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IMPACT OF JIGSAW AND THINK-PAIR-SHARE COOPERATIVE LEARNING STRATEGIES ON STUDENTS' CRITICAL THINKING SKILLS IN MATHEMATICS AT THE ELEMENTARY LEVEL: A QUASI-EXPERIMENTAL STUDY

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Abstract

One of the primary goals of contemporary mathematics education is to develop students' critical thinking abilities. However, traditional teacher-centred instruction often provides limited opportunities for students to engage in higher-order thinking and collaborative problem-solving. This study investigates the effect of cooperative learning strategies on the critical thinking abilities of Grade 8 elementary school students. The study employed a quasi-experimental pretest–posttest control group design. The current study involved intact sections of grade eight. Both sections had 60 students; the researcher purposively selected one section as the experimental Group and the other as the control group. The researcher implemented a twelve-week intervention in which the experimental Group received cooperative learning instruction, while the control group continued with conventional lecture-based instruction. The pretest and posttest consisted of a critical-thinking test developed by the researcher. Descriptive statistics, paired-samples t-tests, and independent-samples t-tests were used to examine the data. The results showed no statistically significant difference between the experimental and control groups at the pretest stage, suggesting the groups were comparable before the intervention. The experimental Group's posttest scores increased significantly more than the control group's, even though the latter showed only a slight gain in critical thinking abilities. These findings suggest that structured cooperative Learning outperforms standard instruction in promoting higher-order thinking, cooperative problem-solving, and active participation. The findings indicate that integrating cooperative learning strategies into elementary mathematics instruction can significantly enhance students' critical thinking abilities.

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1. Introduction

Critical thinking enables students to approach problems systematically, analyze complex tasks, and evaluate alternative problem-solving approaches. Because mathematics often involves complex reasoning, critical thinking helps students develop the skills needed to solve challenging problems effectively. Critical thinking, a useful skill in mathematics and beyond, is thus fostered by pushing students to evaluate their errors and improve their methodology (Aditomo, 2019). Cooperative learning strategies that encourage students to exchange ideas, analyze multiple problem-solving approaches, and consider diverse perspectives contribute to the development of critical thinking in mathematics. Moreover, cooperative Learning gives students opportunities to participate in classroom discussions, strengthen analytical abilities, and develop deeper conceptual understanding. Furthermore, cooperative Learning is a popular teaching approach because it emphasizes active student involvement, peer collaboration, and the development of collective understanding (Calder et al., 2021).

Cooperative learning strategies and critical thinking skills are closely connected because cooperative learning environments promote logical reasoning and reflective thinking. Cooperative learning strategies involve discussion, reasoning, and problem-solving activities that enable students to interpret diverse viewpoints, evaluate arguments, and justify their ideas with evidence. Cooperative Learning supports critical thinking and academic achievement because students not only acquire knowledge but also construct understanding through peer interaction (Smith et al., 2018). Cooperative Learning is an instructional approach that emphasizes student-centred Learning through active participation and Collaboration. Activity-based Learning enhances students' confidence in applying prior knowledge and creates opportunities to develop problem-solving abilities that support intellectual development (Fitzsimons, 2014).

1.2 Objectives of the Study

The study objectives are

1. To evaluate the impact of cooperative learning strategies on the development of critical thinking skills in mathematics among grade eight students.
2. To assess the influence of cooperative learning strategies on students' academic achievement in mathematics among grade eight students.
3. To compare the academic achievement and critical thinking skills of students taught using cooperative learning strategies with those taught through teacher-centred instruction in mathematics.

1.3 Research Hypotheses

H01: There is no significant difference between the control and experimental groups on the jigsaw strategy indicator among pretest group students.

H0 2: There is no significant difference between the control and experimental groups on the jigsaw strategy indicator among posttest-group students.

H0 3: There is no significant difference between the control and experimental groups on the think-pair-share strategy indicator among pretest-group students.

H0 4: There is no significant difference between the control and experimental groups on the indicator of think-pair-share strategy among posttest group students.

H0 5: There is no significant difference between the control and experimental groups on the indicator of critical thinking skills among pretest group students.

H0 6: There is no significant difference between the control and experimental groups on the indicator of critical thinking skills among posttest group students.

2. Literature Review

Cooperative Learning, according to Johnson and Johnson (1999), is the instructional use of small groups in the classroom where students collaborate to optimize their own and each other's Learning. Their method highlights positive interdependence, personal

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responsibility, encouraging connection, social skills, and group processing.

Johnson & Johnson (2009) compiled data from several decades of research and concluded that cooperative Learning produces competitive or individualistic learning environments in terms of academic achievement, critical thinking, and interpersonal skills. According to their findings, structured cooperation promotes students' ability to clarify concepts, assess other viewpoints, and build knowledge as a group.

According to Johnson and Johnson (2009), cooperative Learning depends on;

Positive dependency (cooperation): Students believe they can only accomplish their objectives if other group members do as well.

Negative dependence (competition): Students believe they can succeed only when others cannot.

No interdependence (individualistic): Students believe that reaching their goals is unrelated to others' success.

Güngör et al. (2026) assessed the efficacy of cooperative Learning in educational environments and discovered that students who participated in organized group activities showed enhanced problem-solving, communication, and reasoning abilities. The study made clear that instructor guidance and constructive interdependence are necessary to maximize the cognitive benefits of cooperative Learning.

Al-Kindi et al. (2025) discovered that it typically improves students' academic achievement across a range of subject areas and educational levels. Additionally, the analysis found that cooperative Learning increases students' participation in higher-order cognitive functions such as synthesis, analysis, and assessment. Capar and Tarim's (2015) meta-analysis of studies on cooperative Learning in mathematics education found that cooperative Learning considerably raised math achievement. The researchers found that students improved their conceptual understanding and mathematical reasoning through Collaboration compared with those who received traditional teacher-centred education.

According to Lai and Wong (2022), Collaborative problem-solving greatly improved pupils' computational thinking and higher-order cognitive abilities. Their meta-analysis found that students can strengthen their critical thinking skills, assess viable solutions, and defend their perspectives through cooperative exchanges during problem-solving exercises. Furthermore, Siagian et al. (2023) found that students who participated in cooperative learning interactions showed stronger critical thinking and provided more thorough explanations than students receiving standard classroom instruction. These findings support the idea that organized peer contact promotes introspection, investigation, and evidence-based reasoning—all of which support cognitive development.

Cooperative Learning has been effective in many studies; however, most have been conducted in developed countries across a variety of educational settings. Consequently, an experimental study is required to examine the extent to which cooperative learning strategies improve critical thinking abilities among elementary mathematics students in the Pakistani educational setting (Jamil et al., 2024).

According to Erito et al. (2021), Information must be understood through critical thinking in order to be analyzed, evaluated, and synthesized. In its most basic form, critical thinking is the process of using original ideas to analyze, assess, interpret, or synthesize evidence to formulate a claim, develop a solution, or draw a conclusion. Data analysis, concept generation and organization, belief formation and defence, idea comparison, conclusion drawing, argument evaluation, and problem solving are all components of critical thinking.

Lewittes (2007) found that despite instruction, one-third of language learners could not acquire this capacity. To address this issue, we formed small groups for unstructured conversations and developed strategies to control the learning process and inspire the group members. The findings indicated that applying critical thinking in instruction

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depends on the learning environment and student interactions, particularly cooperation.

According to Facione (1990), critical thinking is a deliberate, self-controlled process that includes interpretation, analysis, assessment, inference, explanation, and self-control. This definition is very helpful for research because students' answers to mathematical problems can be used to measure these abilities.

Mathematics learning requires students to examine data, recognize relationships, analyze procedures, assess potential solutions, and offer logical arguments; critical thinking is especially crucial. Therefore, when classroom activities require students to explain how and why a solution works rather than replicate a memorized process, mathematics offers an opportunity for students to build critical thinking skills (Nafiah et al., 2024).

In mathematics education, Azmi et al. (2025) conceptualize and assess critical thinking differently. Their analysis showed that researchers have used a variety of dimensions and assessment techniques, underscoring the need for accurate definitions of critical-thinking structures and reliable instruments.

1.2 Research Context and Gap

Although critical thinking is increasingly recognized as an essential goal of mathematics education in Pakistan, A research-to-practice gap remains between the curriculum's emphasis on higher-order thinking and empirical evidence on classroom strategies that can successfully develop these abilities among elementary mathematics students.

A recent study of Pakistan's mathematics curriculum found that conceptual comprehension, logical reasoning, problem-solving, and applying mathematics to real-life scenarios all contribute to developing critical thinking skills (Jamil et al., 2024). However, curriculum-level recognition does not determine whether teaching strategies successfully convert these expectations into quantifiable gains in students' critical-thinking abilities.

The main gap in the Pakistani educational system is the absence of comprehensive, strategy-specific, mathematics-focused, quasi-experimental evidence on the growth of elementary students' critical-thinking abilities through the Jigsaw and Think-Pair-Share strategies.

Instead of emphasizing memorization, modern educational innovations emphasize instructional strategies that motivate students to analyze data, solve challenging problems, defend their conclusions, and collaborate with peers. One of the best student-centred teaching strategies for accomplishing these goals is cooperative Learning. Cooperative Learning promotes higher-order thinking and conceptual knowledge by actively involving students in debate, explanation, and group problem-solving.

To close this gap, the current study uses a quasi-experimental methodology to investigate how Jigsaw and Think-Pair-Share cooperative learning strategies affect students' critical-thinking abilities in primary mathematics. By doing this, the study provides context-specific evidence regarding the ability of two structured cooperative-learning strategies to promote critical thinking in Pakistani elementary mathematics classrooms, moving beyond evidence based only on academic achievement in higher-order thinking dimensions.

Even though cooperative Learning is widely acknowledged, teacher-centred teaching methods continue to predominate in Pakistani primary school mathematics classes (Latafat, K., 2024). When teachers use these conventional methods, students often have few opportunities to participate actively, reflect critically, and conduct group inquiry. As a result, many students show sufficient procedural knowledge but struggle to complete activities that require critical thinking in reasoning, problem solving, and assessment.

The current study was conducted in the primary mathematics education system in Punjab, Pakistan. It investigates whether eighth-grade students' mathematics critical-thinking skills can be improved by using cooperative Learning rather than conventional teaching techniques. The study predicted that the findings would provide evidence

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supporting the integration of cooperative Learning into math instruction and improving students' capacity for critical thought. Several earlier empirical studies show that cooperative Learning enhances students' academic achievement, classroom engagement, and social connection. Meta-analyses and experimental studies in various nations also show that cooperative Learning promotes higher-order cognitive skills such as analysis, appraisal, reasoning, and problem-solving (Gałör et al., 2026).

To bridge these gaps, the current study examines how cooperative Learning improves Grade 8 students' critical thinking skills in mathematics at the elementary level in Punjab, Pakistan, using a pretest–posttest experimental method.

1.3 Theoretical framework

This study was based on social interdependence theory, which served as the foundation for the investigation (Johnson & Johnson, 1980). According to Vygotsky's Social Constructivism (1978), scaffolding and peer interaction are the best ways for pupils to learn. According to Piaget's constructivism, children build knowledge by active engagement, which promotes deeper comprehension. These theories support the use of cooperative learning techniques in the classroom. It emphasizes reasoning, critical thinking, and social engagement.

2. Method

Research Design

A quantitative, quasi-experimental pretest-posttest control-group design was used. The study was conducted in one public elementary boys' school in Faisalabad, Pakistan. The target context comprised the city's elementary boys' schools, and the school was purposively selected. The design included an experimental group that received structured cooperative-learning instruction and a control group that received teacher-centred instruction. Both groups completed pretests before the intervention and posttests after the 12-week instructional period.

The design is illustrated as follows.

Groups	Pretest	Intervention	Post Test
Experimental	O1	X	O2
Control	O1	--	O2

3.2 Population of the Study

According to the official Punjab Government Education School Department (2024) annual census, Faisalabad city has 174 elementary boys' schools. The study's target and accessible population consisted of 174 elementary boys' schools in Faisalabad city.

3.3 Sampling

In the present study, the researcher purposively selected one public elementary boys' school in Faisalabad city. The researcher selected participants from an intact Grade 8 section in the selected school. The sample was divided into two groups: 30 students in the experimental Group and 30 in the control group. Because the study was conducted in a natural school setting, students could not be randomly assigned to different groups. Thus, the study employed intact groups while maintaining comparable group sizes for the experimental and control conditions. The researcher conducted a pretest. Following the pretest, the researcher implemented cooperative learning strategies as an intervention. After the intervention, the researcher conducted a posttest.

3.4 Instrumentation

3.4.1 Critical Thinking

To measure critical thinking skills, the researcher developed a test with the assistance of mathematics experts.

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3.4.2 Pilot Testing

The researcher piloted the Critical Thinking Test with a small group of Grade 8 students. Pilot testing assessed the clarity, difficulty, and appropriateness of the test items and determined the instrument's reliability before its use in the main study.

3.5 Instructional Intervention

The intervention lasted 12 weeks and was aligned with the Punjab Textbook Board's Grade 8 mathematics textbook. Instruction covered Grade 8 mathematics topics: estimation and approximation, linear equations and inequalities, number sequences and patterns, and expansion and factorization. In the experimental Group, estimation, approximation, linear equations, and inequalities were taught through Jigsaw and think-pair-share cooperative learning strategies. The control group studied the same curriculum content through teacher-centred instruction as they learned previously.

3.3.1 Jigsaw strategy

The Jigsaw method is a cooperative learning approach in which students work in small, diverse groups, with each member tasked with learning and imparting a specific portion of the curriculum to the others. Students were divided into 5 to 6 small groups, and each student was assigned a topic; these groups were called home groups. Students with the same topic formed an expert group. Students in the expert Group discussed and solved the problem, then returned to their home groups and taught their topic to other members.

3.3.2 Think-Pair-Share

The strategy has three primary implementation phases. First, Think: After the teacher poses a topic, issue, or assignment, each student is given time alone to consider the issue, recall pertinent facts, evaluate the data, and develop a potential solution. Second, in pairs, students collaborate to debate their ideas, compare their reasoning, identify parallels and discrepancies, and explain or justify their responses. Third, Share: Whether on their own initiative or at the teacher's request, students present their findings to the entire class. The instructor leads the conversation, invites students to share their thinking, and offers explanations as needed.

3.4 Statistical Analysis

The researcher used IBM SPSS Statistics to examine the data. Descriptive statistics (means and standard deviations) summarized students' critical thinking scores. To determine whether the experimental and control groups performed similarly on the pretest, the researchers conducted an independent-samples t-test. Pretest and posttest score changes within each Group were examined using paired-samples t-tests. The dependent variable was posttest critical thinking scores, the independent variable was instructional Group, and the covariate was pretest scores. Appropriate effect sizes were reported, and statistical significance was evaluated at the 05 level.

3.5 Data Analysis and Interpretation

Table: 1

Significant Difference between the pretest and posttest control groups in the Jigsaw strategy

		Mean	N	Std. Deviation	t	p
Pair 1	Pretest_Jigs	13.1667	30	3.32268	.60664	.026*
	Posttest_Jigs	13.8333	30	3.20649		

To determine whether the control group students' pretest and posttest results differed significantly using the Jigsaw technique, a paired-samples t-test was used. The mean score increased by about 0.67 points, from 13.17 on the pretest to 13.83 on the posttest. The null hypothesis H01, which stated that there was no significant difference between the pretest and

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posttest scores of the control group students in the jigsaw strategy, was rejected because the Difference was statistically significant at the .05 level, based on the reported significance value, p = .026. However, the effect size calculated from the given t-value using Cohen's dz formula (t/√N) is roughly 0.11, which represents a very small or insignificant impact. Thus, although the reported p-value indicates statistical significance, the real-world increase in pupils' test scores was small and may not reflect a meaningful shift in schooling.

Table: 2
Significant Difference between the Pretest and Posttest experimental groups in the Jigsaw strategy

		Mean	N	Std. Deviation	t	p
Pair 1	Pretest_Jigs	12.2667	30	.98027	15.398	.000*
	Posttest_Jigs	19.1667	30	2.19848		

The paired-samples t-test was conducted to examine whether there was a significant difference between the pretest and posttest scores of the experimental group students in the jigsaw strategy. The results showed a substantial increase in students' mean scores from the pretest (M = 12.27, SD = 0.98) to the posttest (M = 19.17, SD = 2.20), indicating an improvement of approximately 6.90 points after the intervention. This Difference was statistically significant, t(29) = 15.398, p < .001, showing that the improvement in the posttest scores was highly unlikely to have occurred by chance. Therefore, the null hypothesis H02, which stated that there was no significant difference between the pretest and posttest scores of the experimental group students in the jigsaw strategy, was rejected. Additionally, Cohen's dz for paired-samples data was used to quantify the effect size using the method t/√N. A fairly large influence was represented by the obtained effect size of roughly 2.81. This shows that the jigsaw approach had a very high practical impact on students' performance, in addition to a statistically significant effect. Overall, the results indicate that the jigsaw technique greatly enhanced the experimental Group's pupils' learning outcomes.

Table: 3
Significant Difference between the pretest and posttest control groups in the think-pair-share strategy

		Mean	N	Std. Deviation	t	p
Pair 1	Pretest_Think	10.9333	30	2.39156	-.422	.676
	Postest_Think	11.1667	30	3.09709		

A paired-samples t-test was conducted to determine whether there was a significant difference between the pretest and posttest scores of the control group students using the think-pair-share strategy. The results showed only a very slight increase in the mean score from 10.93 in the pretest to 11.17 in the posttest, indicating a small mean gain of 0.23 points. However, this Difference was not statistically significant, t(29) = -0.422, p = .676, as the p-value is greater than the conventional significance level of .05. This means that the small improvement observed in the control group students' scores may be attributed to chance rather than to any meaningful instructional effect. Therefore, the null hypothesis H03, that there was no significant difference between the pretest and posttest scores of the control group students using the think-pair-share strategy, was retained. In terms of practical significance, the effect size was determined using Cohen's dz for paired-samples data, which is based on the t/√N calculation. The effect size was about 0.08, which is extremely tiny and insignificant. Overall, the findings suggest that control-group students did not show meaningful improvement in their use of the think-pair-share strategy during the study period.

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Table:4

Significant Difference between the pretest and posttest experimental groups in the Think-Pair-Share strategy

		Mean	N	Std. Deviation	t	p
Pair 1	Pretest_Think	10.1333	30	2.09652	-7.290	.000*
	Postest_Think	14.3333	30	2.61736		

The paired-samples t-test was conducted to determine whether there was a significant difference between the pretest and posttest scores of the experimental group students in relation to the think-pair-share strategy. The findings revealed that the students' mean score increased from 10.13 on the pretest to 14.33 on the posttest, indicating a mean improvement of 4.20 points after the intervention. This Difference was statistically significant, $t(29) = -7.290$, $p < .001$, indicating that the observed improvement was unlikely to have occurred by chance. The negative t-value reflects only the order of comparison between the pretest and posttest scores and does not indicate a negative result. Ultimately, the null hypothesis H04, which claimed no difference between the experimental group students' think-pair-share method pretest and posttest scores, was rejected. To assess the practical importance of the result, the effect size was calculated using Cohen's dz for paired-samples data, based on the formula $t/\sqrt{N}$. The effect size was approximately 1.33, indicating a strong impact. This implies that the think-pair-share approach had a considerable practical impact on the students' performance in addition to a statistically significant improvement. Overall, the findings show that the intervention was very successful in raising students' think-pair-share strategy learning outcomes.

Table: 5

Significant Difference between the pretest and posttest control groups in critical thinking skills

		Mean	N	Std. Deviation	t	p
Pair 1	Pretest_Critical	9.5000	30	2.38891	-3.166	.004*
	Postest_Critical	10.6667	30	2.36837		

To determine whether the control group students' critical thinking skill pretest and posttest scores differed significantly, the paired-samples t-test was used. The findings showed that students' mean score rose by 1.17 points, from 9.50 on the pretest to 10.67 on the posttest. This improvement was statistically significant ($t(29) = -3.166$, $p = .004$), indicating that the Difference between the two testing points was not due to chance.

Because the pretest mean was lower than the posttest mean, the negative t-value indicates the direction of the Difference. As a result, the null hypothesis H05, which claimed no discernible difference between the control group students' critical thinking skill pretest and posttest results, was rejected. Practically, Cohen's dz for paired-samples data, based on the $t/\sqrt{N}$ computation, was used to determine the effect size. A moderate effect was indicated by the obtained effect size of about 0.58.

This implies that although students in the control group showed a statistically significant improvement in critical thinking skills, the improvement was relatively modest. Although students in the control group improved over time, the practical advantage was not as significant as one might expect from a more demanding educational intervention, according to the data.

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Table: 6
Significant Difference between the pretest and posttest experimental groups in critical thinking skills

		Mean	N	Std. Deviation	T	p
Pair 1	Pretest_Critical	9.7000	30	1.98529	-11.255	.004*
	Postest_Critical	16.9333	30	3.46344		

p<0.01

A paired-samples t-test revealed a statistically significant difference between the experimental Group's critical thinking scores on the pretest and posttest. The students' mean score improved by 7.23 points following the intervention, rising from 9.70 in the pretest to 16.93 in the posttest. The reported p-value of <.004 and the obtained t-value of t = -11.255 were both less than the standard alpha threshold of 05. This indicates that the improvement in students' critical thinking skills was statistically significant and unlikely to have occurred by chance. Therefore, the null hypothesis, which stated that there is no significant difference between the experimental Group's pretest and posttest critical thinking scores, was rejected. The findings suggest that the instructional treatment or intervention applied to the experimental Group had a positive, meaningful effect on students' critical thinking skills.

The negative t-value does not indicate a negative outcome; rather, it reflects the order of comparison, as the pretest mean was lower than the posttest mean. In addition to statistical significance, the effect size was calculated using the paired-samples effect size formula, Cohen's d = t/√N, yielding an effect size of approximately 2.05. It represents a large effect, indicating that the intervention had a strong, practically meaningful impact on students' critical thinking development.

3. Discussion

The current study's results provide evidence that structured cooperative learning strategies can significantly improve students' critical-thinking abilities and learning outcomes at the elementary level. The Think-Pair-Share experimental Group's mean score increased from 10.13 to 14.33, while the Jigsaw experimental group's mean score jumped from 12.27 to 19.17. Both differences were statistically significant and accompanied by substantial effect sizes. By contrast, the equivalent control groups showed little or no statistically significant improvement.

Because it fosters positive interdependence, individual accountability, peer instruction, and opportunities for students to explain and reconstruct mathematical concepts collectively, the Jigsaw group's particularly significant gain suggests the strategy was successful. Because students must interpret Information, analyze relationships, compare explanations, defend solutions, and assess others' reasoning in addition to recalling procedures, these processes are particularly pertinent to critical thinking.

The results of the current study provide evidence that cooperative Learning improved eighth-grade students' mathematical critical-thinking abilities. Prior to the intervention, the independent-samples t-test found no statistically significant difference between the experimental and control groups on the critical thinking abilities pretest. The insignificant effect size further supported the groups' baseline comparability by showing that any differences observed after the intervention were unlikely to be attributable to pre-existing disparities between the groups; this conclusion enhances the study's internal validity. In pretest–posttest experimental investigations, establishing equivalency at the pretest stage is especially crucial because it increases the likelihood that posttest differences can be fairly assigned to the instructional intervention rather than to participant differences at the outset.

According to Ullah et al. (2024), Jigsaw greatly improved elementary students' ability to

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analyze, evaluate, and create, all of which are strongly related to the cognitive processes needed for mathematical critical thinking. Similarly, although their study was conducted in English and at the higher-secondary level, Akbar and Akhtar (2021) found that cooperative-learning methodologies greatly enhanced students' interpretation and analysis skills compared with conventional instruction.

Cooperative Learning offered more opportunities for higher-order mathematical reasoning than traditional instruction, as shown by the experimental Group's significant improvement in critical-thinking performance from 9.70 to 16.93, a gain of 7.23 points and a very large reported effect size. This effect might be explained by the complementary structure of Think-Pair-Share and Jigsaw: Think-Pair-Share first offers individual thinking time, followed by paired discussion and group sharing, while Jigsaw requires students to become experts in a specific area of the content and teach it to peers. Both approaches require students to express their reasoning clearly, consider opposing viewpoints, reevaluate their initial answers, and present defensible conclusions.

Current results and earlier research indicate that the success of cooperative Learning depends on intentionally structured interaction that involves students in explanation, questioning, comparison, evaluation, and reflection, rather than simply putting them in groups. This distinction is especially significant in elementary mathematics in Pakistan because the current study shows that well-executed Jigsaw and Think-Pair-Share can convert cooperative engagement into quantifiable improvements in critical-thinking abilities.

5. Conclusion

The current study investigated the effects of cooperative learning practices on Grade 8 students' critical-thinking skills in elementary mathematics using a pretest–posttest control-group experimental design. The findings showed that students who engaged in cooperative Learning significantly outperformed those who received traditional instruction in developing their critical-thinking skills. Throughout the study, the experimental Group's increases in critical thinking were much higher than those of the control group, suggesting that cooperative Learning offered educational advantages beyond traditional classroom training.

The current study concludes that Jigsaw and Think-Pair-Share (TPS) cooperative learning methodologies enhanced students' critical-thinking abilities in elementary mathematics. Compared with the control groups, students who took part in the experimental interventions showed significantly greater improvement, suggesting that structured cooperative Learning offered better opportunities for students to engage in mathematical reasoning, discussion, explanation, and problem-solving than traditional instruction.

Overall, the results show that TPS and Jigsaw are both useful student-centred strategies for fostering critical thinking in basic math. Opportunities for peer engagement, introspection, explaining ideas, assessing alternative solutions, and cooperative knowledge development may explain their effectiveness. As a result, the study offers empirical evidence in favour of incorporating organized cooperative-learning techniques into elementary arithmetic classes, especially in the context of Pakistani education

According to the findings, students' analytical, evaluative, and reasoning skills, all essential elements of critical thinking in mathematics, were developed through structured peer contact, group problem-solving, and active engagement. The study also found that cooperative Learning fosters a classroom environment where students actively develop knowledge, share ideas, defend their mathematical reasoning, and learn from one another. The social constructivist and social interdependence theories, which highlight that meaningful Learning occurs through social interaction, positive interdependence, and shared responsibility for learning, align with these findings. Overall, the study contributes to the growing body of empirical evidence

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demonstrating the advantages of cooperative Learning in teaching mathematics.

It provides verifiable evidence that using cooperative learning techniques like Jigsaw and Think-Pair-Share in basic math lessons can significantly improve students' critical thinking skills. The results have important ramifications for educators, school administrators, curriculum designers, teacher educators, and legislators who want to advance student-centred teaching methods and raise the standard of math instruction. Cooperative Learning is therefore a successful teaching strategy for encouraging critical thinking and equipping students with the higher-order cognitive skills necessary for success.

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