29 to 66.00 in the PJBL class. The mean gain was 1.79 points higher in the PJBL class (approximate student-level 95% CI [−3.22, 6.79], p = .470). The PJBL class also received higher ratings on all six observed behavioral indicators. With one class per approach, the differences may reflect classroom characteristics, implementation, or opportunities to display the rated behaviors. The study contributes classroom-level evidence by comparing questionnaire scores with behaviors observed during instruction. It also identifies a priority for future comparisons: assess students from multiple classes per approach using the same behavioral tasks and scoring criteria.

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1. Introduction

Environmental education aims to develop the knowledge and skills students need to respond to environmental issues. A review of K–12 programs documented a range of academic and environmental outcomes (Ardoin et al., 2018). In a synthesis focused on conservation, Ardoin et al. (2020) described how school and community programs connect learning with action on local issues.

Evidence across programs also clarifies why environmental awareness is worth measuring by dimension. A meta-analysis of environmental education for children and adolescents found average gains in knowledge, attitudes, intentions, and behavior, with

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substantial variation across studies (van de Wetering et al., 2022). Research on the determinants of environmental behavior links action to knowledge of issues and strategies, perceived control, and social or personal norms (Bamberg & Möser, 2007; Hines et al., 1987).

This study uses environmental awareness as an umbrella term for four related dimensions, drawing on the distinction between environmental understanding and responsible behavior in environmental education (Hungerford & Volk, 1990). Environmental knowledge concerns understanding environmental issues and their consequences. Concern captures how much students value or care about environmental conditions. Self-reported responsible behavior describes practices students say they undertake, and participation describes their reported involvement in environmental activities. The questionnaire provides an overall score across the four dimensions. The analysis did not estimate scores for individual dimensions or establish that the items measure a single latent trait. Classroom observations provide separate evidence of behavior during lessons.

Knowledge and concern can develop even when opportunities to act are limited. Reviews of environmental behavior describe contextual barriers and social influences that can shape whether concern translates into practice (Gifford & Nilsson, 2014; Kollmuss & Agyeman, 2002; Stern, 2000). School tasks may therefore reveal how students participate when opportunities are provided, while the questionnaire composite reflects a broader mix of reported knowledge, concern, and action.

School grounds provide a setting in which students can examine how everyday practices, such as waste disposal and classroom upkeep, relate to environmental change. Informal accounts of these practices motivated the classroom study. The study did not use a systematic baseline observation of those practices to diagnose their causes.

Problem-based learning uses authentic problems as a starting point. Students identify what they need to know, investigate evidence, and develop defensible solutions (Hmelo-Silver, 2004; Savery, 2006). Reviews suggest that the pattern of results depends on whether assessments target knowledge or skills, as well as on the type of problem and the way instruction is implemented (Dochy et al., 2003; Gijbels et al., 2005; Walker & Leary, 2009). This makes the choice of outcome especially important when PBL is used to teach environmental change.

Project-based learning also starts with a meaningful question. Students develop a project over time and produce or present a tangible outcome (Bell, 2010; Krajcik & Blumenfeld, 2006). Barron et al. (1998) illustrate how problem investigation can prepare students for a subsequent project. Reviews and classroom cases identify the importance of aligning the project with curricular goals and supporting student inquiry throughout implementation (Kokotsaki et al., 2016; Markula & Aksela, 2022).

In a direct comparison at an Indonesian madrasah, Faza et al. (2023) reported higher geography achievement among Grade XI students who studied disaster mitigation through PJBL compared with those who studied it through PBL. Sitohang and Damanik (2024) found no statistically significant difference in geography achievement in a

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separate Grade XI comparison. Both studies focused on subject achievement, leaving open how the approaches compare on environmental awareness. More broadly, Loyens et al. (2023) synthesized evidence on higher-order thinking in problem- and project-based environments, highlighting the need to specify the outcome of interest and the learning activities through which it might change.

Meta-analyses of PJBL examine academic achievement or broader learning outcomes and show that results vary across implementations (Chen & Yang, 2019; Zhang & Ma, 2023). A separate synthesis compares motivation across problem-driven approaches (Wijnia et al., 2024). Those outcomes address different questions from how students in two intact classes report environmental awareness and display selected behaviors during an environmental-change unit.

In madrasah classrooms, waste disposal, upkeep of shared spaces, and care for plants can make environmental responsibilities visible in everyday school life. A project may offer repeated opportunities to share and carry out those responsibilities, while a problem-based lesson may devote more time to examining causes and weighing responses. These opportunities offer a reason to examine environmental awareness alongside classroom behavior. The primary comparison was the difference in mean questionnaire change between the two classes. Posttest and within-class comparisons were secondary, and the classroom observations provided descriptive context.

2. Method

2.1 Research Design

The study used a quasi-experimental pretest–posttest design with two nonequivalent Grade X classes (Handley et al., 2018). Students remained in their intact classes. One class received PBL and the other received PJBL. The design included two active instructional groups and no untreated comparison.

Table 1

Research Design

Group	Pretest	Treatment	Posttest
Experimental Group 1	O1	PBL	O2
Experimental Group 2	O3	PJBL	O4

Note. O1 and O3 denote pretests; O2 and O4 denote posttests.

2.2 Participants and Sampling

The analysis included 28 Grade X students from two intact classes at one Indonesian madrasah. Each class contributed 14 matched pretest–posttest score pairs. The original study describes class selection as cluster random sampling. The available records do not specify the eligible class count, the selection procedure, or how the two classes were assigned to the instructional approaches. The comparison therefore treats the classes as nonequivalent groups.

2.3 Variables and Learning Treatments

Both classes studied environmental change. The PBL class worked through problem identification, group investigation, formulation and presentation of proposed solutions,

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and reflection. The PJBL class began with a guiding environmental question and proceeded through project planning, scheduling, implementation, monitoring, presentation, and evaluation of the resulting work. These sequences reflect the intended instructional contrast between investigating a problem and carrying a project through implementation (Barron et al., 1998; Bell, 2010; Savery, 2006).

The instructional descriptions identify the two sequences and their common topic. The available account does not specify the number or duration of lessons, whether the same teacher taught both classes, or the final PJBL product. These details matter when interpreting differences between the classes because instructional time, teacher support, and opportunities for participation may have varied.

2.4 Instruments and Data Collection

The questionnaire was administered before and after instruction. Its five response categories ranged from "strongly disagree" to "strongly agree." The instrument addressed environmental knowledge, concern, self-reported responsible behavior, and participation in environmental activities. The analysis used the recorded composite scores for the matched assessments. The available records do not establish the final item count, whether the same form was used at both assessments, or how the responses were converted to composite scores.

The pilot summary reports that 29 of 36 items met its validity criterion and gives a Cronbach's alpha of .913. The records do not identify the item set used to calculate alpha. The coefficient therefore describes the reported pilot result. Its applicability to the scores analyzed here remains uncertain.

Classroom observations covered cleanliness, waste disposal, cooperation, participation, task responsibility, and care for facilities and plants. Class records, instructional materials, schedules, and photographs served as documentation. The available observation results consist of six mean ratings per class. The scoring scale, observation schedule, rater arrangements, and agreement among observers are not documented in the available materials. The analysis therefore reports the ratings descriptively.

2.5 Data Analysis

For this reanalysis, the primary comparison was the difference in mean change (posttest minus pretest) between PJBL and PBL, chosen to compare how much the mean score changed in each class. The posttest comparison and paired within-class tests were exploratory, with unadjusted two-sided p values. The study scores were originally reported in a thesis. This article uses the available class-level summaries and reported student-level test statistics. The reconstructed intervals use aggregate information, so the individual scores and the original analysis output are needed to independently reproduce the tests. Approximate 95% confidence intervals were reconstructed from the reported means, standard deviations, and sample sizes using t critical values. The standard error for each paired comparison used the SD of the within-student changes divided by the square root of the sample size. Between-class comparisons used the pooled-variance standard error. For between-class comparisons, Cohen's d was calculated by dividing the

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mean difference by the pooled SD. For paired comparisons, the standardized mean change was calculated by dividing the mean change by the SD of the changes. Positive values represent increases or higher values in PJBL. All intervals and tests are conditional on a student-level independence model and omit class clustering. With one class per condition, class and instructional approach are confounded.

2.6 Ethics Statement

All participants provided informed consent before data collection and participated voluntarily. Survey respondents' names and contact details were removed before analysis. Pseudonyms were used to protect the identities of the observed teachers and their schools.

3. Results

3.1 Descriptive Results

The baseline mean was about 2.1 points higher in the PJBL class than in the PBL class. The PBL mean increased from 61.21 to 62.14, a gain of 0.93 points. The PJBL mean increased from 63.29 to 66.00, a gain of 2.71 points. Table 2 summarizes the pretest, posttest, and gain distributions.

Table 2

Descriptive Statistics for Environmental-Awareness Scores

Group and Measure	n	Mean	SD	Minimum	Maximum
PBL pretest	14	61.21	6.59	48	71
PBL posttest	14	62.14	6.41	53	77
PBL gain	14	0.93	6.97	−9	14
PJBL pretest	14	63.29	5.61	50	69
PJBL posttest	14	66.00	4.44	60	75
PJBL gain	14	2.71	5.86	−9	14

Note. Gain = posttest score minus pretest score.

3.2 Assumption Tests

Shapiro–Wilk tests were applied to the posttest scores and to the within-student differences in each class. The difference scores are the relevant distributions for the paired tests. Levene's tests assessed equality of variances between classes for posttest and gain scores. The diagnostic p values exceeded .05, with limited sensitivity at 14 students per class. These tests cannot assess independence within a class.

Table 3

Distribution and Variance Diagnostics

Test	Statistic	p
Shapiro–Wilk W, PBL posttest	0.924	.251
Shapiro–Wilk W, PJBL posttest	0.925	.261
Shapiro–Wilk W, PBL gain	0.957	.667
Shapiro–Wilk W, PJBL gain	0.976	.949
Levene F(1, 26), posttest	1.479	.235
Levene F(1, 26), gain	0.625	.436

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3.3 Exploratory Class Comparisons

The PJBL class gained an estimated 1.79 points more than the PBL class (approximate 95% CI [−3.22, 6.79], p = .470). The interval includes values favoring either class. The posttest contrast was 3.86 points in favor of the PJBL class, which also had the higher pretest mean. Both within-class intervals included zero. Table 4 summarizes the estimates for both classes.

Table 4

Mean Contrasts in Environmental-Awareness Scores

Comparison	Mean diff.	95% CI	t (df)	p	Effect size
Gain, between classes (primary)	1.79	[−3.22, 6.79]	0.734 (26)	.470	d = 0.28
Posttest, between classes	3.86	[−0.43, 8.14]	1.852 (26)	.075	d = 0.70
Change within PBL	0.93	[−3.10, 4.95]	0.499 (13)	.626	d_z = 0.13
Change within PJBL	2.71	[−0.67, 6.10]	1.732 (13)	.107	d_z = 0.46

Note. Within-class contrasts are posttest minus pretest. Between-class contrasts are PJBL minus PBL. Intervals are approximate and do not account for class clustering. Displayed means are rounded, so subtracting them can yield a difference that varies by 0.01 points from the reported contrast. Secondary p values are unadjusted.

3.4 Observation Results

The PJBL class had higher mean ratings on all six observed behaviors. The largest differences were for completing tasks responsibly and caring for school facilities and plants, both 0.71 points. Summing the six displayed indicator means gives 18.57 for PBL and 22.21 for PJBL. These sums describe ratings during classroom activities.

Table 5

Observed Classroom Behaviors

Observed Behavior	PBL	PJBL
Maintaining classroom cleanliness	3.21	3.79
Disposing of waste properly	3.07	3.71
Working actively with the group	3.21	3.86
Participating in environmental activities	3.29	3.64
Completing tasks responsibly	3.00	3.71
Caring for school facilities and plants	2.79	3.50
Sum of displayed indicator means	18.57	22.21

4. Discussion

The two classes recorded higher questionnaire means after instruction. The larger gain in the PJBL class was estimated imprecisely. The interval around the primary comparison allows for a greater gain in either class, so the evidence leaves both superiority and equivalence unresolved. With one class per approach, classroom characteristics and instructional differences could each contribute to the observed contrast.

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Greenland et al. (2016) emphasize the importance of interpreting a confidence interval alongside the assumptions used to compute it. Here, the interval provides a student-level description and cannot quantify variation across classrooms. Baseline adjustment could address the difference in starting scores if the paired data were available (Vickers & Altman, 2001), but with one class per approach it still could not separate class effects from instructional effects.

PBL asks students to investigate an environmental problem, weigh evidence, and formulate a response (Hmelo-Silver, 2004; Savery, 2006). This kind of inquiry provides a route through which students may build environmental understanding. Because the questionnaire was analyzed as a composite, the present comparison cannot determine whether students' knowledge, concern, reported practices, or participation changed individually.

The project structure may help explain why the rated behaviors received higher scores in the PJBL class. Project work can assign roles and require students to carry out and present shared tasks (Bell, 2010; Krajcik & Blumenfeld, 2006). Those tasks may create more occasions for an observer to see cooperation, responsibility, or care for shared spaces. The observation ratings cannot distinguish this difference in opportunity from a difference in students' dispositions. The study did not test whether sustained project action explained the questionnaire scores.

The classroom ratings capture behavior visible during instruction, while the questionnaire captures students' self-reported awareness before and after instruction. Higher classroom ratings therefore provide context for interpreting participation during PJBL. Repeated observations using comparable tasks and follow-up beyond the unit would help determine whether students carry those practices into other settings (Ardoin et al., 2020).

The distinction between measurement methods is consistent with a meta-analysis showing that self-reports and objective behavioral measures overlap to a limited degree (Kormos & Gifford, 2014). A review of PJBL in higher education likewise found that studies often relied on self-reports and used project artifacts less often as evidence of outcomes (Guo et al., 2020). In a school environmental unit, a common behavioral task offered to both classes and assessed with the same rubric could help separate opportunities to demonstrate a behavior from differences in how students perform it.

The madrasah comparison by Faza et al. (2023) illustrates why the outcome matters when interpreting evidence about PBL and PJBL. Performance on a geography achievement test answers a different question from a composite of students' environmental understanding, concern, and reported practices. The estimates in this study are specific to the latter outcome and the two participating classes.

For teachers designing an environmental-change unit, PBL offers a structure for investigating causes and proposing evidence-based responses. PJBL offers a structure for planning and implementing a shared environmental task. These instructional features can guide model selection according to the lesson objective.

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5. Conclusion

Mean environmental-awareness scores rose in both Grade X classes. The PJBL class showed the larger mean gain and higher classroom ratings, with substantial uncertainty around the difference in gain. The comparison leaves the relative effects of PBL and PJBL unresolved. With no untreated comparison, the study also cannot determine how much of either class's change is attributable to instruction.

Limitations and Future Research

The comparison involved two intact classes at one school. With a single class per model, neither individual-level confidence intervals nor statistical adjustment for pretest scores can establish a class-level treatment effect. The primary gain contrast describes differences in observed change. A covariate-adjusted model would answer a separate question about posttest scores at comparable baselines and would require checking its assumptions against the paired data. Uncertainty about the final questionnaire and the classroom observation protocol also limits measurement interpretation. A follow-up study with several classes per approach, documented implementation, and repeated observations could test whether the patterns recur and persist.

Statements and Declarations

Competing Interests

The author declares no competing interests.

Ethics and Participant Consent

The study involved Grade X students. The materials available for this report do not document ethics approval or exemption, school permission, parent or guardian consent, or student assent. The procedures used in the original study require confirmation from the study records.

Data Availability

The class-level statistics used in this report are presented in Tables 2–5. The individual paired scores are not included in this article. Access to those records and permission to share them have not been established.

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Declaration of Generative AI Use

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) to improve the clarity and organization of the text, refine the presentation of the methods and findings, and assist in identifying relevant literature and checking reference details. The authors reviewed and edited the AI-assisted material and take full responsibility for the final content of the manuscript.

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