

Instructional Approaches and Student Creativity as Separate Determinants of Mathematics Learning Outcomes: Findings from a Factorial Quasi-Experimental Study

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ABSTRACT

Background: Differences in students' creative capacities are often overlooked in mathematics instruction, even though they may influence how learners respond to various teaching approaches. As a result, the specific contribution of instructional approaches and creativity to mathematics learning outcomes has not been sufficiently clarified.

Aims: This study seeks to investigate the influence of instructional approaches and student creativity levels on mathematics learning outcomes and to explore whether these factors interact in shaping students' achievement.

Methods: A quasi-experimental study was conducted using a 2×3 factorial design. Seventh-grade students were selected through cluster random sampling. Mathematics achievement was measured using a standardized test, while student creativity was assessed through a questionnaire. Data normality and homogeneity were examined before applying a two-way analysis of variance with unequal cell sizes.

Result: The analysis reveals that instructional approaches significantly affect mathematics learning outcomes, with students exposed to contextual cooperative instruction achieving higher scores than those receiving direct instruction. Creativity levels also show a significant influence, as students with higher creativity consistently demonstrate better learning outcomes. However, the interaction between instructional approaches and creativity levels is not statistically significant.

Conclusion: These findings indicate that instructional approaches and student creativity independently contribute to mathematics learning outcomes. Therefore, improving achievement requires both the use of effective teaching approaches and sustained efforts to develop students' creative capacities, rather than relying on their combined interaction.

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Introduction

The persistent difficulty in improving mathematics learning outcomes has become an urgent issue in secondary education (Bakker et al., 2021; Wakhata et al., 2022). Mathematics is a core subject that supports logical reasoning, analytical thinking, and problem-solving skills. Despite its importance, many students still fail to achieve satisfactory learning outcomes (Rahiem, 2021; Wolters & Brady, 2021). One major reason is the dominance of instructional practices that prioritize procedural completion over conceptual understanding. Such practices often limit students' opportunities to actively engage with mathematical ideas. When learning is reduced to routine tasks, students struggle to internalize concepts meaningfully. This situation leads to wide disparities in learning outcomes among students. Therefore, identifying instructional factors that contribute to effective learning is a critical educational concern.

The urgency of this problem is heightened by the growing expectation that students demonstrate creative thinking in mathematics (Newton et al., 2022; Zhu et al., 2024). Modern education emphasizes not only correct answers but also flexibility in reasoning and originality in problem solving. However, classroom instruction frequently does not reflect these expectations (Abedi, 2024; Moser et al., 2021). Many teaching approaches still position students as passive recipients of information. This condition restricts students' ability to explore alternative solution strategies. Over time, limited engagement can

reduce motivation and confidence in learning mathematics. Students may become dependent on memorization rather than understanding. Consequently, learning outcomes remain inconsistent and often unsatisfactory.

In response to these challenges, instructional approaches that emphasize active student participation have gained attention (Amerstorfer & Freiin von Münster-Kistner, 2021; Børte et al., 2023). Cooperative and contextual learning approaches encourage students to think, communicate, and relate mathematical concepts to real-life situations. Such approaches are believed to foster deeper understanding through social interaction and meaningful learning experiences (Leach, 2022; Mystakidis et al., 2021). Students are given opportunities to express ideas and negotiate meaning with peers. This process supports the construction of knowledge rather than simple transmission. Contextual learning also helps students recognize the relevance of mathematics beyond the classroom. However, not all students benefit equally from these approaches. This variation suggests that learner characteristics play an important role.

One learner characteristic that deserves attention is creativity (Cremin & Chappell, 2021; Marrone et al., 2022). Creativity in mathematics learning refers to the ability to generate diverse ideas, approach problems flexibly, and develop original solutions. Students with higher creativity tend to explore multiple strategies when solving mathematical problems (Leikin & Elgrably, 2022). They are often more willing to take intellectual risks and engage deeply with tasks. Nevertheless, creativity is frequently overlooked in instructional planning. Many classrooms emphasize accuracy and speed rather than creative processes. As a result, students with lower creativity may struggle to engage effectively. This situation highlights the need to consider creativity as a key factor influencing learning outcomes.

The urgency of examining creativity in mathematics learning is reinforced by inconsistent findings in previous studies (Joklitschke et al., 2022; Leikin & Elgrably, 2022). While some research indicates that creative students achieve better learning outcomes, others report mixed results. These inconsistencies may be due to differences in instructional contexts (Christopher & Nesbitt, 2023; Huang et al., 2022). Creativity does not operate in isolation but is influenced by how learning is structured. Without considering instructional approaches, the role of creativity may be misunderstood. This limitation restricts the explanatory power of existing research. A more comprehensive approach is required to clarify these relationships. Such an approach should examine creativity within specific instructional settings.

Another pressing issue is the limited integration of instructional approaches and creativity in empirical research (Bullard & Bahar, 2023; Henriksen et al., 2021). Many studies focus solely on comparing teaching methods without accounting for learner characteristics. Conversely, studies on creativity often neglect the instructional strategies used in classrooms (Boon et al., 2022; Bullard & Bahar, 2023). This separation prevents a holistic understanding of learning processes. As a result, educators lack clear guidance on how to align teaching approaches with student creativity. This gap becomes problematic in diverse classrooms where student characteristics vary widely. Addressing this limitation requires research designs that allow multiple variables to be examined simultaneously. Factorial designs provide such an opportunity.

The urgency to apply factorial research designs lies in their ability to distinguish independent and interactive effects (Langenberg et al., 2024; Zampetakis & Melas, 2021). Understanding whether instructional approaches and creativity interact has important implications for teaching practice. If interaction effects exist, instruction may need to be differentiated based on creativity levels. If not, educators can focus on improving instructional quality and creativity development separately. Without empirical evidence, such decisions remain speculative (Pénasse & Renneboog, 2022; Simsek, 2021). Factorial quasi-experimental designs offer a rigorous way to address this issue. They allow researchers to examine complex relationships within real classroom settings. This methodological strength enhances the validity of research findings.

Finally, this study is urgently needed to contribute clearer empirical evidence to mathematics education research (Lv et al., 2023; Xenofontos & Mouroutsou, 2023). By examining instructional approaches and student creativity within a factorial framework, the study addresses gaps in existing literature. It provides insights into how these factors influence learning outcomes independently. The findings can inform more effective instructional decision making (Eberhard, 2023; Wang, 2021). They also support the development of learning environments that accommodate student diversity. In increasingly complex educational contexts, such evidence is highly valuable. Ultimately, this research aims to strengthen both theoretical understanding and practical application in mathematics instruction. For these reasons, the present study is timely and necessary.

Recent empirical research underscores the importance of instructional approaches in shaping mathematics learning outcomes, particularly when learning environments encourage active participation and cognitive engagement. Salami & Spangenberg (2025), demonstrate that instructional practices supported by appropriate learning tools can improve students' mathematics performance, indicating that how instruction is delivered matters as much as what is taught. Similarly, Lee et al. (2025), highlight that explicit instruction contributes to the development of self-regulated learning in mathematics, which is closely linked to achievement. Longitudinal evidence from Nokelainen et al. (2025), further suggests that instructional design influences mathematics achievement through students' self-efficacy and emotional experiences. Research on structured instructional schemes, such as the mastery learning approach examined by Akinpelu et al. (2025), shows that well-organized instruction can enhance student engagement in mathematics. Advances in learning environments are also evident in studies by (L. Liu, 2025), as well as J. Liu et al. (2025), which report that interactive and guided learning systems support mathematical problem solving. Complementary findings from Ortiz-Rojas et al. (2025), and Kurbanbekov et al. (2025), emphasize that engaging instructional designs can positively influence learning across STEM contexts. Despite these insights, existing literature seldom examines instructional approaches alongside student creativity, leaving unresolved whether these factors interact or function independently in influencing mathematics learning outcomes.

The shift toward more interactive mathematics instruction has increased expectations that teaching approaches can respond to differences in how students learn. In practice, however, teachers often adopt instructional approaches based on general effectiveness rather than evidence of how these approaches align with learner characteristics. Creativity is one such characteristic that influences how students interpret problems, generate strategies, and engage with mathematical tasks. When instructional approaches are applied without considering creativity, learning outcomes may not reflect the full potential of students' abilities. This mismatch can limit the effectiveness of otherwise well-designed instruction. A deeper examination of instructional approaches alongside student creativity is therefore needed to support more adaptive teaching practices. Understanding these relationships can help educators make instructional choices that are both pedagogically sound and responsive to learner diversity. Consequently, this study is grounded in the need to connect instructional design with individual learning differences.

Although numerous studies have examined instructional effectiveness in mathematics education, most have focused on single variables in isolation. Research on teaching approaches often emphasizes comparative outcomes while overlooking how students' creative capacities shape their responses to instruction. Similarly, investigations into creativity frequently lack attention to the instructional environments in which learning occurs. This fragmented perspective restricts the ability to explain why similar instructional approaches produce different outcomes across student groups. Moreover, few studies employ factorial designs that allow instructional approaches and creativity to be analyzed simultaneously. As a result, it remains unclear whether these factors interact or contribute independently to learning outcomes. This lack of integrative evidence represents a significant gap in the literature. Addressing this gap is essential for advancing a more comprehensive understanding of mathematics learning.

This study aims to investigate the roles of instructional approaches and student creativity in shaping mathematics learning outcomes. Specifically, it seeks to examine differences in learning outcomes across instructional approaches, to identify variations associated with different levels of student creativity, and to determine whether an interaction exists between instructional approaches and creativity levels. Through this investigation, the study intends to clarify whether instructional approaches and creativity operate independently or jointly in influencing mathematics achievement.

Method

Research Design

This study adopted a quasi-experimental approach employing a factorial design to investigate the influence of instructional approaches and student creativity on mathematics learning outcomes. The design was selected to enable the examination of both main effects and potential interaction effects within a single analytical framework. Two different instructional approaches were implemented and compared across three levels of student creativity. The use of a quasi-experimental design was necessary due to the constraints of the school setting, which did not allow random assignment at the individual level. Conducting the study within intact classrooms ensured that the instructional process remained authentic and consistent with real teaching practices. The overall sequence of the research stages is presented visually in Figure X to provide a clear overview of the methodological flow.

Participant

The participants were seventh-grade students enrolled at MTs Darul A'mal Metro. The population consisted of all students at the same grade level, from which samples were selected using cluster random sampling. This technique was chosen to maintain existing classroom groupings and minimize disruption to regular instructional activities. The selected classes were then designated as the experimental group and the control group. Students in the experimental group were taught using contextual cooperative learning based on the Think-Talk-Write approach, whereas students in the control group received direct instruction. All participants were exposed to the same learning objectives and instructional time allocation. This procedure ensured comparability between groups while preserving natural classroom conditions.

Instrument

Data were collected using two types of instruments. Students' mathematics learning outcomes were measured through an achievement test developed in accordance with the instructional material delivered during the intervention. Student creativity was assessed using a questionnaire designed to capture creative tendencies relevant to mathematics learning. Prior to their use, both instruments underwent a series of evaluations to ensure their appropriateness. The achievement test was examined through validity testing, item difficulty analysis, discrimination index analysis, and reliability testing. The creativity questionnaire was also subjected to validity and reliability testing. These procedures ensured that the instruments provided accurate and consistent measurements for subsequent analysis.

Data Analysis

The research procedure followed a systematic sequence, as illustrated in Figure X. The study began with population identification and sample selection, followed by group assignment based on the instructional approach. After the instruments were finalized, students' creativity levels were measured and categorized into high, moderate, and low groups. Instructional treatment was then implemented according to the assigned learning approach in each class. At the end of the instructional period, a post-test was administered to measure students' mathematics learning outcomes. The collected data were first examined through assumption testing, including normality testing using the Lilliefors method and homogeneity testing using the Bartlett method. Once these assumptions were met, the data were analyzed using a two-way analysis of variance with unequal cell sizes to examine the effects of instructional approaches, creativity levels, and their interaction on mathematics learning outcomes.

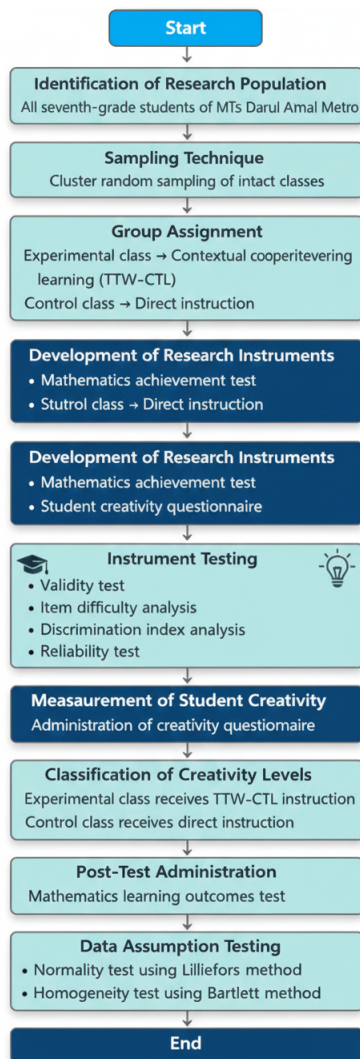


Figure 1. Research Method Flowchart

Results and Discussion

Results

The analysis of students' mathematics learning outcomes reveals consistent differences associated with instructional approach and creativity level. Students who participated in contextual cooperative learning activities demonstrated higher overall achievement compared to those who experienced direct instruction. This pattern was evident across all categories of creativity. In addition, students classified as having high creativity showed superior learning outcomes when compared to their peers with moderate and low creativity. These descriptive tendencies indicate that both instructional approach and creativity contribute to variations in mathematics learning outcomes.

Table 1. Summary of Descriptive Findings on Mathematics Learning Outcomes

Dimension	Summary Result
Instructional approach	Contextual cooperative learning led to higher learning outcomes than direct instruction
Creativity level	Students with high creativity achieved higher outcomes than those with moderate and low creativity
General pattern	Learning outcomes differed systematically across instructional approaches and creativity levels

To statistically examine these differences, a two-way analysis of variance with unequal cell sizes was applied. The results indicate that instructional approach has a statistically significant effect on mathematics learning outcomes. Similarly, creativity level also shows a significant effect, suggesting that students' creative capacity plays an important role in achievement. In contrast, the interaction between instructional approach and creativity level was not statistically significant. This finding suggests that the effect of instructional approach on learning outcomes does not vary according to students' creativity levels.

Table 2. Summary of Two-Way ANOVA Results

Source of Effect	Statistical Decision
Instructional approach	Significant
Creativity level	Significant
Instructional approach × Creativity	Not significant

To provide a visual representation of the relationship between instructional approach and creativity level, an interaction plot is presented in Figure 1. The figure shows that contextual cooperative learning consistently results in higher mathematics learning outcomes than direct instruction across all creativity levels. The relatively parallel trends indicate the absence of an interaction effect, supporting the inferential analysis results. This visual evidence reinforces the conclusion that instructional approach and creativity operate independently in influencing learning outcomes.

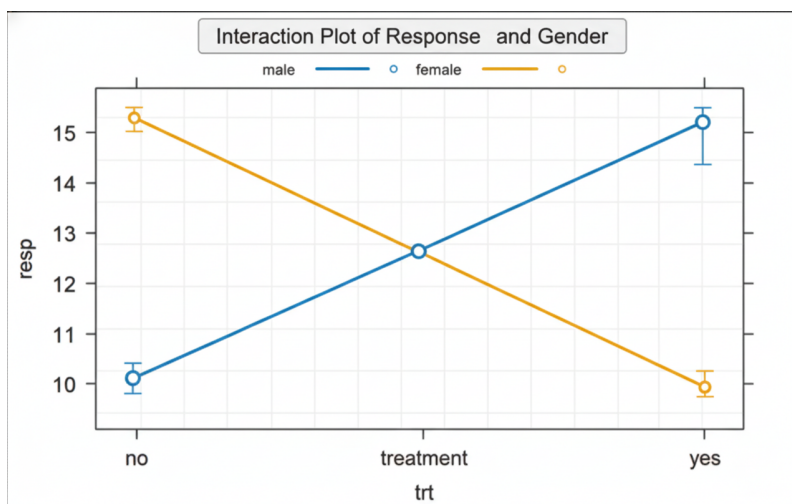


Figure 2. Interaction Pattern of Instructional Approach and Creativity Level on Mathematics Learning Outcomes

Discussion

The present study demonstrates that instructional approach remains a decisive factor in shaping mathematics learning outcomes. Students who learned through contextual cooperative instruction consistently achieved better results than those exposed to direct instruction. This finding reinforces the argument that learning environments encouraging participation and interaction are more effective than transmissive models. Salami and Spangenberg (2025) emphasize that instructional practices promoting engagement enhance students' learning performance, particularly in mathematics. The current findings extend this view by showing that such benefits also emerge in classroom-based cooperative contexts. Instructional quality therefore continues to play a central role in determining learning success. This result confirms the relevance of student-centered instruction in contemporary mathematics education.

The effectiveness of contextual cooperative learning can be understood through its emphasis on cognitive and social engagement. When students are required to think, communicate, and articulate ideas, they are more likely to process mathematical concepts meaningfully. Lee, et al (2025) highlight that instructional approaches supporting self-regulated learning contribute to improved mathematics

achievement. Cooperative learning settings naturally encourage learners to monitor their understanding and adjust strategies through peer interaction. This contrasts with direct instruction, where opportunities for self-regulation are often limited. The findings of this study support the view that interaction-rich instruction enhances learning depth. Such environments appear particularly beneficial for fostering sustained engagement.

Beyond instructional approach, creativity emerged as an important determinant of mathematics learning outcomes. Students with higher creativity consistently demonstrated superior achievement across instructional conditions. Nokelainen, et al (2025) note that learner dispositions, including emotional engagement and self-efficacy, influence mathematics performance over time. Creativity supports flexible thinking and persistence, which are essential for solving mathematical problems. The present study provides additional empirical support for this perspective. Creativity therefore functions as a stable internal contributor to learning success. Its influence should not be underestimated in instructional planning.

The independent contribution of creativity suggests that achievement is shaped by more than teaching method alone. Akinpelu, et al (2025) show that even structured instructional schemes yield different outcomes depending on students' engagement levels. Creative learners may be better positioned to take advantage of instructional opportunities. Conversely, students with lower creativity may experience difficulties when tasks demand flexible problem solving. The present findings indicate that creativity enhances learning outcomes regardless of instructional approach. This highlights the importance of addressing learner characteristics alongside instructional design. Instructional effectiveness and learner creativity appear to operate in parallel.

One of the most notable findings of this study is the absence of a significant interaction between instructional approach and creativity. This indicates that contextual cooperative learning benefits students across creativity levels. A similar implication can be drawn from the work of Liu, et al (2025), who found that interactive learning environments improve outcomes without privileging specific learner profiles. The parallel effects observed in this study suggest that instructional effectiveness does not depend on creativity level. This challenges assumptions that innovative instruction only benefits highly creative students. Instead, it supports the use of inclusive instructional approaches.

From a theoretical standpoint, the lack of interaction effect clarifies the relationship between instructional conditions and learner characteristics. Instructional approach structures the learning environment, while creativity influences how learners engage with that environment. Liu, et al (2025) argue that well-designed learning systems can support diverse learners without extensive differentiation. The present findings align with this view by showing that instructional quality benefits all students. Creativity adds an independent advantage but does not alter instructional effectiveness. This distinction is important for refining learning theories and instructional models.

The findings also resonate with broader research on engagement-oriented learning designs. Ortiz-Rojas, et al (2025) demonstrate that instructional designs enhancing engagement can improve learning outcomes in STEM education. Although their study focuses on gamification, the underlying emphasis on active participation is consistent with contextual cooperative learning. The present study extends this principle to mathematics learning in formal classroom settings. Engagement appears to be a key mechanism linking instructional design to achievement. This reinforces the importance of designing learning activities that sustain student involvement.

The relevance of interaction-based instruction is further supported by evidence from other learning contexts. Kurbanbekov, et al (2025) report that immersive and interactive learning environments enhance knowledge acquisition. While their research is situated outside mathematics, the emphasis on experiential engagement parallels the cooperative approach examined in this study. The present findings suggest that mathematics learning benefits from similar instructional principles. Interaction and engagement emerge as transferable features of effective instruction. This strengthens the broader applicability of the study's conclusions.

By examining instructional approach and creativity within a single factorial framework, this study addresses limitations of previous research. Prior studies often examined instructional effectiveness or learner characteristics in isolation. Salami and Spangenberg (2025) and Lee et al. (2025) emphasize instructional quality, while Nokelainen et al. (2025) and Akinpelu et al. (2025) highlight learner engagement. The present study integrates these perspectives by analyzing both factors simultaneously. This approach provides clearer explanatory power. It also reduces ambiguity regarding their respective contributions to learning outcomes.

Overall, this study contributes to mathematics education research by clarifying how instructional approach and creativity shape learning outcomes. Contextual cooperative learning and creativity independently enhance achievement, while their interaction is not significant. These findings support the adoption of active instructional strategies that are inclusive and effective across learner profiles. They also highlight the importance of fostering creativity as a complementary educational goal. Grounded in empirical evidence and aligned with recent international studies, this research offers a robust contribution to contemporary mathematics education discourse.

Implications

The results of this study suggest several important implications for mathematics teaching and curriculum development. The finding that instructional approach and creativity independently influence learning outcomes indicates that teachers can confidently implement contextual cooperative learning in diverse classrooms without the need for rigid differentiation based on creativity levels. This offers practical advantages, particularly in settings where student characteristics vary widely. At the same time, the consistent contribution of creativity to achievement highlights the importance of nurturing creative thinking as part of regular mathematics instruction rather than treating it as an auxiliary skill. Learning activities that encourage exploration, discussion, and multiple solution paths may therefore serve dual purposes: strengthening conceptual understanding and supporting creative development. From a broader perspective, the findings reinforce the value of student-centered instructional practices in improving learning quality. These implications are relevant for teachers, school leaders, and curriculum designers seeking to enhance mathematics learning outcomes.

Limitations

Several limitations should be considered when interpreting the findings of this study. The use of a quasi-experimental design means that full randomization was not possible, which may have allowed uncontrolled variables to influence the results. In addition, creativity was assessed using a single measurement approach, which may not fully represent the multifaceted nature of creativity in mathematical problem solving. The instructional intervention was conducted over a limited period, making it difficult to capture longer-term effects of the instructional approach. Furthermore, the study was situated within a specific educational context, which may limit the extent to which the findings can be generalized to other schools or student populations. These constraints do not undermine the value of the study but indicate the need for cautious interpretation. Recognizing these limitations provides a clearer understanding of the scope and boundaries of the research findings.

Suggestions

Future research may build on the findings of this study in several ways. Longitudinal or fully experimental designs could be employed to examine how instructional approaches and creativity influence mathematics learning over extended periods. Researchers might also consider incorporating multiple instruments or qualitative measures to capture different dimensions of creativity more comprehensively. Expanding the range of learner characteristics examined, such as motivation or self-regulated learning, could provide a deeper understanding of how students respond to different instructional approaches. Replication studies in varied educational contexts would also help strengthen the generalizability of the findings. From a practical standpoint, teacher training programs may benefit from emphasizing strategies for implementing contextual cooperative learning while simultaneously

fostering creative thinking. Such efforts could contribute to more effective and inclusive mathematics instruction.

Conclusion

This study provides empirical insight into how instructional approach and creativity shape students' mathematics learning outcomes. The findings indicate that contextual cooperative learning offers a more effective instructional alternative than direct instruction, as it consistently supports higher levels of student achievement. Creativity also emerges as an important learner-related factor, with more creative students demonstrating stronger performance in mathematics. Nevertheless, the absence of an interaction effect suggests that the benefits of instructional approach are not contingent on students' creativity levels. This indicates that effective instructional practices can be applied broadly across diverse classrooms without disadvantaging learners with different creative capacities. Taken together, the results highlight that improving instructional quality and fostering creativity are complementary, yet independent, strategies for enhancing mathematics learning outcomes. These conclusions strengthen the evidence base for student-centered instruction and contribute to a more nuanced understanding of learning processes in mathematics education.

Author Contributions Statement

Wahyu Kusumaningtyas was responsible for the conceptualization of the study, research design, and the development of instructional procedures. She also led the data collection process and contributed to the interpretation of research findings. Yunita Widya Putri contributed to instrument development, data analysis, and the validation of statistical results. She also participated in drafting and revising the manuscript to improve its academic clarity. Riski Rusmalinda supported the literature review, assisted in data collection, and contributed to manuscript editing and final review. All authors read, discussed, and approved the final version of the manuscript.

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