



Integrating Gamelan into Problem-Based Learning and Culturally Responsive Teaching-Oriented E-Learning to Enhance Students' Problem-Solving Skills

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Abstract: This study aims to evaluate the effectiveness of gamelan-integrated e-learning Problem-Based Learning combined with Culturally Responsive Teaching (PBL-CRT) in improving middle school students' problem-solving skills and cultural awareness. A quantitative pre-experimental approach using a one-group pretest-posttest design was employed, involving 33 eighth-grade students. Data were collected through problem-solving tests and cultural awareness questionnaires administered before and after the intervention. The data were analyzed using nonparametric statistical tests and effect size analysis. The results showed significant improvements in both students' problem-solving skills and cultural awareness after the implementation of gamelan-integrated e-learning PBL-CRT. The Wilcoxon Signed-Rank Test revealed a significant difference between pretest and posttest scores ($Z = -4.937$, $p = 0.001$), while the effect size analysis indicated a very large effect ($r = 0.85$). Improvements were observed across all indicators of both variables. These findings indicate that gamelan-integrated e-learning PBL-CRT serves as an effective contextual learning approach for enhancing students' problem-solving skills while fostering greater appreciation and awareness of local culture.

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Introduction

The rapid advancement of science and technology in the 21st century has transformed education and increased the demand for competencies such as creative thinking, critical thinking, and problem-solving skills (Maria et al., 2022; Muqorrobin & Fathoni, 2021; Jelodari et al., 2025). In response to these challenges and the demands of globalization, Indonesia continues to promote curriculum and pedagogical innovations aimed at enhancing students' problem-solving abilities (Primayana, 2019).

Problem-solving skills involve identifying problems, formulating solutions, and selecting appropriate actions to achieve desired outcomes (Dewey, 1910). These skills are essential for students' cognitive development and future decision-making abilities (Ismet et al., 2020). However, Indonesian students' problem-solving skills remain relatively low. Aras (2020) reported that students at a Madrasah Tsanawiyah (MTs) in Wajo Regency demonstrated limited problem-solving abilities, partly due to ineffective learning models and teacher-centered practices that emphasized lower-order thinking skills. These conditions highlight the need for active learning approaches and support the implementation of deep learning-oriented curricula in Indonesia.



Current educational policy in Indonesia is shifting toward a deep learning approach that promotes meaningful, mindful, and engaging learning experiences (Kemendikbudristek, 2024; Ministry of Education and Culture, 2022). This approach supports the development of graduate competencies and character, particularly critical reasoning, which is closely related to problem-solving skills (Cholilah et al., 2023; Herman et al., 2022). It also encourages the integration of local cultural values to create contextual learning experiences and strengthen students' cultural identity amid global challenges (Arifin, 2020; Firmayanti & Fardhani, 2023). However, these educational goals have not yet been fully realized in school practice.

Empirical evidence suggests that the Deep Learning approach has not been fully implemented in classroom practice despite its inclusion in the curriculum (Amini Rahayu & El Hakim, 2022). Observations at the study site revealed that learning activities had not consistently reflected the principles of meaningful, mindful, and joyful learning, while technology integration remained limited. These conditions hinder the development of students' problem-solving skills and cultural awareness. Although local cultural elements were occasionally incorporated into science learning, students often perceived them superficially and failed to understand their cultural significance. Consequently, efforts to strengthen both problem-solving skills and cultural awareness remain necessary, particularly in science education.

Natural Science is a foundational subject within the middle school curriculum, with 'vibrations and waves' being one of its core topics. However, students frequently encounter difficulties grasping these concepts, as instructional delivery often remains overly theoretical and mathematically oriented (Liza et al., 2016). Research by Auli et al. (2018) further indicates that eighth-grade students experience significant misconceptions regarding vibrational and wave phenomena. These challenges stem from the continued reliance on conventional, lecture-dominated teaching methods. Such teacher-centered approaches facilitate only a unidirectional transfer of knowledge, hindering students from constructing a meaningful and scientifically accurate understanding of physics concepts.

To address these challenges, Problem-Based Learning (PBL) can be implemented to support students in constructing conceptual understanding through active problem-solving processes (Siregar & Aghni, 2021). Its effectiveness can be enhanced through e-learning, which provides flexible access to learning resources and facilitates collaboration beyond classroom boundaries (Sari & Ekohariadi, 2021; Nugroho, 2022). Moreover, the integration of e-learning supports the implementation of Deep Learning through the meaningful use of digital technology.

Beyond digital technology, learning can be enriched through local cultural contexts. Culturally Responsive Teaching (CRT) connects scientific concepts with students' cultural experiences, making learning more meaningful (Wijayanto, 2025; Lestari et al., 2025). In this study, gamelan served as a contextual medium for learning science while fostering appreciation for local culture. Previous studies have shown that culture-based learning enhances conceptual understanding and cultural awareness by linking abstract concepts to real-world experiences (Choirrunisa & Maryati, 2025). Therefore, integrating e-learning-assisted Problem-Based Learning (PBL) and CRT within a gamelan context can support both conceptual mastery and 21st-century skills.

This study aims to evaluate the effectiveness of gamelan-integrated PBL-CRT e-learning in improving students' problem-solving skills and cultural awareness in science learning. The proposed approach serves as a contextual solution to the limited integration of local culture in science classrooms and the persistent challenges of developing problem-



solving competencies. The novelty of this study lies in the integration of Problem-Based Learning, Culturally Responsive Teaching, e-learning, and gamelan ethnoscience within a single instructional framework. Theoretically, PBL promotes active inquiry and systematic problem-solving through authentic learning experiences (Arends, 2012; Hmelo-Silver, 2004), while CRT facilitates meaningful learning by connecting scientific concepts with students' cultural backgrounds (Gay, 2018; Ladson-Billings, 2021). In addition, e-learning provides flexible access to interactive learning resources that support student engagement and knowledge construction (Clark & Mayer, 2016). Through the integration of gamelan as a local cultural context, the learning process is expected to simultaneously strengthen cultural awareness and support deeper conceptual understanding of vibrations and waves.

Research Method

This study employed a quantitative method with a pre-experimental one-group pretest-posttest design (Arikunto, 2014). The research sought to evaluate the effectiveness of gamelan-integrated PBL-CRT e-learning on the problem-solving skills and cultural awareness of middle school students. The research design can be seen in Table 1.

Table 1. Research Design

Pretest	Treatment	Posttest
O1	X	O2

This research was conducted at a middle school in Yogyakarta during the even semester of the 2025/2026 academic year. The subjects were 33 eighth-grade students selected using a purposive sampling technique based on the suitability of the material and research needs (Arikunto, 2014). The sample consisted of one class. A one-group pretest-posttest design was utilized to assess improvements in students' abilities before and after the implementation of the learning model.

The instruments used in this study are learning instruments and measuring instrument. Learning instrument was carried out using vibration e-learning and PBL-CRT waves loaded with gamelan. The problem-solving test and cultural awareness questionnaire were adapted from instruments developed and validated in the author's master's thesis. Prior to implementation, the instruments underwent expert review and empirical testing and were considered appropriate for measuring students' problem-solving skills and cultural awareness in this study. The learning intervention was implemented using the PBL model, which comprises five phases: orientation to the problem, organizing students for study, independent and group investigation, developing and presenting results, and evaluation (Arends, 2012). This e-learning also integrates the context of gamelan culture in learning activities. The e-learning products developed for this study underwent feasibility testing by expert lecturers, the results of which are presented in Figure 1.



Figure 1. PBL-CRT E-Learning Products



The research measuring instruments consisted of a problem-solving ability test and a cultural awareness questionnaire. The problem-solving test was compiled based on the indicator of problem-solving ability, while the cultural awareness questionnaire was compiled using cultural awareness indicators. Measuring instruments of problem-solving skills and cultural awareness can be seen in Table 2 and Table 3.

Table 2. Problem Solving Instruments

Variable	Indicator	Number of Items
Problem Solving	Understanding the problem	1
	Strategizing	1
	Implement solutions	1
	Evaluating solutions	1

Source: (Pólya, 1945)

Table 3. Cultural Awareness Instruments

Variable	Indicator	Number of Items
Cultural Awareness	Cultural considerations	1
	Cultural knowledge	1
	Cultural understanding	1
	Cultural competence	1

Source: (Wunderlee et al., 2006)

Data collection was conducted through pretest and posttest problem-solving tests and cultural awareness questionnaires administered before and after the intervention.

a) Data interval

As cultural awareness data were collected using a 4-point Likert scale, the ordinal scores were converted into interval data using the Method of Successive Interval (MSI).

b) Normality

The Shapiro-Wilk test was employed to examine the normality of the data distribution. The results were used to determine the appropriate statistical analysis.

c) Hypothesis Test

Because the data were not normally distributed, the Wilcoxon Signed-Rank Test was used to examine differences between pretest and posttest scores of students' problem-solving skills and cultural awareness. Statistical significance was determined at $\alpha = 0.05$.

d) Effect Size

Effect size analysis was conducted to evaluate the magnitude of the intervention effect on students' problem-solving skills and cultural awareness. The results were interpreted according to Cohen's (1988) criteria. Effect size values interpretation criteria presented in Table 4.

Table 4. Interpretation of Effect Size

Effect Size	Interpretation
$0 < d < 0.2$	Small
$0.2 < d < 0.5$	Medium
$0.5 < d < 0.8$	Large
$d > 0.8$	Very Large

Source: (Cohen, 1998)



Results and Discussion

Description of Research Results

This study examined the effect of Problem-Based Learning integrated with Culturally Responsive Teaching on students' problem-solving skills and cultural awareness. The findings indicate that culturally integrated e-learning positively influenced both variables by helping students connect scientific concepts with their cultural experiences and prior knowledge (Lestari et al., 2025). The learning activities were structured according to the stages of Problem-Based Learning, including problem orientation, student organization, investigation, presentation, and evaluation, which actively engaged students in analyzing problems and developing solutions (Arends, 2012).

Problem Solving

The data obtained from the pretest, posttest, and questionnaire underwent analysis via the Wilcoxon Signed-Rank Test. This non-parametric method was employed due to the outcomes of preliminary normality assessments, which revealed that the distributions of the pretest-posttest problem-solving and cultural awareness data deviated from normality (Sugiyono, 2009). Comprehensive findings pertaining to both the normality assessments and the Wilcoxon Signed-Rank Tests are delineated in Table 5 and Table 6.

Table 5. Normality Test of Problem-Solving Results

Data	Sig.	Remarks
Pretest	0,001	Not Normal
Posttest	0,001	Not Normal

Table 6. Wilcoxon Signed-Ranked Test Results

Aspects	Value
Sample Count (N)	33
Sig. (2-tailed)	< 0.001
Hypothesis	H ₀ rejected
Pretest Average	62,9
Posttest Average	81,9

The results of the normality assessment indicated a significance value of 0.001 ($p < 0.05$), thereby demonstrating that the dataset did not conform to a normal distribution. As a result, non-parametric statistical methods were utilized to correspond with the inherent characteristics of the data. The Wilcoxon-Signed-Rank Test indicated a statistically significant enhancement between the pretest and posttest scores of students subsequent to the implementation of PBL-CRT integrated e-learning. Descriptively, the average pretest score rose from 62.9 to 81.9 in the posttest.

The increase in students' average score from 62.9 to 81.9 indicates that the gamelan-integrated PBL-CRT e-learning effectively supported meaningful learning. By connecting scientific concepts with students' cultural experiences, the gamelan context enhanced learning relevance and engagement, consistent with sociocultural learning theory (Vygotsky, 1978) and previous studies on culturally responsive teaching (Rasyada et al., 2024; Saenab et al., 2024). Moreover, the Problem-Based Learning approach encouraged active inquiry and problem-solving, while the e-learning platform facilitated access to interactive learning resources. The integration of CRT, PBL, and e-learning therefore contributed to improved learning outcomes and scientific literacy.

Furthermore, all students demonstrated improved scores following the intervention, with no cases of decline or stagnation. The Wilcoxon Signed-Rank Test confirmed a significant difference between pretest and posttest scores ($p < 0.001$), indicating that the

gamelan-integrated PBL-CRT e-learning effectively enhanced students' problem-solving skills. Detailed results for each problem-solving indicator are presented in Figures 2 and 3.

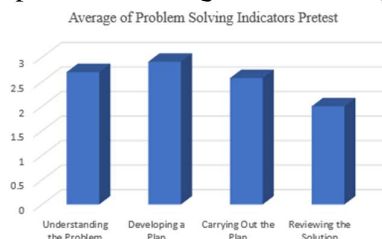


Figure 2. Average Pretest Score Problem Solving Indicators

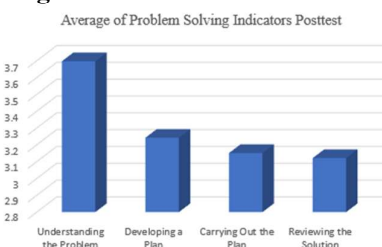


Figure 3. Average Posttest Score Problem Solving Indicators

Analysis of the problem-solving indicators showed improvement across all stages following the intervention. The average scores increased from 2.54 to 3.67 for understanding the problem, 2.91 to 3.27 for developing a plan, 2.58 to 3.15 for implementing the plan, and 2.00 to 3.00 for reviewing results. The greatest improvement was observed in understanding the problem, suggesting that students became more capable of identifying relevant information and interpreting problem situations. In contrast, reviewing results showed the lowest improvement, indicating that students were still less accustomed to evaluating and verifying their solutions. Overall, the findings demonstrate the effectiveness of gamelan-integrated PBL-CRT e-learning in improving students' problem-solving skills. Detailed effect size results are presented in Table 7.

Table 7. Effect Size Results of Problem Solving

Aspects	Value
Number of Samples	33
Z Value	5,038
Effect Size	0,88
Categories	Very Large

The effect size analysis yielded a value of 0.88, indicating a large effect of the intervention on students' problem-solving skills (Cohen, 1988). This finding suggests that the integration of PBL, e-learning, and Culturally Responsive Teaching (CRT) effectively supported students' problem-solving development. Through PBL, students actively engaged in identifying problems, exploring information, and constructing solutions, which promoted higher-order thinking skills (Arends, 2012). Consistent with Polya's (1973) problem-solving framework, the stages of PBL facilitate understanding problems, planning solutions, implementing strategies, and evaluating results, thereby enhancing students' problem-solving competencies (Hmelo-Silver, 2004).

Learning success was further supported by the integration of e-learning as an instructional medium. E-learning provides flexible access to learning resources, interactive multimedia, and immediate feedback, enabling students to engage in independent learning



and review challenging concepts more effectively (Clark & Mayer, 2016; Moore & Kearsley, 2012). These features contributed to the improvement of students' problem-solving skills.

The Culturally Responsive Teaching (CRT) approach, integrated with the ethnoscience context of gamelan, enabled students to understand vibrations and waves in a more meaningful and contextual manner (Wibowo & Krismandana, 2020). By connecting scientific concepts with students' cultural backgrounds and experiences, CRT promotes inclusive and relevant learning (Gay, 2018), resulting in greater engagement and learning effectiveness (Nuur & Ahsani, 2025). The integration of PBL and CRT within the e-learning environment effectively enhanced students' learning outcomes and problem-solving skills.

Cultural Awareness

Students' cultural awareness was analyzed to evaluate the impact of gamelan-integrated PBL-CRT e-learning. Questionnaire data were analyzed using normality testing, the Wilcoxon Signed-Rank Test, comparison of empirical and theoretical means, and effect size analysis. The results showed a significant improvement in students' cultural awareness following the intervention, indicating that the integration of local culture into the learning process effectively fostered cultural awareness. Detailed results of the normality and Wilcoxon tests are presented in Tables 8 and 9.

Table 8. Results of the Normality Test of Cultural Awareness Questionnaire

Data	Sig.	Remarks
Pretest Questionnaire	0,300	Normal
Posttest Questionnaire	0,001	Not Normal

Table 9. Wilcoxon Signed-Ranked Test Results

Aspects	Value
Sample Count (N)	33
Sig. (2-tailed)	< 0.001
Hypothesis	H ₀ rejected
Pretest Average	3,516
Posttest Average	4,296

The normality test indicated that the data were not normally distributed ($p < 0.05$); therefore, the Wilcoxon Signed-Rank Test was employed. The results revealed a significant improvement in students' cultural awareness following the intervention ($p < 0.001$), with the mean score increasing from 3.516 in the pretest to 4.296 in the posttest. Moreover, all students demonstrated positive score gains, indicating a consistent impact of the intervention across participants. A comparison of the empirical and theoretical means is presented in Figures 4 and 5.

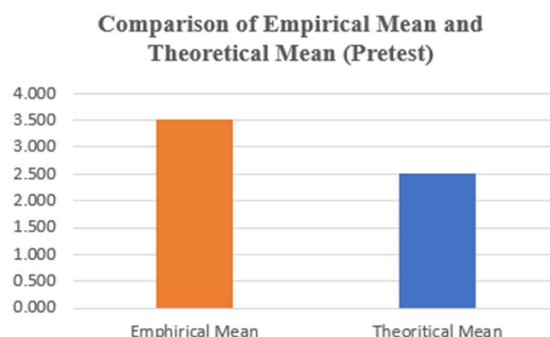


Figure 4. Comparison of Empirical Mean and Pretest Theoretical Mean (Pretest)

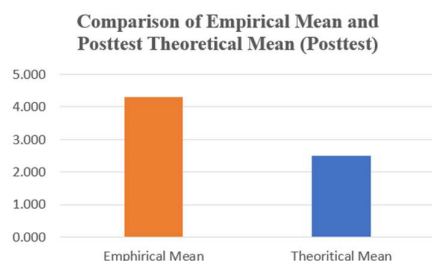


Figure 5. Comparison of Empirical Mean and Posttest Theoretical Mean (Posttest)

Descriptive analysis results indicate that the empirical average of students' cultural awareness was 3.516 before the intervention and increased to 4.296 afterward. Both values exceed the theoretical average of 2.5, categorizing students' cultural awareness as being at a high level. The increase in the empirical mean after the implementation of e-learning-based Problem-Based Learning (PBL) integrated with Culturally Responsive Teaching (CRT) using gamelan content demonstrates that incorporating local culture effectively enhances students' cultural awareness. Utilizing gamelan as a learning context fosters a more meaningful process, enabling students to better understand, appreciate, and familiarize themselves with their regional heritage. The average of cultural awareness pretest and posttest questionnaire scores per-indicators are illustrated in Figure 6 and Figure 7.

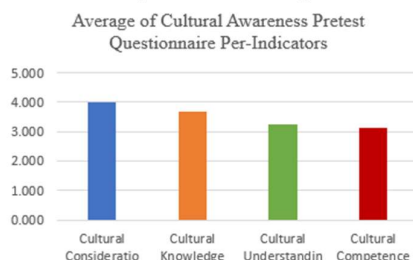


Figure 6. Average of Cultural Awareness Pretest Questionnaires Scores Every Indicators

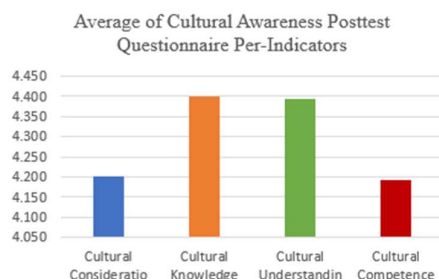


Figure 7. Average of Cultural Awareness Posttest Questionnaires Scores Every Indicators

The 'cultural considerations' aspect rose from 4.019 to 4.202, demonstrating an enhanced ability among students to integrate cultural values into their learning process. Cultural knowledge similarly increased from 3.685 to 4.398, indicating that students became more knowledgeable about local traditions. Furthermore, cultural comprehension scores grew from 3.252 to 4.392, suggesting a deeper understanding of the cultural nuances being studied. Additionally, cultural competence improved from 3.110 to 4.193, reflecting the development of students' capacity to appreciate and apply cultural values. These advancements were facilitated by instructional activities that utilized problem-solving tasks centered on gamelan instruments, such as the saron and gender kyai arum.



The greatest improvement was observed in the cultural understanding indicator, suggesting that the intervention effectively enhanced students' understanding of local cultural values and heritage. In contrast, cultural consideration showed the smallest gain, likely due to its relatively high baseline score prior to the intervention. Nevertheless, the effect size analysis confirmed that the gamelan-integrated PBL-CRT e-learning had a substantial impact on students' cultural awareness. Detailed effect size results are presented in Table 10.

Table 10. Effects of Cultural Awareness Test

Aspects	Value
Z Value	-4,937
N	33
r	0,85
Categories	Very Large

Overall, the findings indicate that gamelan-integrated PBL-CRT e-learning positively influenced students' problem-solving skills and cultural awareness. The improvement in cultural awareness can be attributed to learning experiences that connected scientific concepts with students' cultural identities through local gamelan contexts. This approach aligns with CRT principles, which emphasize the integration of students' cultural backgrounds into the learning process to enhance relevance and meaning (Rahmalia et al., 2025). Furthermore, the findings support previous studies showing that e-learning integrated with local wisdom can strengthen students' appreciation of regional culture amid the challenges of modernization (Rahmawati & Ridwan, 2017).

The incorporation of local culture into the curriculum not only promotes a more contextual understanding of scientific concepts, but also fosters deeper appreciation and comprehension of regional heritage. Culturally responsive pedagogy has been shown to enhance student engagement, motivation, and respect for diverse cultural backgrounds (Gay, 2018). Furthermore, culture-based instruction contributes to the development of students' self-identity, cultural pride, and social competence (Ladson-Billings, 1995). Consequently, these findings suggest that the future of science education should move beyond the transmission of scientific knowledge toward learning experiences that meaningfully connect science with local cultural contexts. The success of the gamelan-integrated PBL-CRT approach demonstrates that cultural heritage can function not only as instructional content but also as a pedagogical resource for developing critical thinking, problem-solving skills, and cultural awareness. Therefore, integrating local wisdom into technology-supported science learning may provide a sustainable pathway for promoting scientific literacy while preserving cultural identity in an increasingly globalized world.

Conclusion

In conclusion, the integration of e-learning-oriented Problem-Based Learning (PBL) with Culturally Responsive Teaching (CRT) grounded in gamelan culture effectively promoted students' problem-solving competencies and cultural awareness. The findings suggest that contextualizing science learning through local cultural practices enables students to engage more meaningfully with scientific concepts while simultaneously strengthening their appreciation of cultural heritage. Among the assessed dimensions, the greatest improvement was observed in students' ability to understanding the problem and their cultural consideration toward cultural understanding, indicating that culturally contextualized problem-solving activities successfully encouraged both analytical thinking and cultural engagement. In contrast, the least improvement was found in developing a plan and cultural



considerations suggesting that these aspects may require additional instructional support and longer-term intervention.

Overall, the study demonstrates that the combination of PBL, e-learning, CRT, and local cultural content creates a learning environment that bridges cognitive and sociocultural dimensions of learning. Beyond improving academic performance, this approach fosters students' capacity to formulate strategies, consider cultural perspectives, and apply scientific knowledge within meaningful real-world contexts. These findings highlight the potential of culturally responsive and technology-enhanced pedagogies to support holistic student development in science education.

Recommendation

Based on the findings of this study, teachers are encouraged to integrate local cultural contexts, such as gamelan, into science instruction to make learning more meaningful and relevant to students' everyday experiences. The implementation of the PBL-CRT approach through e-learning platforms can be utilized to promote active participation, collaborative problem-solving, and scientific literacy. To maximize its effectiveness, teachers should provide adequate scaffolding, facilitate inquiry-based discussions, and ensure that digital learning resources are accessible to all students regardless of their technological proficiency.

For future researchers, further studies are recommended to involve larger and more diverse samples across different educational levels, schools, and geographical regions to enhance the generalizability of the findings. Researchers may also examine the long-term effects of gamelan-integrated e-learning PBL-CRT on students' scientific literacy, critical thinking, problem-solving skills, and cultural awareness. In addition, future investigations could explore the integration of other forms of local wisdom and cultural heritage into science education, as well as compare their effectiveness with different instructional approaches. Such studies would contribute to a deeper understanding of how culturally responsive and technology-enhanced learning environments support students' cognitive and sociocultural development.

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