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Building Students' Creative Thinking: Problem-Solving in Project-Based Culturally Responsive Teaching

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Abstract. *Students' problem-solving skills remains a challenge because mathematics instruction often emphasizes procedures over creativity and rarely incorporates students' cultural contexts. This study explores the impact of Project-Based Culturally Responsive Teaching (CRT) on students' creative thinking and problem-solving skill, as well as teacher's perceptions of cultural integration in mathematics instruction. This explanatory sequential design study involved a class of 15 eighth-grade students and a mathematics teacher. Data were collected through observations, project assignments, tests, and questionnaires. The results showed that students' creative thinking indicators—fluency, flexibility, and originality—were in the excellent category, while elaboration increased from 79.17 (good) to 87.5 (excellent). Furthermore, there was a significant improvement in students' problem-solving skills, with an average pre-test score of 49.33 increasing to 64.33 ($p < 0.05$). The teacher responded that project-based CRT helped students develop more effective problem-solving strategies. These findings suggest that project-based CRT can foster students' creative thinking and problem-solving skill in mathematics. Teachers are encouraged to design problem-solving activities that connect mathematical concepts to students' cultural experiences to foster deeper understanding and more equitable learning opportunities.*

Keywords*: mathematics, creative thinking, culturally responsive teaching, problem-solving, project-based learning*

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Introduction

The creative thinking and problem-solving skill that require High Order Thinking Skills (HOTS) have become invaluable skills for the students in an increasingly complex and connected world (Cheng & Singh, 2024; Jihannita et al., 2023; Kolesnikova et al., 2022; Mulia & Rahayu, 2023). Creative thinking can be identified through four indicators: fluency, flexibility, originality, and elaboration. Fluency is closely related to the ability to generate a high number of ideas. Flexibility relates to the ability to switch between different strategic approaches. Originality refers to generating unique and unusual ideas. Elaboration relates to developing and refining ideas

(Lasia et al., 2024; Vale & Barbosa, 2024). Therefore, creative thinking skills are key skills that need to be developed in learning to prepare students to face challenges and changes in the 21st century.

In the current information era, students are expected not only to comprehend information but also to develop innovative approaches for solving problems (Akinci-Ceylan et al., 2018; Ryan et al., 2007), the students are proud and more confident when they can find a solution to a problem in learning mathematics (Inganah et al., 2023), the students with high and medium mathematical abilities can solve problems well, while students with low mathematical abilities are still lacking (Inganah et al., 2023). However, the way students learn these skills in culturally diverse environments remains a critical issue in education. This study attempts for examining students' creative thinking and problem-solving skill that require HOTS through culturally responsive teaching.

The Culturally Responsive Teaching (CRT) emerged in the modern educational world as an approach that focuses on recognizing and appreciating students' cultural backgrounds (Abdalla & Moussa, 2024; Caingcoy, 2023; Sukmanasa et al., 2024). This approach not only aims to create an inclusive learning environment (Caingcoy, 2023), but helps the students get motivated (Sukmanasa et al., 2024), present meaningful learning (Murti, 2023), increase self-efficacy relating subject matter to their experiences and cultural contexts (Cruz et al., 2020). Meanwhile, teaching in culturally diverse classrooms remains a major challenge for educators, as it requires the ability to design and implement instructional models that accommodate students from various cultural backgrounds (Alhanachi et al., 2021). On the other hand, the reduced opportunities to address cultural differences and the spirit of collaboration require further research on culturally responsive learning (Schirmer & Lockman, 2022). In this context, linking culturally responsive pedagogy with HOTS development becomes essential.

The HOTS problems, which include skills such as analysis, synthesis, and evaluation, require more than just the ability to recall information; they require the students to think deeply and creatively (Muhibbuddin et al., 2023). Interaction with the peers and learning motivation have a direct influence on the students' problem skills (Lu et al., 2021). Project Based Learning (PjBL) which engages the students in solving real and complex projects (Leong & Zhang, 2024; Subiyantoro, 2024), can be an effective way to encourage HOTS. The integration of PjBL syntax and HOTS problems can foster the students' high-level thinking skills and improve their cognitive learning outcomes (Liline et al., 2024). HOTS and CRT can provide a strong foundation for instilling character, critical thinking, and appreciation for cultural diversity (Safirah et al., 2024). However, the integration of PjBL with CRT has not been widely explored in educational research, especially in the contexts that incorporate the students' diverse cultural backgrounds.

The CRT is a pedagogical approach that adapts teaching materials and methods to students' cultural backgrounds, which has been shown to increase engagement and learning outcomes (Abdalla & Moussa, 2024; Sukmanasa et al., 2024). Meanwhile, PjBL engages students in real projects that encourage contextual application of knowledge and skills (Leong & Zhang, 2024; Subiyantoro, 2024), However, its integration with CRT in the HOTS context is still limited. The creative thinking, which involves the ability to think originally and flexibly, can be developed through various teaching methods that support creativity (Fatmawati et al., 2022; Li et al., 2022). Recent research suggests that CRT and PjBL can enhance HOTS skills such as analysis and evaluation, but in-depth research on the integration of these two approaches within the students' cultural contexts is lacking (Anyichie et al., 2023; Nabella et al., 2023). Therefore, the novelty of this study lies in the integration of CRT and PjBL with a focus on the HOTS, especially creative thinking and problem-solving skill, in the cultural context of the students.

The importance of understanding how project-based CRT can influence the students' creative thinking and problem-solving skill in the HOTS contexts has not been fully researched. Therefore, the formulation of the research problems is as follows: 1) How do the students' creative thinking processes through the implementation of project-based CRT? 2) What is the impact of project-based CRT implementation on the students' problem-solving skills? and 3) What is the teacher's perception of cultural integration in mathematics learning to improve students' problem-solving skills? The findings of this study are expected to provide new insights into more effective and inclusive educational practices, as well as offer recommendations for developing curricula that are more responsive to the students' cultural needs.

Method

This research used a mixed-methods approach with an explanatory sequential design (Azman & Hon, 2023). The project-based CRT learning design was developed collaboratively through Focus Group Discussions (FGD) between researchers and the teacher. The study subjects included a class of six male and nine female students aged 14-15 in eighth grade, and a mathematics teacher from a private school in East Java, Indonesia. This class was purposively selected, with a mathematics teacher implementing project-based CRT learning. This limited number of subjects was chosen to allow the researcher to conduct in-depth observations and analysis of each student individually, particularly on aspects of creative thinking during the process of completing culture-based project assignments and problem-solving. This aligns with the objectives of qualitative research, which emphasizes depth over breadth (Cohen et al., 2018; Creswell & Creswell, 2023).

Data collection began with quantitative data and continued with qualitative data. First, the impact of project-based CRT on students' creative thinking and problem-solving skill was measured using a quantitative approach. Second, a qualitative approach was used as a triangulation method to deepen the impact of project-based CRT on creative thinking skills, as well as to explore teacher's perceptions of cultural integration in mathematics learning to improve students' HOTS problem-solving skill. The research procedure is presented in Figure 1.

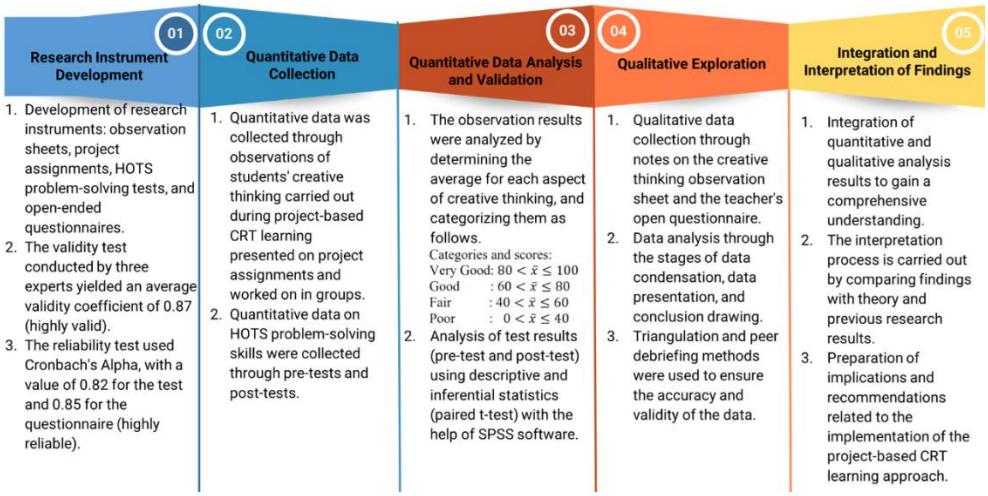


Figure 1. Research procedures

Figure 1 illustrates the data collection and analysis procedures in this study. Quantitative data were collected to explore the impact of project-based CRT on creative thinking processes through observation and problem-solving skill through HOTS problem-solving tests (including pre-tests and post-tests). The observation sheet instrument covered aspects of fluency, flexibility, originality, and elaboration in the use of HOTS problem-solving strategies in a cultural context, as suggested by Suherman and Vidákovich (2022). Observations of students' creative thinking processes were conducted during project-based CRT (two learning sessions) through group project assignments presented on worksheets. The project assignments included identifying geometric spaces and creating replicas of geometric spaces based on local culture. The test instrument emphasized the strategies used by students in HOTS problem-solving. Qualitative data were collected through notes on observations of creative thinking processes supported by project assignment data through worksheets, as well as open-ended teacher questionnaires used to explore teacher's perceptions of cultural integration in mathematics learning to improve students' HOTS problem-solving skill. Quantitative data were analyzed using descriptive and inferential statistics, while qualitative data were analyzed through data condensation, data presentation, and drawing conclusions as shown in Figure 1. In this study, the following hypotheses were proposed:

H_0: There is no difference in pre-test and post-test scores for problem-solving skill after the implementation of project-based CRT.

H_1: There is a difference in pre-test and post-test scores for problem-solving skill after the implementation of project-based CRT.

Results and Discussion

Students' Creative Thinking in Project-Based CRT

Project-based CRT learning was implemented in two meetings. Learning activities were designed in groups of five students to complete project assignments that encouraged the emergence of creative thinking processes. In the first and second meetings, students completed assignments in groups with a circular table arrangement to facilitate discussion. Each group was observed by one observer to observe the students' thinking processes during the completion of the project assignments. Learning activities began with exploring the problem context, followed by formulating initial ideas, completing the project assignments through discussions within each group, and refining the project solutions. During this process, students generated many ideas from various perspectives, revised ideas based on group mates' suggestions, and presented the resulting project products. The results of observations by three observers on the creative thinking processes during the two project-based CRT learning sessions are presented in Table 1.

Table 1. Students' creative thinking during project-based CRT

Creative Thinking Indicators	**Score The first meeting**					**Score Second meeting**				
	O_1	**O_2**	**O_3**	**Mean**	**Criteria**	**O_1**	**O_2**	**O_3**	**Mean**	**Criteria**
Ability to generate of ideas (Fluency)	7,5	5	7,5	83,33	Very good	7,5	7,5	7,5	87,5	Very good
Ability to see problems from multiple perspectives (Flexibility)	5	7,5	7,5	83,33	Very good	5	7,5	7,5	83,33	Very good
The ability to generate unique and different ideas (Originality)	7,5	5	7,5	83,33	Very good	7,5	5	7,5	83,33	Very good
Students' ability to develop solutions (Elaboration)	5	7,5	5	79,17	Good	7,5	7,5	7,5	87,5	Very good

Information:
O_1 : First observer
O_2 : Second observer
O_3 : Third observer

Categories and scores:
Very Good: $80 < \bar{x} \leq 100$
Good : $60 < \bar{x} \leq 80$
Fair : $40 < \bar{x} \leq 60$
Poor : $0 < \bar{x} \leq 40$

Table 1 shows the progressive improvement in creative thinking from the first meeting to the second. At the learning meeting, students began designing the project assignment through group discussions using worksheets. Each group of five students prepared tools and materials according to the project assignment instructions, as shown in Figure 2.

B. Alat dan Bahan

- Kertas karton, spidol, dan lem
- Laptop atau smartphone
- Buku catatan
- Referensi dari buku atau internet

Translate:
B. Tools and Materials

- *Cardboard, markers, and glue*
- *Laptop or smartphone*
- *Notebook*
- *References from books or the internet*

Figure 2. Tool and material in project-based CRT

The tools and materials in Figure 2 were used by students to identify geometric shapes and create replicas of objects based on local culture. In this meeting, aspects of fluency, flexibility, originality, and elaboration began to emerge, demonstrated by the results of identifying geometric spaces in local culture-based project assignments. Fluency was demonstrated by the emergence of various product ideas that resemble spheres, such as ball and balloon. Flexibility emerged when viewing problems from different perspectives, namely products that resemble geometric spaces not only objects around students but also local cultural products such as tumpeng (cone rice). Originality emerged when students chose a tube-spaces gateway that was different from their classmates. Elaboration emerged when students detailed the benefits of the local cultural products they had chosen, as shown in Figure 3.

1. Kegiatan 1 (Identifikasi Bangun Ruang Sisi lengkung)

No	Nama Benda	Bentuk Bangun	Fungsi dari benda
1	Bola	Bola	Untuk bermain
2	Celengan	Tabung	Untuk menabung dan menyimpan uang
3	Gapura	Tabung	Penanda masuk pada wilayah tersebut
4	Tumpeng	Kerucut	Untuk dimakan dan perayaan hari-hari tertentu
5	Balon	Bola	Untuk bermain dan hiasan
6	Topi Ulang Tahun	Kerucut	Untuk dipakai dan merayakan ulang tahun

Translate:
Activity 1 (Identifying Curved-sided Geometric Spaces)

Name	*Geometric Spaces*	*The benefits*
Ball	*Sphere*	*to play*
Money box	*Tube*	*to save and store money*
Gateway	*Tube*	*Area entry marker*
Tumpeng	*Cone*	*for eating and celebrating holidays*
Balloon	*Sphere*	*for play and decoration*
Birthday hat	*Cone*	*for use and birthday celebrations*

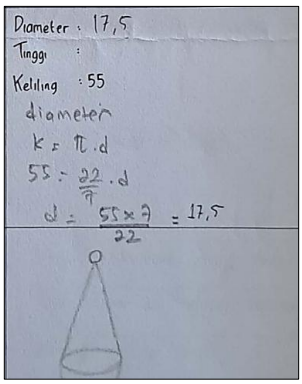
Figure 3. Fluency in identifying geometric spaces in project-based CRT

Based on identifying geometric spaces in Figure 3, students create a birthday hat project that represents a cone. Students determine the circumference of the hat hole for the head so that the diameter matches the head circumference, as in Figure 4 and the process in Figure 5.

Tahap	Deskripsi
Pemilihan Benda	Topi Ulang Tahun

Translate:

Stage	*Description*
Selection of objects	*Birthday hat*



Translate:
Diameter: 17.5
Height:
Circumference:
55

Figure 4. Planning to make a cone-shaped birthday hat in project-based CRT

Figure 4 illustrates the project assignment planning. Next, students practice constructing a concrete product based on their plan. In this stage, students implement diameter and circumference measurements in cutting and assembling the materials needed to create a cone-shaped birthday hat, as shown in Figure 5. Figure 5 depicts students carrying out the construction process of creating a birthday hat by shaping paper into a cone and adjusting its dimensions. This transition from conceptual planning to a concrete product encourages students to validate their geometric reasoning and engage in culturally meaningful problem-solving.

Figure 5. Processing to make a cone-shaped birthday hat in project-based CRT

Students completed projects using worksheets in groups. Students were able to provide various solutions to a problem clearly and easily understood. The flexibility indicator, students' ability to view problems from various perspectives, was in the very good category. Most students were able to correctly view problems from different perspectives. Students were able to adapt and change their approach when faced with problems in project assignments. This shows that adaptive thinking can change thinking and problem-solving approaches according to context. This is relevant to the concept of flexible thinking from Torrance (2012). The originality indicator, the ability to generate unique and different ideas from the usual, was in the very good category. Students were able to generate unique and different ideas from the usual by involving the context of the students' environment and local culture. The elaboration indicator, students' ability to develop ideas, was in the good category in the first session and in the very good category in the second session. These findings are relevant to constructivism and sociocultural theory Vygotsky (1978), which argues that social interaction and cultural context support meaningful learning. The CRT pedagogical approach encourages students to actively construct knowledge through learning experiences that engage their culture. Furthermore, teachers, as facilitators, can encourage students to connect mathematical concepts with their local cultural values, thereby encouraging them to connect mathematical concepts with everyday life.

Furthermore, the findings of this study are relevant to Dilekçi and Karatay (2023) research, which found that current educational innovations demand learning that encourages students' 4Cs:

creativity, critical thinking, collaboration, and communication. A project-based learning approach with a local cultural context can result in more meaningful learning. This suggests that students are better able to understand mathematical concepts when cultural and contextual contexts are incorporated into their learning activities. This not only improves students' cognitive outcomes but also develops more complex creative and social thinking skills.

The Effect of Implementing Project-Based CRT on Students' Problem-Solving Skills

The implementation of project-based CRT learning contributed to students' problem-solving skills. This contribution is evident in the differences in pre-test and post-test results. Before the implementation of project-based CRT learning, the average pre-test score was 49.33, indicating that most students still experienced difficulty in problem-solving. After the implementation of project-based CRT learning, the average post-test score increased to 64.33. The SPSS output results are presented in Table 2.

Table 2. SPSS output related to student score improvement

Paired Samples Statistics

		Mean	N	Standard Deviation	Standard Error Mean
Pair 1	Pre Test	49.3333	15	17.71467	4.57391
	Post Test	64.3333	15	17.91514	4.62567

The improvement in problem-solving test results in Table 2 indicates that student engagement in group project assignments and exploration of problem contexts requiring higher-order thinking support students' ability to understand, analyze, and solve problems more effectively. Furthermore, the test data were examined using the Shapiro–Wilk test to determine normality due to the number of students being less than 50 (n = 15). The results showed that the pre-test (p = 0.437) and post-test (p = 0.372) data had p-values ≥ 0.05. Therefore, it can be concluded that both test data were normally distributed. The analysis was continued with a paired t-test using SPSS to determine the impact of implementing project-based CRT on students' problem-solving skills. Next, the results of the paired sample t-test can be seen in the Table 3.

Table 3. Paired sample t-test results

Paired Samples Test

	Paired Differences					t	df	Sig.(2-tailled)
	Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1 Pre Test-Post Test	-15.00000	2.67261	.69007	-16.48004	-13.51996	-21.737	14	.000

Based on the Table 3 it is shown that the Sig. (2-tailed) value is 0.000 < 0.05, so it can be concluded that there is a significant difference between HOTS problem-solving skill in the pre-test and post-test data. Thus, there is an influence of the application of project-based CRT on

students' skills in HOTS problem-solving. The analysis results show a significant impact of implementing project-based CRT learning on students' HOTS problem-solving skills. Project-based CRT learning facilitates students' exploration of problems relevant to their daily lives, fostering deeper problem-solving skills. Students can meaningfully identify key elements of a problem, then connect the problem to their individual experiences and cultural context and use more effective problem-solving strategies.

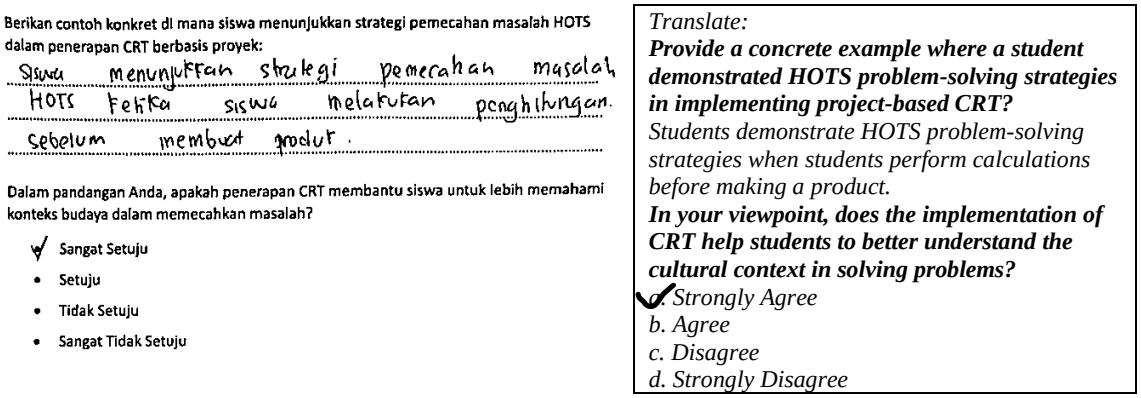
This improvement in problem-solving skills does not occur spontaneously; rather, it is the result of the characteristics of project-based CRT learning, which facilitates students' construction of new knowledge. The projects presented contain real-life situations close to everyday cultural experiences familiar to students, enabling them to understand the problems presented. This finding is consistent with research by Anwar et al. (2024) and Zaki et al. (2024), which showed that projects based on real-life situations close to students' cultural experiences, such as daily practices in the local community, can improve problem-solving skills.

Meanwhile, an eighth-grade teacher involved in this study explained that problems close to the students' cultural context play a role in increasing the effectiveness of their problem-solving strategies. Students can visualize the problem context, relate new information to previous experiences, and construct better mental representations. However, implementing project-based CRT requires adequate pedagogical competence, requiring teachers to design learning that incorporates the students' culture and environment. Douglas (2020) emphasized that teachers can improve their competence through specialized training to implement CRT effectively, ensuring consistent implementation of this learning practice.

Furthermore, problem-solving is an effective approach to facilitate students' in-depth understanding of mathematical content. Glazewski and Ertmer (2020) and Inganah et al. (2018) explain that the problem-solving approach not only improves students' mathematical thinking skills but also helps them develop non-cognitive skills such as collaboration, communication, perseverance, and reflective abilities. In this study, through project-based CRT learning, students were not only asked to complete assignments but also to engage in group discussions, communicate the results of the discussions, and reflect on the results obtained. This process facilitates students in developing a more adaptive and flexible mathematical mindset, as well as building a deeper understanding of the relationship between mathematics, culture, and everyday life. Therefore, the implementation of project-based CRT can provide meaningful mathematics learning experiences and enhance students' problem-solving skills comprehensively.

Teacher's Perceptions of Cultural Integration in Mathematics Learning

Teachers responded to the implementation of project-based CRT. Based on the results of the teacher's open-ended questionnaire, it was shown that project-based CRT learning, which involved local cultural contexts, had an impact on students' HOTS problem-solving strategies. The teacher strongly agreed that implementing project-based CRT helped students better understand the cultural context in problem-solving, as shown in Figure 6.


Berikan contoh konkret di mana siswa menunjukkan strategi pemecahan masalah HOTS dalam penerapan CRT berbasis proyek:

Siswa menunjukkan strategi pemecahan masalah HOTS ketika siswa melakukan penghitungan sebelum membuat produk.

Dalam pandangan Anda, apakah penerapan CRT membantu siswa untuk lebih memahami konteks budaya dalam memecahkan masalah?

- ✓ Sangat Setuju
- Setuju
- Tidak Setuju
- Sangat Tidak Setuju

Translate:
Provide a concrete example where a student demonstrated HOTS problem-solving strategies in implementing project-based CRT?
Students demonstrate HOTS problem-solving strategies when students perform calculations before making a product.
In your viewpoint, does the implementation of CRT help students to better understand the cultural context in solving problems?
✓ *a. Strongly Agree*
b. Agree
c. Disagree
d. Strongly Disagree

Figure 6. Teacher perceptions in an open questionnaire

Figure 6 illustrates how engaging students in a cultural context close to their own can enhance the effectiveness of their problem-solving strategies. For example, when students came up with the idea of making a cone-shaped birthday hat, they gained an understanding of the diameter and circumference of the cone's base, thus appropriately fitting it to their head circumference. This is relevant to the teacher's perspective that linking the selection of materials and project tasks to the students' immediate cultural context can support the success of problem-solving strategies.

The teacher stated that understanding students' cultural contexts can improve the effectiveness of their problem-solving strategies, such as when students encounter problems that are close to their daily lives, students who are in a cultural context can provide good understanding. Students understand and are able to identify problems related to their culture well. This excellent ability to identify cultural problems leads students to strategies or plans to solve them. Based on this, the teacher provides the perception that the selection of learning materials that can be contextualized with the culture around students and the selection of project assignments to support it.

The problems students faced in project-based learning in this study were contextual and relevant to their cultural background, making it easier for them to understand concepts and apply them in real-life situations. By linking mathematical problems to local cultural experiences, such as daily activities, traditional motifs, or patterns familiar to students, the learning process becomes more meaningful and connected to the realities of their lives. This approach aligns with the

principles of CRT, which emphasize that culture is a crucial resource in building students' conceptual understanding (Mustafa et al., 2025).

The problems faced by students in project-based learning are relevant to their cultural context, making it easier for students to understand and apply learning concepts. The use of problem-based learning can improve mathematical problem-solving skill effectively (Amin et al., 2021). Students are able to develop their strategies in contextual problem-solving through project-based CRT. Mathematics learning with a contextual approach is effective in terms of students' understanding of mathematical concepts (Rahmayanti et al., 2020).

Conclusion

The implementation of project-based CRT can improve students' creative thinking and problem-solving skill, which require HOTS. The results showed that students' creative thinking indicators—including fluency, flexibility, and originality—were in the very good category, while the elaboration indicator increased from good to very good. Quantitative analysis showed a significant increase in students' problem-solving skills after the implementation of project-based CRT. In addition, the teacher believes that project-based CRT stimulates problem-solving strategies more effective.

The integration of project-based CRT enables students to understand mathematical concepts with their cultural experiences, making learning more meaningful and contextual. Theoretically, this study strengthens the relationship between culturally responsive pedagogy and the development of higher-order thinking skills. Practically, the results provide recommendations for teachers and curriculum developers to integrate local cultural values into project-based mathematics learning to foster creativity and inclusiveness. The limitations of this study lie in the small sample size and short duration. Further research is recommended at various levels and in broader cultural contexts. Overall, project-based CRT proved to be a potential pedagogical approach in developing students' creative thinking and problem-solving skill in mathematics learning.

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