

Effects of Contextual Problem-Based Learning on Creative Problem-Solving Skills in Environmental Education: A Study of Pre-Service Biology Teachers

Submitted 29 June 2024, Revised 23 September 2026, Accepted 24 September 2026

Nuraini Sirajudin^{1*}, Sumarni Sahjat², Joko Suratno³

^{1,2,3}Department of Mathematics and Science Education, Faculty of Training Teacher and Education,
Universitas Khairun, Ternate, Indonesia

Corresponding Email: *nurainisirajudin@gmail.com

Abstract

Environmental education requires learners to generate original and feasible responses to complex, ill-structured problems, yet previous studies have more often emphasized environmental literacy or critical thinking than creative problem-solving among pre-service biology teachers. This study examined whether Contextual Problem-Based Learning (CPBL), which integrates authentic environmental contexts with a structured problem-solving cycle, is associated with stronger creative problem-solving performance. A posttest-only, nonequivalent-groups quasi-experimental design involved two intact Environmental Education classes at Universitas Khairun (CPBL $n = 29$; conventional instruction $n = 27$). Creative problem-solving was assessed using an expert-reviewed instrument with acceptable internal consistency (Cronbach's $\alpha = 0.76$). The CPBL group achieved a higher mean score ($M = 11.724$, $SD = 1.750$) than the control group ($M = 8.778$, $SD = 1.601$). The between-group difference was statistically significant, $t(54) = 6.56$, $p < 0.001$, with a mean difference of 2.946 (95% CI [2.05, 3.85]) and a large effect size (Cohen's $d = 1.75$). These findings indicate that CPBL is a promising course-level approach for strengthening creative problem-solving in environmental teacher education. However, the use of intact classes, the absence of a documented baseline measure, and the single-institution sample limit causal and generalizable claims.

Keywords: Contextual Problem-based Learning, Creative Problem-solving, Environmental Education, Pre-service Biology Teachers, Quasi-experimental Design

INTRODUCTION

Environmental education increasingly requires learners to address climate change, pollution, biodiversity loss, and other ecological problems that do not have single, predetermined solutions. Such problems demand the ability to connect scientific knowledge with real-world conditions and to formulate defensible actions. In teacher education, this demand is especially important because pre-service biology teachers must develop these competencies before they can foster them in future learners. Contextual learning has therefore gained attention for linking disciplinary concepts with authentic environmental situations and making ecological knowledge more meaningful and action oriented (Yaya et al., 2025; Schmäing et al., 2026)

Contextual learning and Problem-Based Learning (PBL) are complementary but not identical. Contextual learning situates concepts in meaningful social, ecological, or local settings, whereas PBL organizes learning around the investigation of an ill-structured problem. Studies in environmental and biology education show that local environmental issues, field-based contexts, and problem-centered activities can strengthen environmental understanding and students' capacity to apply knowledge to ecological situations (Yaya et al., 2025; Islam et

al., 2025; Yusup et al., 2021; Yani et al., 2021). When these approaches are deliberately integrated, context is not merely an example added to instruction; it becomes the setting in which the problem is identified, investigated, and resolved.

Creative problem-solving is another distinct outcome to emerge in the process. While critical thinking deals with assessing the claims, evidence, and alternatives in a situation, creative problem-solving requires the learners to come up with different options, as well as choose original yet practical solutions to the problems. Modern studies refer to the interplay between divergent thinking for idea generation and convergent thinking for evaluation as key for solving complex problems (Willemsen et al., 2024; Affandy et al., 2024). The point of difference in environmental education is that an academically credible response must be innovative and capable of addressing the uncertainties yet ecologically realistic and situational.

It follows from the research conducted among the pre-service teachers that there is also a need to look at creativity as an independent outcome. Research in the field of biology and science teacher education focused on such concepts as critical thinking, systems thinking, environmental awareness, and environmental literacy (Schmäing et al., 2026; Arsih et al., 2021; Yani et al., 2021). More recent studies have also argued that pre-service science teachers require specific experiences in fostering their creativity and critical thinking skills since these abilities affect the learning experience that they will eventually provide for the pupils (Marangio et al., 2024; Muñoz-Salinas et al., 2025). Yet, usually, creativity was integrated into the higher-order thinking constructs.

The current research closes this gap by looking into the application of Contextual Problem-Based Learning (CPBL). In the current research, CPBL is seen as a six-stage instructional cycle where the learners (1) are introduced to a real-world environmental problem, (2) clarify it, (3) search and investigate information together, (4) find out the possible solutions, (5) present and defend the solutions, and (6) discuss how relevant the proposed solutions are to the environmental practice. The approach differs from those which utilize either contextual examples or PBL independently since the purpose of contextual information is to support the entire process of problem-solving including the solution generation and evaluation. It also differs from the research focusing mostly on environmental literacy since creative problem-solving is the main focus of learning here (Islam et al., 2025; Affandy et al., 2024; Suryawati et al., 2020).

As such, the purpose of this research was to find out whether pre-service biology teachers who participated in CPBL performed better in terms of post intervention creativity problem solving test scores than those who did not receive any CPBL but received traditional

teaching in the Environmental Education course. This paper adds to the knowledge on the topic both from an empirical perspective as it gives a precise estimate of the size of the difference between groups, as well as from the conceptual point of view as it investigates the possibility of using the real-life context as a scaffolding mechanism for producing feasible solutions.

METHOD

This quantitative study used a posttest-only, nonequivalent-groups quasi-experimental design. The study was conducted at a public university in Ternate, Indonesia with Biology Education students enrolled in an Environmental Education course. Two intact classes were selected purposively because both were existing course groups that could be compared without disrupting normal enrollment: one class received CPBL ($n=29$) and the other received conventional instruction ($n=27$). Both groups studied the same course content under their respective instructional conditions. The available study record does not document a pre-intervention creative problem-solving test or a separate analysis of prior academic equivalence; consequently, statistical baseline equivalence cannot be confirmed and is treated as a limitation of the design.

In the experimental class, instruction followed six CPBL stages: (1) orientation to an authentic environmental problem, (2) identification and clarification of the problem, (3) collaborative information search and investigation, (4) development of alternative solutions, (5) presentation and defense of solutions, and (6) reflection on the relevance of the proposed solution to environmental practice. For the control group, traditional teaching was used to provide conventional education within the framework of Environmental Education, including the same topics but without the described cycle of contextual problem-solving learning. Learning documents, class reports, and other sources were reviewed descriptively to present learning context and intervention implementation process; no qualitative data analysis was performed separately from that.

Creative problem-solving test in environmental problem scenarios was chosen as a primary outcome measurement tool. The test was designed to correspond to the study construct and the subject matter content. In addition to the study record description, four dimensions intended to be measured by the test were mentioned explicitly: originality, appropriateness, future orientation, and problem-solving ability. Content, comprehensiveness, and comprehensibility were verified by expert review (Mokkink et al., 2025). Reliability analysis resulted in Cronbach's $\alpha = 0.76$ and was considered to be acceptable. The number of test items, the scoring rubric, and the theoretical score range are not mentioned in the

archived manuscript and, therefore, could not be found accurately in the available files; this can be considered a limitation of reporting.

Original quantitative analysis was conducted using IBM SPSS Statistics software. The version used is not mentioned in the available manuscript. Descriptive statistics were calculated for both groups, followed by the independent-samples t-test with $\alpha=0.05$. To make the information reported here transparent, t statistic, degrees of freedom, mean difference, 95% confidence interval, and Cohen's d were calculated based on the reported group size, mean, and standard deviation values. Formal Shapiro-Wilk and Levene tests statistics were not retained in the available record and are, therefore, not reported here. To serve as a sensitivity check without equal variance assumption, Welch t-test was also calculated using the same summary statistics.

According to the study record, it was designed to respect the rights, privacy, and academic interests of the participants and all the students were de-identified in the data set and reporting. No identifier of institutional ethics approval and no informed consent documentation is available in the provided manuscript, and no approval number is claimed. For reproducibility, intervention protocol, lesson plans, scoring guide, de-identified data set, and analysis syntax should be preserved along with the final study report.

RESULTS AND DISCUSSION

Table 1. Descriptive and Inferential Statistics for Creative Problem-solving Scores

Group	n	Mean	SD	Comparison	Inferential result
Experimental (CPBL)	29	11.724	1.750	Higher	$t(54) = 6.56, p < 0.001$
Control (Conventional)	27	8.778	1.601	Lower	Mean difference = 2.946
Effect estimate				95% CI [2.05, 3.85]	Cohen's $d = 1.75$

The experimental group demonstrated a higher score for the creativity problem solving task ($M=11.724$, $SD=1.750$) than the control group ($M=8.778$, $SD=1.601$). This yielded an average difference of 2.946 points between the groups. The result from an ordinary t-test for independent samples showed that $t(54) = 6.56, p < 0.001$ with a 95% CI for the difference between the means of [2.05, 3.85]. The effect size was large ($d=1.75$).

There were no results for the tests for normality and homogeneity of variances in the archived analysis, so exact values for the Shapiro-Wilk and Levene's test could not be calculated. However, a Welch Sensitivity Analysis using the given summary data resulted in almost identical conclusions, $t(53.99) = 6.58, p < 0.001$ with a 95% CI of [2.05, 3.84]. Thus, the statistical inference does not depend on assuming exactly equal group variances.

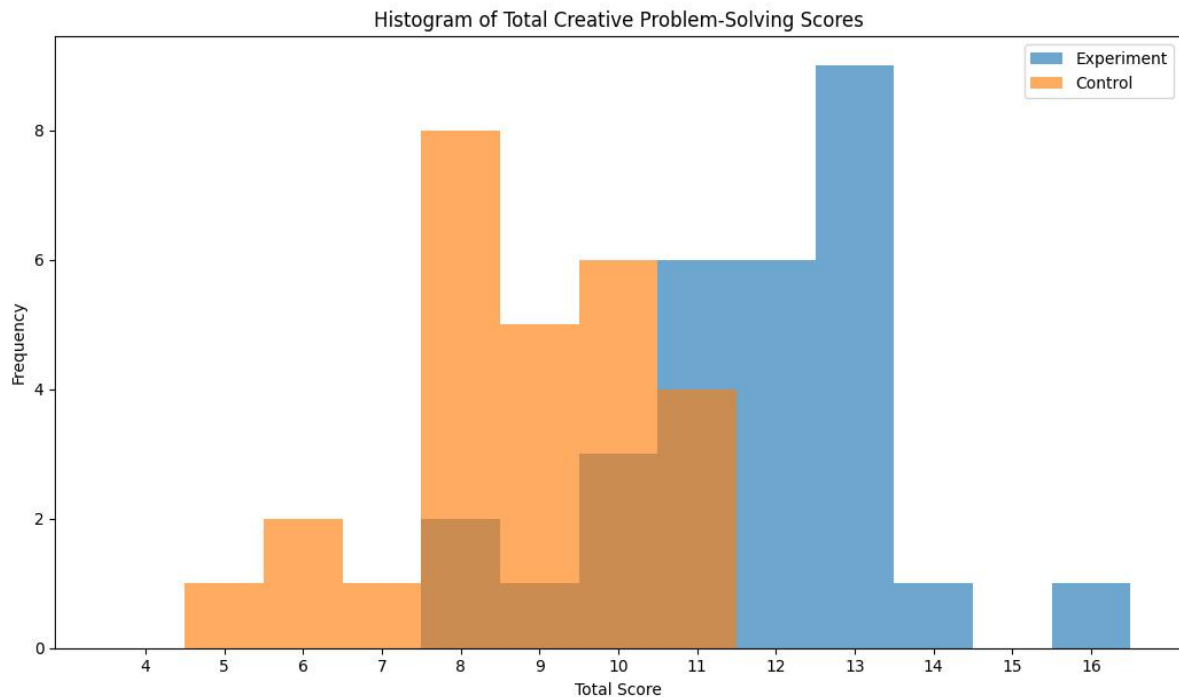


Figure 1. Distribution of Total Creative Problem-solving Scores by Instructional Group

Figure 1 demonstrates that the distribution of CPBL is positively shifted compared to that of CON, even though there is some overlapping between the groups. This figure describes data and should be understood in conjunction with inferential statistics presented in Table 1 and not as a proof of baseline equivalence or individual changes.

The primary result of this study is that pre-service biology teachers who learned with the help of CPBL demonstrated significantly higher creative problem-solving scores after the intervention period than their counterparts taught conventionally. The difference between the mean scores is statistically significant and large enough from the standardized point of view ($d = 1.75$). In the context of this single university quasi-experimental design, the conclusion is that CPBL may be used as an effective method for achieving creative response to environmental problems if the goal of the education process is to generate and evaluate it. The finding is in line with evidence about the positive influence of combining creative teaching methods and PBL on higher-order skills acquisition in science education (Affandy et al., 2024).

Environmental education serves as a suitable context for the observed results because ecological problems are always contextual, multiple causal and constrained by scientific, social and practical limitations. Students cannot find solutions to such problems by merely remembering something; they need to determine which aspects are important in the concrete situation, analyze the evidence, predict consequences, and take actions based on realistic

conditions. The same improvement in students' ability to comprehend ecological problems and transform theoretical knowledge into practical reasoning has been found in studies involving local environmental issues and problem-based learning material (Islam et al., 2025; Suryawati et al., 2020).

Another possible mechanism is collaboration. The CPBL procedure had students working together in searching, investigating, ideating and justifying alternative solutions. Collaboration could allow students to become exposed to alternative explanations and solutions to a problem that might expand the pool of ideas while justifying and refining those solutions. Empirical research in project-based learning environments found significant correlations between metacognition, creativity, and critical thinking during collaboration on complex problems (Maor et al., 2023). However, since the study does not measure the effectiveness of collaboration independently, it cannot be said that the effect was due to collaboration itself.

Contextual familiarity could have also played a role in how well students performed. Contextual cases that are familiar to students could help them utilize existing knowledge in solving complex problems (Yaya et al., 2025, Yani et al., 2021). At the same time, familiarity can be a source of variation: students who know a problem context better may identify constraints or stakeholders more readily than students who do not. Because prior familiarity with the environmental cases was not measured, the present study cannot determine whether contextual familiarity strengthened, moderated, or had no independent influence on the treatment effect. Future studies should measure this variable directly.

The focus on pre-service biology teachers is educationally important. These participants are not only learners of environmental science but also future teachers who will be expected to design learning experiences that develop inquiry, creativity, and evidence-based decision making. Research in science teacher education emphasizes that pre-service teachers need opportunities to develop their own creativity and critical thinking before they can meaningfully cultivate these capacities in school students (Marangio et al., 2024; Muñoz-Salinas et al., 2025). The present result extends that concern to environmental education by showing that a context-rich problem-solving sequence is associated with stronger creative problem-solving performance in this population.

The concept of an 'ecological creativity scaffold' should be interpreted as a mid-level explanatory proposition rather than as a new learning theory. Constructivist perspectives explain learning as active knowledge construction, and situated-learning perspectives explain why knowledge use is shaped by context. The ecological creativity scaffold proposition is

more specific: it suggests that environmental context can structure what learners notice as constraints, whose interests they consider, and which alternatives remain scientifically and ecologically defensible during creative problem solving. In this sense, context is proposed to channel creativity rather than merely make learning more engaging. This proposition is consistent with scholarly literature that connects creativity, critical thinking, metacognition, and teacher education for sustainability (Maor et al., 2023; Echegoyen-San et al., 2024); however, it needs empirical confirmation to be regarded as a mechanism.

The implication of the results should stay within the scope of the experiment. Thus, the results support the idea of implementing CPBL into Environmental Education and other related teacher education courses through the repeated use of the authentic ecological cases, cooperative investigations and the process of generating and defending alternatives. However, the findings do not prove the need for any changes in the educational policy yet. Any possible use of technology-enabled data, simulations, or other tools for inquiry could be helpful, although it needs to be checked as well (Ramadani et al., 2025).

There are several limitations of the study. It was based on two intact non-randomly selected classes of one institution. The lack of data on the initial creative problem-solving ability of students makes it possible to assume that there may be some selection effects. The outcomes were assessed only post-intervention, so any conclusion about individual changes cannot be drawn. Also, the intervention period, assumption-test output, SPSS version and other technical information were missing from the manuscript, which reduces the reproducibility of the results. For further research, the pretest-posttest design, multi-site and/or longitudinal design, randomization/matching should be considered. In addition, the instrument used and its criteria need to be reported.

CONCLUSION

Compared to the group which received conventional learning, the class which underwent Contextual Problem-Based Learning demonstrated significantly greater post-intervention gains in creative problem solving abilities (mean difference = 2.946; $t(54) = 6.56$; $p < 0.001$; Cohen's $d = 1.75$). The most important contribution of this study is the demonstration that contextualized PBL process is a good candidate for promoting creative problem solving in environmental education and the development of an ecological creativity scaffold hypothesis, according to which real-world environmental context can guide divergent ideas toward original, feasible and environmentally sound solutions.

The results of the study must be cautiously interpreted due to the facts that it was conducted using intact classes which were not randomized, that there was no baseline

documentation, that it was carried out at one institution only and that the post-intervention effect was evaluated immediately after the intervention; moreover, some methodological details were not provided in the archived data. Further research should use multi-site designs of pretest-posttest and longitudinal type, provide full information about instruments used and assumptions tested and measure contextual knowledge, cooperation and ecological constraints use explicitly.

REFERENCES

- Affandy, H., Sunarno, W., Suryana, R., & Harjana. (2024). Integrating creative pedagogy into problem-based learning: The effects on higher order thinking skills in science education. *Thinking Skills and Creativity*, 53, 101575. <https://doi.org/10.1016/j.tsc.2024.101575>
- Arsih, F., Zubaidah, S., Suwono, H., & Gofur, A. (2021). RANDAI learning model to enhance pre-service biology teachers' critical thinking skills. *International Journal of Instruction*, 14(2), 845–860. <https://doi.org/10.29333/iji.2021.14247a>
- Echegoyen-Sanz, Y., Morote, Á., & Martín-Ezpeleta, A. (2024). Transdisciplinary education for sustainability: Creativity and awareness in teacher training. *Frontiers in Education*, 8. <https://doi.org/10.3389/feduc.2023.1327641>
- Islam, A. Z., Rachmadiarti, F., & Indana, S. (2025). Integrating local environmental issues into a problem-based learning e-book to improve students' science competencies. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 11(2), 511–523. <https://doi.org/10.22219/jpbi.v11i2.40907>
- Marangio, K., Carpendale, J., Cooper, R., & Mansfield, J. (2024). Supporting the development of science pre-service teachers' creativity and critical thinking in secondary science initial teacher education. *Research in Science Education*, 54(1), 65–81. <https://doi.org/10.1007/s11165-023-10104-x>
- Maor, R., Paz-Baruch, N., Grinshpan, N., Milman, A., Mevarech, Z., Levi, R., ... & Zion, M. (2023). Relationships between metacognition, creativity, and critical thinking in self-reported teaching performances in project-based learning settings. *Thinking Skills and Creativity*, 50, 101425. <https://doi.org/10.1016/j.tsc.2023.101425>
- Mokkink, L. B., Herbelet, S., Tuinman, P. R., & Terwee, C. B. (2025). Content validity: Judging the relevance, comprehensiveness, and comprehensibility of an outcome measurement instrument – A COSMIN perspective. *Journal of Clinical Epidemiology*, 185, 111879. <https://doi.org/10.1016/j.jclinepi.2025.111879>
- Muñoz-Salinas, Y., Caro-Zúñiga, D., & Jeria, I. (2025). Creativity and preservice teachers: A literature review of an underexplored field (2014–2024). *Education Sciences*, 15(3), 395. <https://doi.org/10.3390/educsci15030395>
- Ramadani, L., Rahimitabar, P., Caka, F., & Boeckmann, M. (2025). Pre-service teachers as partners in climate change and health education. *Frontiers in Education*, 10. <https://doi.org/10.3389/feduc.2025.1613246>

- Schmäing, T., Ben-Zvi Assaraf, O., Bielik, T., & Krell, M. (2026). Exploring correlations between pre-service biology teachers' systems thinking skills and environmental awareness. *Research in Science Education*. <https://doi.org/10.1007/s11165-026-10333-w>
- Suryawati, E., Suzanti, F., Zulfarina, Z., Putriana, A. R., & Febrianti, L. (2020). The implementation of local environmental problem-based learning student worksheets to strengthen environmental literacy. *Jurnal Pendidikan IPA Indonesia*, 9(2), 169–178. <https://doi.org/10.15294/jpii.v9i2.22892>
- Willemsen, R. H., de Vink, I. C., Kroesbergen, E. H., & Lazonder, A. W. (2024). Strengthening creative problem-solving within upper-elementary science education. *Journal of Creative Behavior*, 58(1), 137–150. <https://doi.org/10.1002/jocb.639>
- Yani, A., Amin, M., Rohman, F., Suarsini, E., & Rijal, M. (2021). Pre-service biology teacher's perception on local environment problems as contextual learning resources. *International Journal of Evaluation and Research in Education (IJERE)*, 10(3), 768. <https://doi.org/10.11591/ijere.v10i3.21091>
- Yaya, E., Selia, I., Imelda, I., Aprilia, A., Azhari, M., & Hasanah, M. R. (2025). Integration of field work practices in contextual learning of ecology in Biology Education Program Muhammadiyah Palangka Raya University. *Jurnal Pembelajaran Biologi: Kajian Biologi dan Pembelajarannya*, 12(1), 45–51. <https://doi.org/10.36706/jpb.v12i1.128>
- Yusup, F., Istiqamah, I., & Khairunnisa, K. (2021). Learning methods on environmental education to improve pre-service teachers' environmental literacy. *Journal of Biology Education Research (JBER)*, 2(2), 50–55. <https://doi.org/10.55215/jber.v2i2.4137>