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Implementation of Culturally Responsive Teaching-Based Problem-Based Learning on Students' Analytical Thinking Skills in the Digestive System Topic in Grade XI at SMAIT Nur Hidayah

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Abstract: This study aimed to examine the effectiveness of a Problem-Based Learning (PBL) model integrated with Culturally Responsive Teaching (CRT) in enhancing students' analytical thinking skills in learning the digestive system. A quantitative approach was employed using a quasi-experimental research design. Specifically, the study adopted a non-equivalent control group design with purposive sampling, involving 28 students in the experimental class and 28 students in the control class. Data were collected through pretest and posttest assessments and were analyzed using an independent samples *t*-test. The results showed that the mean posttest score of the experimental class (84.82) was higher than that of the control class (71.43), with a significance value of $p < 0.001$, indicating a statistically significant difference between the two groups. These findings suggest that the integration of Problem-Based Learning (PBL) and Culturally Responsive Teaching (CRT) is effective in improving students' analytical thinking skills through culturally contextualized learning. This study contributes to the development of biology instruction grounded in local contexts, an area that remains relatively underexplored.
Keywords: Problem-Based Learning; culturally responsive teaching; analytical thinking skills; digestive system

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INTRODUCTION

Analytical thinking skills are among the essential competencies required in the twenty-first century, as they play a crucial role in preparing students to meet the demands of a rapidly changing global workforce and society. The World Economic Forum (2020) identified analytical thinking and innovation as key skills needed in the future workplace, alongside complex problem-solving, creativity, and critical thinking. Similarly, twenty-first-century learning frameworks emphasize the importance of equipping students with higher-order thinking skills, communication, collaboration, and adaptability to respond effectively to real-world challenges (Trilling & Fadel, 2009). This suggests that education can no longer focus solely on the mastery of factual knowledge; rather, it must also foster students' ability to analyze information, evaluate data, and make decisions based on logic and evidence. Therefore, education plays an important role in preparing students not only to understand subject matter but also to develop higher-order thinking skills and adaptability (Saputra, 2024). In this context, Biology learning serves as an appropriate medium for developing analytical thinking skills because it engages students with natural phenomena that are directly related to everyday life.

Biology education at the senior high school level plays an important role in developing students' scientific thinking. Biology learning does not merely teach knowledge in the form of concepts and natural laws; it also trains students to investigate, understand, and solve problems they encounter in daily life (Ardianti et al., 2024). Students are more likely to connect classroom learning with everyday experiences when they are actively involved in the learning process (Sumaryani & Parmithi, 2021). Moreover, Biology learning is closely related to scientific literacy, which requires students to use scientific knowledge to explain phenomena, interpret evidence, and draw conclusions based on data (OECD, 2023). Thus, the objectives of Biology learning are not limited to introducing facts and concepts related to organ structures and physiological processes. They also include the development of higher-order thinking skills, particularly analytical thinking. These skills are essential for enabling students to filter information appropriately, identify relationships among concepts, and draw logical conclusions from observed phenomena. With strong analytical abilities, students are expected to solve various problems in daily life, particularly those related to Biology.

Several indicators of analytical thinking have been proposed by experts. One widely used framework is the revised Bloom's taxonomy developed by Anderson and Krathwohl (2001), in which the cognitive process of analyzing consists of three main indicators: differentiating, organizing, and attributing. These indicators describe students' ability to distinguish relevant from irrelevant information, determine how elements are structured within a system, and identify the underlying purpose or point of view of information. In this study, these indicators were integrated into the development of pretest and posttest items, so that each question was designed to represent the specific aspect of analytical ability being measured. Accordingly, the test results are expected to reflect students' analytical thinking skills in a more measurable and systematic manner.

In practice, however, students' analytical thinking skills in Indonesia remain relatively low. The results of international assessments also indicate that Indonesian students still face challenges in applying knowledge to solve complex problems and communicate scientific reasoning effectively (OECD, 2023). Based on classroom observations, teacher interviews, and documentation studies conducted at SMAIT Nur Hidayah, students' analytical thinking skills have not yet reached an optimal level. Students still experience difficulty in answering analysis-level questions, particularly those categorized as C4. Similarly, Prawita et al. (2019) reported that students' analytical thinking skills reached an average score of only 28.17%. One strategy that can be used to improve students' analytical thinking skills is the implementation of a problem-based learning model (Viona Delfiza & Fuadiyah, 2024). Nevertheless, many studies have examined the implementation of Problem-Based Learning (PBL) to improve analytical thinking skills, indicating the need for innovation to strengthen the effectiveness of this model. One approach that can be combined with PBL is Culturally Responsive Teaching (CRT), an instructional approach that integrates students' cultural backgrounds into the learning process. The integration of PBL and CRT is expected not only to increase students' engagement in learning but also to help them understand Biology concepts in a more contextual and meaningful way through cultural experiences that are closely connected to their lives.

Problem-Based Learning (PBL) is a learning model that emphasizes real-world issues and enables students to construct knowledge through inquiry, collaboration, and problem-solving. Hmelo-Silver (2004) explains that PBL allows students to learn both subject matter and thinking strategies through the experience of solving meaningful problems. In Biology learning, PBL provides opportunities for students to investigate authentic biological phenomena, analyze relevant information, and formulate evidence-based solutions (Daniswara, 2023). Through the stages of PBL, such as identifying problems, collecting information, analyzing data, and formulating solutions, students are directly trained to develop analytical thinking skills. These skills are particularly reflected in their ability to deconstruct problems, connect concepts, and draw evidence-based conclusions. However, problem-based learning is often implemented in ways that are still insufficiently contextual. Therefore, learning designs that are connected to students' environments and lived experiences are needed to make learning more meaningful (Hasibuan et al., 2024).

Culturally Responsive Teaching (CRT) offers a potential approach to addressing this issue. CRT is an instructional strategy that places students' cultural backgrounds, experiences, and values at the center of the learning process (Gay, 2002). In a similar perspective, Ladson-Billings (1995) emphasizes that culturally relevant pedagogy supports students' academic success by connecting learning with their cultural identities and social realities. CRT enables students to understand learning materials by relating them to their cultural experiences, values, and everyday practices. When PBL is combined with CRT, the problems presented to students are not only authentic but also contextual and relevant to their identities (Hidayah et al., 2025). The integration of PBL and CRT creates a complementary learning mechanism: PBL provides a problem-solving framework through real-world problems, while CRT strengthens the learning context by incorporating students' cultural experiences as learning resources. This combination encourages students to become more actively involved in identifying the components of a problem, connecting concepts with cultural realities, and making decisions based on logical and evidence-based analysis.

The digestive system topic was selected in this study because it is contextual and closely related to students' everyday lives, particularly in relation to food consumption patterns. Concepts within the digestive system, such as types of nutrients, mechanical and chemical digestion, and nutrient absorption, are highly relevant to students' eating habits in their surrounding environment. In addition, this topic allows for integration with local cultural contexts, such as regional foods, enabling students not only to understand concepts theoretically but also to relate them to real-life practices they experience. Such contextualization is consistent with culturally responsive science education, which emphasizes the importance of connecting scientific concepts with students' cultural knowledge, local practices, and everyday experiences (Smith et al., 2022). Given these characteristics, the digestive system provides an appropriate context for implementing a Culturally Responsive Teaching-based Problem-Based Learning model, as it allows authentic problems to be presented in ways that are relevant to students' lived experiences.

This study aims to examine the effectiveness of a Culturally Responsive Teaching-based Problem-Based Learning model on students' analytical thinking skills in the digestive system topic. This study is important because it offers an alternative Biology learning model that is more contextual through the integration of PBL and CRT. Furthermore, it may assist teachers in developing instructional designs that align with students' characteristics and backgrounds, thereby making the learning process more relevant and meaningful. Thus, the findings of this study are expected to contribute to improving the quality of Biology learning in schools, particularly in developing students' analytical thinking skills.

METHOD

This study employed a quantitative approach using a quasi-experimental research design. Specifically, the study adopted a Non-Equivalent Control Group Design, which involves two groups that are not randomly selected but are instead drawn from pre-existing classes. Consequently, the initial characteristics of the two groups may not be entirely equivalent. The study was conducted at SMAIT Nur Hidayah Sukoharjo during the even semester of the 2025/2026 academic year. The population consisted of all Grade XI students, while the research sample was selected using purposive sampling, with consideration given to the equivalence of students' academic ability. The sample comprised students from Class XI-6 as the control group and Class XI-7 as the experimental group, with each class consisting of 28 students. Because class selection was conducted without randomization, this study is categorized as a quasi-experiment with non-equivalent groups. The research design is presented in Table 1.

Table 1. Non-equivalent control group design

Group	Treatment	Pretest	Posttest
Experimental Group	X	O_1	O_2
Control Group	–	O_3	O_4

Notes:
O_1 = Pretest administered to the experimental group
O_2 = Posttest administered to the experimental group
O_3 = Pretest administered to the control group
O_4 = Posttest administered to the control group
X = Treatment using Problem-Based Learning integrated with Culturally Responsive Teaching
– = No treatment; conventional instruction was implemented

The variables in this study consisted of an independent variable and a dependent variable. The independent variable was the Problem-Based Learning (PBL) model integrated with Culturally Responsive Teaching (CRT), while the dependent variable was students' analytical thinking ability. Operationally, analytical thinking ability was defined as students' ability to decompose information, identify relationships among concepts, and draw logical conclusions. This ability was measured based on the analytical thinking indicators proposed by Anderson and Krathwohl, namely differentiating, which refers to distinguishing relevant from irrelevant information; organizing, which involves identifying and connecting components or structures within a problem; and attributing, which refers to determining causal relationships and drawing inferences based on available information.

The treatment administered to the experimental group consisted of the implementation of the Problem-Based Learning model integrated with a Culturally Responsive Teaching approach. Learning activities were conducted through the presentation of contextual problems related to students' local culture. In contrast, the control group received conventional lecture-based instruction. The research instrument was an analytical thinking ability test administered as both a pretest and a posttest. The test consisted of 20 multiple-choice items, with each item worth 5 points. The instrument was developed based on Anderson and Krathwohl's indicators of analytical thinking ability. Prior to its use in the study, the instrument was constructed using a test blueprint aligned with these indicators and was subsequently validated by subject-matter experts and evaluation experts to ensure content appropriateness and the quality of the instrument in measuring the intended ability. In addition, the instrument was tested to determine item validity, reliability, difficulty level, and discrimination index, thereby ensuring its suitability for data collection.

Data analysis began with prerequisite tests, namely tests of normality and homogeneity. The normality test was conducted using the Kolmogorov–Smirnov test to determine whether the data were normally distributed, while the homogeneity test was conducted using Levene's test to examine the equality of variances between groups. The data were considered normally distributed and homogeneous when the significance value was greater than 0.05. After the prerequisite assumptions were met, hypothesis testing was conducted using an Independent Samples *t*-test to determine whether there was a significant difference in analytical thinking ability between the experimental and control groups. The decision criterion was that if $p < 0.05$, a significant difference existed between the two groups. All data analyses were performed using IBM SPSS Statistics version 26.

RESULTS AND DISCUSSION

This study was conducted in Grade XI at SMAIT Nur Hidayah Sukoharjo on the topic of the digestive system. Before hypothesis testing, prerequisite statistical analyses were performed, including tests of normality and homogeneity. The normality test results for Class XI 6, which served as the control class, showed that both the pretest and posttest data were normally distributed, with significance values of 0.496 and 0.232, respectively. Similarly, the normality test results for Class XI 7, which served as the experimental class, indicated that the pretest and posttest data were normally distributed, with significance values of 0.172 and 0.716, respectively. These results indicate that the data on students' analytical thinking skills from both classes met the assumption of normality.

A homogeneity test was subsequently conducted to determine whether the variances of the two groups were equivalent. The analysis yielded a significance value of 0.140, indicating that the variances of the control and experimental groups were homogeneous. Therefore, the data met the homogeneity assumption, which is an essential requirement for conducting parametric statistical analysis.

After the assumptions of normality and homogeneity had been fulfilled, an independent samples t-test was conducted using SPSS version 26. The decision criterion was based on the significance value: if the significance value was less than 0.05, H_0 was rejected and H_1 was accepted, indicating a statistically significant difference between the two groups. The descriptive statistics and independent samples t-test results are presented in Tables 2 and 3.

Table 2. Descriptive statistics of the control and experimental groups

Group	N	Mean	Std. Deviation	Std. Error Mean
Control	28	71.43	14.133	2.671
Experiment	28	84.82	8.973	1.696

Table 3. Independent samples test results

Assumption	t	df	One-Sided p	Two-Sided p	Mean Difference	Std. Error Difference	95% CI Lower	95% CI Upper
Equal variances assumed	-4.233	54	< 0.001	< 0.001	-13.393	3.164	-19.736	-7.050
Equal variances not assumed	-4.233	45.726	< 0.001	< 0.001	-13.393	3.164	-19.762	-7.024

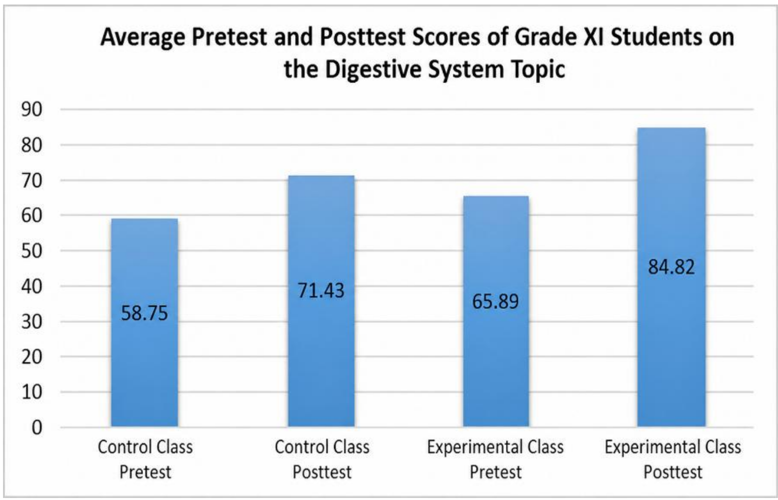

Figure 1. Students' analytical thinking skills

As shown in Table 3, the independent samples t-test produced a significance value of < 0.001. This result indicates that H_0 was rejected and H_1 was accepted. Thus, there was a statistically significant difference in students' analytical thinking skills between the experimental and control classes. The higher mean score obtained by the experimental class suggests that the implementation of Problem-Based Learning (PBL) integrated with Culturally Responsive Teaching (CRT) significantly improved students' analytical thinking skills compared with conventional instruction.

This finding is also supported by the score comparison presented in Figure 1. Both the control and experimental classes showed improvement from pretest to posttest. However, the increase in the experimental class was greater than that in the control class. The mean score of the control class increased from 58.75 to 71.43, while the mean score of the experimental class increased from 65.89 to 84.82. These results indicate that PBL integrated with CRT provided a more effective learning experience for developing students' analytical thinking skills. Therefore, the statistical findings and descriptive score patterns consistently demonstrate that the treatment applied in the experimental class contributed positively to students' analytical thinking development.

Problem-Based Learning is an instructional model that engages students in collaborative problem-solving activities based on real-world issues. Through this model, students are encouraged to investigate problems, analyze information, propose solutions, and construct knowledge actively. PBL stimulates curiosity, analytical reasoning, and student initiative in understanding the subject matter (Very et al., 2025). One of the main strengths of PBL is its student-centered orientation, which allows learners to develop problem-solving skills in authentic and meaningful contexts (Priyanti et al., 2023). By involving students in the analysis of problems related to their surrounding environment, PBL supports the development of a more comprehensive understanding of the learning material (Lailiyah et al., 2024).

Culturally Responsive Teaching is an instructional approach that uses students' cultural knowledge, values, and personal experiences as meaningful resources for learning. CRT aims to create learning experiences that are relevant, effective, and meaningful for students from diverse cultural backgrounds (Rochaminah et al., 2024). This approach enables students to connect new knowledge with their own cultural and social experiences. As a result, students are not only exposed to scientific concepts but are also guided to understand these concepts through contexts that are familiar and meaningful to them (Fitria, 2023).

The integration of CRT into PBL strengthens the learning process because students are encouraged to solve problems that are closely related to their cultural background and daily experiences. In this study, the use of culturally familiar contexts helped students engage more actively with the learning material. When biological concepts were connected to cultural practices and local food traditions, students were able to construct understanding more concretely. This connection between culture, real-life problems, and scientific concepts made the learning process less abstract and more relevant to students' lives.

In this study, CRT was implemented in digestive system learning by connecting biological concepts with local cultural contexts that were familiar to students. Learning becomes more accessible when students encounter examples and problems related to their daily experiences (Susanti et al., 2025). Therefore, traditional foods from Solo, such as gudeg, timlo, serabi, nasi liwet, and other local dishes, were used as contextual learning materials. Through this approach, students did not only learn the structure and function of digestive organs theoretically but also examined how familiar foods are processed in the human body.

During the learning activities, students worked in groups to analyze the nutrient content of traditional Solo foods. They identified nutrients such as carbohydrates, proteins, fats, vitamins, and minerals, and then connected these nutrients with the digestive processes occurring in the body. The discussion covered mechanical digestion in the mouth, chemical digestion involving digestive enzymes, and nutrient absorption in the small intestine. Through these activities, students were guided to understand not only the types of nutrients contained in food but also how these nutrients are processed by digestive organs to produce energy and support bodily functions.

The learning process was also connected to health-related issues found in students' surrounding environment. For example, students discussed cases related to the frequent consumption of traditional foods high in coconut milk, which may affect digestive health when consumed excessively. This case encouraged students to analyze the relationship between food composition, digestive processes, and potential health impacts. Such contextual problems provided opportunities for students to apply biological concepts to real-life situations.

Through these activities, students' analytical thinking skills were developed in several ways. First, students identified relevant information from the given problem. Second, they connected this information with biological concepts related to the digestive system. Third, they interpreted the relationship between food nutrients, digestion, and health. Finally, they drew conclusions based on the evidence obtained from their analysis. This process is consistent with Magdalena (2016), who stated that contextual learning supports analytical thinking because it provides students with opportunities to solve real problems encountered in everyday life.

Theoretically, these findings are in line with constructivist learning theory, which emphasizes that knowledge is constructed through experience and interaction with the environment (Nurjamilah et al., 2025). The integration of CRT into digestive system learning enabled students to link scientific concepts with concrete cultural experiences. As a result, students were able to build stronger conceptual understanding and develop analytical thinking through meaningful learning contexts.

Previous studies also support the effectiveness of integrating PBL with CRT in classroom learning. Shoit et al. (2023) reported an improvement in students' problem-solving skills from Cycle I to Cycle II, indicating the effectiveness of PBL combined with CRT. Similarly, Mawadah et al. (2025) found that students in the experimental class achieved higher posttest scores than those in the control class. These findings suggest that PBL integrated with CRT can be implemented effectively to support active, meaningful, and culturally relevant learning. In addition, the present findings are consistent with Rahim et al. (2025), who found that the implementation of PBL can improve students' analytical thinking skills.

The improvement in students' analytical thinking skills can be explained by the complementary characteristics of PBL and CRT. PBL requires students to examine problems, gather information, discuss possible explanations, and formulate solutions. These activities naturally train students to analyze information and connect concepts logically. Meanwhile, CRT strengthens this process by situating learning within cultural contexts that are close to students' lives. When students analyze biological concepts through familiar cultural examples, they are more likely to engage actively and construct meaningful understanding.

In the context of digestive system learning, the use of traditional Solo foods provided a relevant and concrete entry point for students to understand biological processes. Students were able to connect the structure and function of digestive organs with the food they consume in daily life. They also analyzed nutrient content, mechanical and chemical digestion, enzyme activity, nutrient absorption, and the possible health effects of certain eating habits. These learning experiences encouraged students to move beyond memorization and engage in deeper conceptual analysis.

Furthermore, integrating local culture into biology learning helped students recognize the relevance of science to their everyday lives. The use of local foods as learning contexts not only supported the development of analytical thinking skills but also fostered appreciation of local culture as part of students' identity. Thus, biology learning became more meaningful, contextual, and culturally relevant.

Based on these findings, PBL integrated with CRT can be considered an effective instructional approach for improving students' analytical thinking skills in digestive system learning. By combining real-world problem-solving with culturally meaningful contexts, this approach helps students identify information, connect scientific concepts, evaluate problems, and draw logical conclusions. In addition, it promotes awareness of the importance of healthy eating patterns in maintaining digestive system function. Therefore, the integration of PBL and CRT offers a valuable strategy for creating biology learning that is both scientifically rigorous and relevant to students' lived experiences.

CONCLUSION

Based on the research findings, the implementation of a Culturally Responsive Teaching (CRT)-based Problem-Based Learning (PBL) model had a significant effect on students' analytical thinking skills. The mean score of the experimental class was higher than that of the control class, indicating that integrating learning problems with local cultural contexts can effectively encourage students to identify relevant information, connect concepts, and draw logical conclusions. The incorporation of cultural contexts, such as analyzing the nutritional content of local foods and relating it to the digestive process, provided students with a more contextualized learning experience. Theoretically, this study contributes to the development of biology education research by integrating Problem-Based Learning (PBL) and Culturally Responsive Teaching (CRT) as a culturally contextualized instructional framework that supports the development of analytical thinking skills. Practically, the findings suggest that the implementation of CRT-based PBL can serve as an effective alternative instructional strategy for enhancing students' analytical thinking skills.

RECOMMENDATION

The authors recommend the implementation of the Culturally Responsive Teaching (CRT)-based Problem-Based Learning (PBL) model as an alternative instructional approach that teachers can use to develop students' analytical thinking skills.

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