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ENHANCING STUDENTS' CRITICAL THINKING, CREATIVITY, AND MATHEMATICAL SELF-ESTEEM THROUGH WORKED-EXAMPLE LEARNING WITH CULTURALLY RESPONSIVE PEDAGOGY

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ABSTRACT

This study aims to examine the impact of worked-example learning integrated with Culturally Responsive Pedagogy (CRP) on enhancing students' critical thinking, creativity, and mathematical self-esteem. The research design employed was quasi-experimental, involving two groups of students: a control group that received conventional instruction and an experimental group that experienced the worked-example method based on Culturally Responsive Pedagogy. The participants in this study is 20 students of Natural Sciences Education program at Sultan Ageng Tirtayasa University during the first semester. Tests and questionnaires were used to gather data, and independent sample t-tests were used to compare the mean scores of the various groups. The worked-example method provides structured problem-solving examples to help students learn solution steps, while the CRP approach offers a culturally relevant learning environment and encourages students' emotional engagement. Results indicated that students in the experimental group achieved higher averages in critical thinking, creativity, and mathematical self-esteem compared to those in the control group. These findings suggest that the combination of the worked-example method and Culturally Responsive Pedagogy effectively enhances students' critical and creative thinking skills and fosters positive mathematical self-esteem. Moreover, this approach has been shown to make mathematics learning more inclusive and meaningful for students from diverse cultural backgrounds. This study contributes to mathematics education by proposing a learning strategy that not only supports cognitive development but also prioritizes cultural inclusivity, thereby promoting students' academic success and personal growth

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INTRODUCTION

Critical and creative thinking skills are increasingly prioritized in higher education, especially in disciplines requiring analytical and problem-solving abilities, such as mathematics. Critical thinking involves cognitive processes like in-depth analysis, evaluation, and interpretation of information to make logical and rational decisions or solve problems. Setiana and Purwoko (2020) describe critical thinking as encompassing focus, reasoning, inference, situational understanding, clarification, and comprehensive review. Meanwhile, creative thinking is also needed in learning where, Suherman & Vidákovich (2022) defines creative thinking in mathematical defense as an important competency for students and is usually based on the underlying process. For creative thinking, Khairiah and Amir (2019) define mathematical creative thinking as the ability to generate novel ideas to solve problems, characterized by fluency, flexibility, originality, and elaboration.

In today's information era, students must not only understand foundational mathematical concepts but also be skilled in critiquing, analyzing, and developing innovative solutions to complex problems. Moreover, mathematical self-esteem—students' confidence in solving math problems—plays a critical role in academic success. Mathematical self-esteem involves individuals' assessments of their abilities and values within the mathematics context, including beliefs in competence, self-confidence, and a positive sense of worth in learning and applying mathematical concepts. Makilan (2025) revealed that self-esteem significantly affects mathematical performance, while students' attitudes towards collaborative learning positively shape self-esteem. Baumeister, et.al (2003) also points out that individuals with high self-esteem tend to form better relationships and make positive impressions compared to those with low self-esteem. In groups, those with high self-esteem are often more confident and critical.

Currently, critical thinking skills, creativity, and mathematical self-esteem are essential for comprehension skills in the 21st century. These skills are interrelated. Critical thinking is the ability to generate thoughts aimed at solving problems, drawing conclusions, and making wise decisions (Alberth et al, 2023) . The purpose of critical thinking can be obtained by students' creativity in concluding a problem, because there is a correlation between these abilities. Wechsler et al (2017) stated that research aims to investigate whether creativity and critical thinking are independent or complementary processes. while according to Ling & Loh (2020) explains that Evidence shows that creativity and critical thinking are quite independent processes. There is a correlation between critical thinking and creativity, but the context can also operate independently. In mathematics learning, these two abilities are correlated and have an important role in the nature of mathematical self-esteem. The problem of mathematical comprehension cannot be solved in just one way, but also encourages students to be creative and think critically (Fitria et al., 2023).

However, many students today still exhibit low self-esteem in mathematics and have yet to fully develop their critical and

creative thinking abilities. One of the problems is due to the lack of motivation of students in learning activities. Contextual learning that incorporates cultural elements is one approach that can increase student motivation in learning, especially in mathematics. This highlights the need for a more inclusive and culturally responsive approach to help students improve and develop critical and creative thinking skills.

The 21st-century skills that are currently in the spotlight are critical thinking, creativity, and students' mathematical self-esteem. One improvement that needs to be made is to use work-examples. The worked-example approach is widely discussed as an effective method to enhance students' critical and creative thinking skills. This approach presents problems along with their complete solutions, allowing students to observe the thought processes and strategies involved in solving them. Adeniji & Baker (2023) Explain that worked examples arepresented to students to study, and each studied worked example is paired with a similarly structured practice problem. Worked examples make it easier for students to minimize learning, reduce cognitive load, and allow students to focus on understanding concepts. Worked-example helps students to focus the fundamental structure of material and procedural flexibility, and encourages the exploration of solutions in analytical thinking (Ke & Newton, 2024). Worked example makes it easier for students to focus on understanding the principles and patterns of completion. One of the approaches that is in line with the use of worked examples

While the worked-example method has significant potential, it can be even more effective when implemented alongside Culturally Responsive Pedagogy (CRP). Culturally Responsive Pedagogy is an educational approach that not only acknowledges and respects students' cultural diversity but also incorporates it into the learning process. Ladson-Billings (1995) describes CRP as a means to "use students' cultural framework, knowledge, and experiences as a foundation to make learning more effective and relevant."

Culturally Responsive Pedagogy (CRP) in mathematics makes learning more meaningful, relative, inclusive, and encourages the development of students' analytical skills. Implementation of CRP through a context that are closely to students' daily lives can foster more meaningful and relevant learning experiances (Murti, 2023). That stetment reinforced by Gay (2020) who emphasizes that in mathematics, CRP can assist students in feeling more connected to the subject, as they are able to perceive relevance and application in their own cultural context. Relevant pedagogy fosters educational equity through the inclusion of marginalized and minority students within the dominant educational system.

Similarly, Bonner (2014)**)** found that CRP can enhance student engagement and improve self-esteem, as students feel valued and acknowledged. This is strengthened by the results of research conducted by Ricky et al., (2024)that learning combined with a cultural approach can increase mathematical literacy skills from pre-cycle by 45.60 to 55.54. Therefore, the worked-example method combined with Culturally Responsive Pedagogy is expected to enhance students' mathematical self-esteem as well as their critical and creative thinking skills in mathematics.

Furthermore, Culturally Responsive Pedagogy not only fosters students' self-confidence but also helps shape their diverse academic identities. Research by Nasir et al. (2008) indicates that students from various ethnic and cultural backgrounds often struggle to identify as 'mathematics learners' in traditional educational settings. This opinion is strengthened by the results of research conducted by Nurramadhani et al (2025) that classes with a richer cultural background also show a greater improvement in creative thinking skills compared to classes with a less diverse cultural background. By adopting a culturally responsive approach, students can build a stronger connection to the subject and recognize its relevance to their everyday lives, promoting a more meaningful learning experience.

The low level of critical thinking, creative thinking, and self-esteem of

students during the learning process is what drives research to be conducted. According to initial observations, many students still find it difficult to cope with non-routine situations that require in-depth analytical skills and instead rely on processes they have memorized rather than coming up with original and innovative solutions. Based on a theoretical explanation, to solve the problem, to collaborate worked learning with the Culturally Responsive Pedagogy (CRP) approach to assesss students' critical thinking, creativity, and mathematical self-esteem. This study was conducted to assess the extent of students' understanding and mastery of these skills, which serves foundation for developing a more effective learning methodology.

METHOD

This research employs a quantitative approach, specifically a quasi-experimental method, where the researcher works with participants in their pre-existing conditions (Creswell, 2009). Quasi-experimental research was chosen because random assignment was considered impractical. A similar study and using quasi-experimental random assignment to the intervention and control groups was conducted by Sharleen (2024) the use of this method was carried out to test the effectiveness of CRP-based seminars. In this study, students were already grouped into classes based on course registration, rather than through random selection. The participants were divided into two groups: an experimental class and a control class. Quasi-Experiment can have an influence from the application of Cullturally Responsive pedagogy-based working ecample learning on the ability of critical thinking, creativity, and mathematical self-esteem to understand grouping. As is the case with the research conducted by Capili & Anastasi (2024) bahwa the quasi-experimental designs can provide valuable insights into causal relationships in real-world settings, provided steps are taken to minimize potential confounders.

The study took place in the Natural Sciences Education program at Sultan Ageng Tirtayasa University during the first semester.The population of this study consisted of all first-year Science Education students at Sultan Ageng Tirtayasa University. These beginner-level students generally have limited knowledge and a high propensity for errors (Cooper, 1998), unlike experts who possess extensive knowledge on specific topics and are expected to make fewer mistakes in problem-solving. One class was designated as the experimental group and another as the control group, selected through purposive sampling, a technique chosen for its efficiency in overseeing subjects and accommodating logistical considerations of time and location (Sugiyono, 2010). Purposes sampling includes a non-probabilistic technique, which is the researcher selects students based on certain characteristics and criteria according to the purpose of the research. Chudasama (2023)Desrcibe In purposive sampling, individuals are chosen for inclusion in a sample based on their relevance to the research objectives.

To collect data, both test and non-test instruments were used. The test instrument included descriptive cognitive questions aimed at assessing students' initial mathematical abilities as well as their critical and creative mathematical thinking. The non-test instruments included a mathematical self-esteem scale, observation sheets during teh lesson, and teaching materials. All instruments, both test and non-test, underwent empirical and non-empirical validation to ensure reliability.

The initial test (pretest) was not administered to ensure that the mathematical problems were entirely new to the students. As Martinez (1998) explains, problem-solving is the process of finding solutions to unfamiliar problems without having solved similar ones previously. This explanation is strengthened by research conducted by Denny et al (2023) that the use of quasi-experimental with a static group comparison design was used to conduct research to measure the behavior and social of the use of methods for solving the problem of tenure.Thus, problem-solving here is defined as finding solutions without prior guidance. The experimental design is outlined as follows:

X *O*

O

Description:
X = Worked-example method integrated with culturally responsive pedagogy
O = Posttest measuring critical and creative thinking skills, and mathematical self-esteem

RESULT AND DISCUSSION

This study examines the effectiveness of combining the worked-example method with Culturally Responsive Pedagogy (CRP) on students' critical thinking, creative thinking, and mathematical self-esteem. The worked-example method aims to enhance students' conceptual understanding and critical thinking by providing structured problem-solving examples. This statement is strengthened by the results of research conducted by Nur Azizah (2025) which states that worked examples can improve learning achievement, understanding, problem-solving, as well as proportional reasoning, and representation. Meanwhile, The CRP approach, meanwhile, is intended to boost student engagement by incorporating their cultural backgrounds into the learning process.` By emphasizing the use of culture, students can feel the relevance of the material to daily life. Herda et al (2025) also explained that Students are more inclined to participate actively when they observe the cultures represented in the educational materials from a motivational perspective. That statement is strengthened by the results of a literature study conducted by Nagasawa (2020) that Teachers who practice CRP could improve students' performance at the test.

By integrating these two methods, the study anticipates that students will find the learning material more relevant to their daily experiences, eventually improving their mathematical self-esteem. The data below represent the average scores of 20 students each from the control and experimental classes across three assessment categories: critical thinking, creative thinking, and mathematical self-esteem.

Table 1. Overall Average Scores

Category	Control Class	Experimental Class
Critical Thinking	60.25	83.50
Creative Thinking	58.75	80.25
Mathematical Self-Esteem	59.85	85.10

The results indicate a notable difference between the experimental class, which received the CRP-based worked-example approach, and the control class across all three categories. In critical thinking, the experimental class achieved an average score of 83.50, significantly higher than the control class's average of 60.25. This result suggests that the combined approach effectively enhances critical thinking by offering students structured problem-solving flows through worked examples, while CRP contextualizes learning within relevant cultural frameworks, helping students to analyze and interpret information more critically.

Similarly, in creative thinking, the experimental class showed superior results with an average score of 80.25 compared to the control class's 58.75. These results are relevant to the research conducted by Herda et al (2025)emphasizing that students who learn to use CRP can develop critical thinking, analytic and problem solving, because they are able to evaluate the material in aligning it in the context of daily life. From this statement, eating CRP can hone students' creativity skills and support critical thinking skills. This difference underscores CRP's importance in creating a space for innovation and creativity. By integrating students' cultural backgrounds, CRP allows students to relate better to the material, encouraging them to express new ideas and develop creative solutions in familiar contexts. The CRP method thus goes beyond technical

skills, encouraging students to think beyond conventional boundaries while further promoting flexibility and originality in students' thinking.

In mathematical self-esteem, the experimental class also outperformed the control class, with an average score of 85.10 versus 59.85. This higher self-esteem reflects students' increased confidence and a more positive perception of their mathematical abilities. Self-confidence plays a positive role in enhancing comprehension of mathematic (Emmanuel, . Mathematical self-esteem contributes to increasing student confidence which will later increase student achievement. Through CRP, students feel their experiences and cultural identities are acknowledged, which in turn strengthens their confidence to tackle mathematical challenges. CRP helps students develop confidence in mathematical discussions and problem-solving, and strengthen their self-confidence and improve learning outcomes (Luzano, 2025). Positive mathematical self-esteem is crucial as it fosters engagement, participation in discussions, and willingness to take risks when solving complex problems.

In conclusion, the comparison of average scores between the control and experimental classes demonstrates that the CRP-based worked-example approach significantly impacts students' critical thinking, creativity, and mathematical self-esteem. This method successfully creates an inclusive and supportive learning environment, helping students not only improve their mathematical understanding but also develop positive attitudes and confidence in their skills.

To further illustrate these findings, the diagram below provides a visual comparison of the average abilities in the control and experimental classes. Here is the bar chart comparing the average scores between the control and experimental classes across the three assessment categories: Critical thinking, creative Ttinking, and mathematical self-esteem. The experimental class, which used the CRP-based worked-example approach, consistently shows higher average scores in each category compared to the control class.

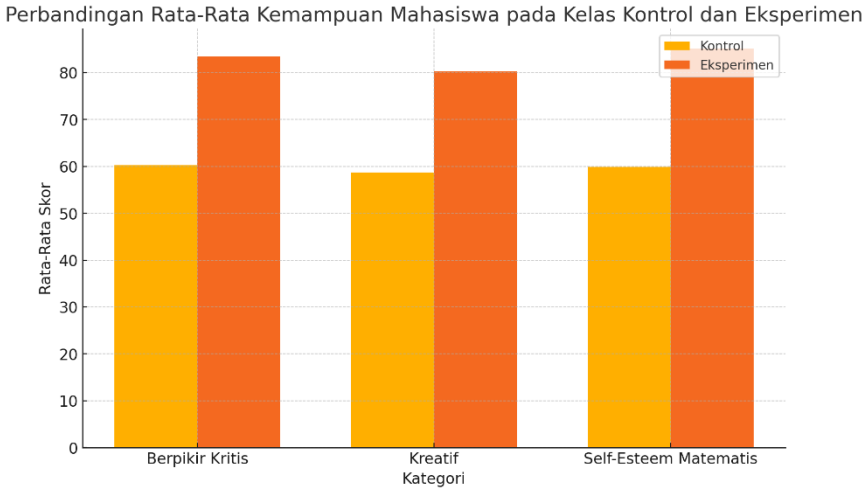

Diagram 1. Average Ability of Students in Control and Experimental Classes

The diagram shows that there is a significant difference in the average scores for critical thinking, creativity, and mathematical self-esteem between the control and experimental classes. The experimental class, which used the worked-example method based on Culturally Responsive Pedagogy (CRP), scored higher on average across all three categories. The increase in critical thinking skills in the experimental class is especially notable, suggesting that students were better able to analyze and evaluate information when this method was applied. The worked-example approach provided structured guidance for solving complex problems, while CRP made

the material more relevant by connecting it to students' cultural backgrounds.

In terms of creativity, students in the experimental class also showed a marked improvement, displaying greater ability to generate new and diverse ideas for solving mathematical problems. The application of Culturally Responsive Pedagogy encouraged flexible and original thinking by making the learning material more relatable and meaningful. Halimah & Dewi (2024) in her research explained that culturally responsive teaching (CRT) can improve students' creative thinking skills and students' ethnicity or cultural background affects their creative thinking skills, especially in mathematics materials.The improvement in mathematical self-esteem among experimental class students indicates that this combined approach was also effective in fostering students' confidence in understanding and tackling mathematical problems. Higher mathematical self-esteem reflects a stronger sense of capability and self-worth in learning mathematics, which is essential for active engagement and academic success. These results are strengthened by Gonzaga, (2023) which states that self-esteem has effects on emotional and behavioral disengagement. Self esteem mathematics has a fundamental role in learning related to students' attitudes, behaviors, and confidence.

Overall, this diagram highlights that the worked-example method integrated with Culturally Responsive Pedagogy not only enhances cognitive skills but also fosters a positive attitude toward mathematics. This approach provides structured learning alongside cultural recognition, thus creating an inclusive learning environment that supports the development of critical and creative thinking skills, as well as mathematical self-esteem.

CONCLUSION

The findings of this study demonstrate that the integration of worked-example learning with Culturally Responsive Pedagogy (CRP) significantly improves students' critical and creative thinking skills, as well as their mathematical self-esteem. The worked-example method offers students structured examples to understand mathematical concepts and problem-solving steps, thereby reducing cognitive load and facilitating comprehension. Meanwhile, CRP helps students see the relevance of learning in relation to their cultural backgrounds, which has been shown to increase both engagement and motivation.

The comparison between the control and experimental classes shows that students who learned through the CRP-based worked-example method achieved higher average scores in all three tested aspects: critical thinking, creativity, and mathematical self-esteem. Therefore, this method can serve as an effective alternative for enhancing the quality of mathematics education, especially in culturally diverse classrooms. These results also suggest that implementing an inclusive, culturally responsive approach not only boosts academic skills but also strengthens students' self-esteem, fostering a learning environment that values both intellectual and personal growth.

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AUTHOR CONTRIBUTIONS

Author one : Conceptualization, writing, supervision,data acquisition, data analysis/ interpretation and concept and design, statistical analysis;

Author two : Conceptualization, statistical analysis, design, writing and drafting manuscript; analysis/interpretation and drafting manuscript.

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