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The CORE model: An innovative strategy to strengthen students' mathematical connections and problem-solving skills in junior high school

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***Abstract*:**
Developing students' mathematical connection and problem-solving skills remains a persistent challenge in Indonesian secondary mathematics education. This study examined the impact of the CORE (Connecting, Organizing, Reflecting, Extending) instructional model on students' mathematical connections and problem-solving abilities at SMPN 02 Kota Bengkulu. A quantitative approach with a controlled-comparison design was employed, and data were analyzed using Analysis of Covariance (ANCOVA) to assess the model's effects while controlling for prior ability. The findings revealed that prior mathematical ability significantly explained 25.3% of the variance in students' mathematical connection skills and 55.3% of the variance in their problem-solving performance. After implementing the CORE model, students demonstrated substantial improvement in both areas. The model accounted for 57.0% of the variance in mathematical connection ability, particularly enhancing students' capacity to relate mathematics to other disciplines and real-life contexts, and 19.9% of the variance in problem-solving skills, especially in understanding problems, planning, and reviewing solutions. These results suggest that the CORE model effectively promotes cross-disciplinary integration, contextual understanding, and reflective reasoning in mathematics learning. Theoretically, the findings reinforce the role of constructivist and reflective learning frameworks in strengthening students' higher-order thinking and meaningful engagement with mathematical concepts.

Keywords: CORE; Mathematical Connection; Mathematical Problem Solving; Prior Knowledge.

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Introduction

Mathematics plays a vital role in developing students' logical, critical, and reflective thinking skills, which are essential for effective problem-solving (Isnaina et al., 2022). In everyday life, mathematical concepts are applied in diverse situations ranging from simple decision-making to complex data analysis. Therefore, mathematics learning should not only aim at academic achievement but also equip students with the ability to apply mathematical reasoning in real-life contexts. According to Kemdikbudristek (2022), mathematics instruction should strengthen students' conceptual understanding and their capacity to think logically, creatively, and systematically in addressing problems.

Two essential competencies in mathematics learning are mathematical connection skills and problem-solving abilities. Mathematical connection refers to students' ability to relate mathematical ideas across topics, representations, and real-world contexts (Zengin, 2019). Without strong connection skills, students tend to perceive mathematical concepts as isolated and fragmented, resulting in shallow understanding (Siregar et al., 2020). Similarly, problem-solving ability involves analyzing a problem, choosing appropriate strategies, applying them systematically, and evaluating the results (Polya, 1973). These abilities are central to mathematics learning, as emphasized by Posamentier and Krulik (2009), who regard problem-solving not merely as a teaching method but as the ultimate goal of mathematics education.

However, empirical evidence shows that students' mathematical connections and problem-solving abilities remain low. Studies by Yusron et al. (2020), Damayanti et al. (2023), and Asmara et al. (2021) indicate that many students struggle to retrieve and apply mathematical concepts in authentic contexts. Similarly, findings by Jatisunda and Nahdi (2020), Albab et al. (2021), Ulfa et al. (2022), and Thamsir et al. (2019) show that students' average performance in solving mathematical problems remains below the Minimum Mastery Criteria (KKM). Observations and interviews conducted at SMPN 02 Bengkulu City (November 11, 2024) further confirmed that students find it challenging to connect mathematical ideas to daily life and display low motivation and engagement in mathematics learning.

One major contributing factor is the dominance of conventional, teacher-centred learning models that emphasize memorisation rather than conceptual understanding (Khaidir and Suhaili, 2023). Such approaches make students passive, reduce their confidence, and hinder their ability to apply mathematical reasoning in new or complex situations (Buyung et al., 2022). Therefore, an alternative instructional approach is needed, one that promotes active participation, meaningful engagement, and reflective learning.

The CORE (Connecting, Organising, Reflecting, Extending) model is one such approach designed to help students construct knowledge by linking new and prior concepts, organising ideas, reflecting on learning processes, and extending understanding to new contexts (Miller and Calfee, 2004). Udyani et al. (2018) demonstrated that the CORE model fosters students' critical and creative thinking by engaging them in activities that require organising, analyzing, and expanding knowledge. Niarti et al. (2021) emphasised that implementing the CORE model increases students' active participation, cultivates positive attitudes toward mathematics, and strengthens their conceptual understanding. Furthermore, Mardiana et al. (2020)found that the CORE model effectively enhances students' mathematical connections across topics. However, previous studies have not examined the influence of the CORE model while statistically controlling for students' prior mathematical ability, even though prior ability can significantly shape learning outcomes. Addressing this methodological limitation is essential to obtain a more accurate and robust estimation of the model's effectiveness.

Therefore, this study aims to assess the impact of the CORE learning model on students' mathematical connection and problem-solving abilities at SMPN 02 Kota Bengkulu, while controlling for prior ability using Analysis of Covariance (ANCOVA). The following hypotheses guide the study:

1. The CORE learning model has a significant effect on students' mathematical connection ability after controlling for prior ability.
2. The CORE learning model has a significant effect on students' mathematical problem-solving ability after controlling for prior ability.

Through this research, it is expected that a deeper understanding of the CORE model's effectiveness will contribute, both theoretically and practically, to the development of innovative, student-centred mathematics learning strategies aligned with the principles of the Independent Curriculum (Kurikulum Merdeka).

Research Methods

1. Research Genius

This study employed a quasi-experimental design with a non-equivalent control group structure. The design included one experimental class taught using the CORE learning model and one control class taught using conventional instruction. Intervention effectiveness was measured using pre-test and post-test scores assessing students' mathematical connection ability and mathematical problem-solving competence.

2. Core Model Implementation

The instructional intervention in the experimental class implemented the four phases of the CORE (Connecting, Organizing, Reflecting, Extending) learning model. The following activities illustrate how each phase was carried out during the fifth meeting on April 24, 2025, covering the topic of determining, interpreting, and applying the mode of ungrouped and grouped data.

a. Connecting
   Students were grouped into teams of 2–3 and received LKPD. The teacher activated prior knowledge by asking guiding questions. A short learning video related to the concept of mode was shown to strengthen students' initial understanding. Students then connected the information from the video and questions to the introductory section of LKPD, which introduced real-life contexts involving mode.
b. Organizing
   Students examined the problems in LKPD and organized key ideas using definitions, examples, and the provided data. They discussed in their groups how to arrange the solution steps and identify the appropriate method for determining the mode. During this phase, the teacher guided clarification and facilitated questions to ensure the reasoning process was structured and accurate.
c. Reflecting
   Students worked through the guided steps in LKPD to reflect on the problem-solving process. They evaluated their reasoning, justified each step, and refined their solutions based on group discussion. Each group then presented its results to the class, followed by peer feedback and questions. The teacher facilitated the discussion to deepen conceptual understanding.
d. Extending

Students individually explored new examples from real-life situations related to the concept of mode and applied the idea beyond the LKPD problems. They were encouraged to identify additional contexts in which the mode is meaningful and to interpret the results. As an extension, students were given an individual task to reinforce and apply the concept independently.

3. Research Population

The population consisted of all eighth-grade students at SMPN 02 Bengkulu City in the 2024/2025 academic year, totalling 397 students in 11 classes. Because classes were pre-established by the school, purposive cluster sampling using intact classes was applied.

Class VIII A (n = 38) – Experimental group

Class VIII B (n = 38) – Control group

Selection was based on comparable instructional schedules and teacher assignments.

4. Data Collection Techniques

The research instrument consisted of a five-item essay test measuring students' mathematical connections and problem-solving abilities. Before field testing, the instrument underwent expert review by five validators (three lecturers and three mathematics teachers). The panellist evaluation included Aiken's V validity analysis and Hoyt's reliability testing.

Aiken's V was used to determine content validity, with V ≥ 0.60 serving as the minimum acceptable criterion. Based on expert judgments, the obtained Aiken's V coefficients were 0.8346 for the Teaching Module, 0.8300 for the Mathematical Connection Test, and 0.8288 for the Problem-Solving Test. All of these values fall within the high validity range, indicating that the instruments are appropriate for use in the study.

Reliability was assessed using the Hoyt ANOVA method; $r_{11} \geq 0.70$ indicated high reliability. The results showed coefficients of 0.7162 for the Teaching Module, 0.7183 for the Mathematical Connection Test, and 0.7276 for the Problem-Solving Test. These findings confirm that all instruments demonstrated high reliability. After expert validation and revision, empirical testing produced item validity coefficients r = 0.52–0.78 (above r_table = 0.30). Cronbach's Alpha reached 0.82, confirming strong internal consistency. Thus, all instruments were deemed valid and reliable for use in the study.

5. Data Analysis

Descriptive-analytical computation is used to characterize research data in general. This analysis aims to present information about maximum, minimum, mean, standard deviation (standard deviation), variance, and frequency distribution from student test result data, both for pre-test and post-test. From this description, researchers can get a preliminary sense of the data's trends and variations before conducting inferential statistical testing. The data analyzed in this stage include mathematical connection ability and learners' competency in solving mathematical tasks.

Hypothesis testing was conducted to determine whether the CORE learning model significantly affects students' mathematical connections and problem-solving abilities.

The inferential analysis employed Analysis of Covariance (ANCOVA), as the study involved a covariate (initial ability/pre-test) that needed to be statistically controlled.

ANCOVA enables controlling the influence of covariates when comparing post-test scores between the experimental and control groups. The analysis was performed using IBM SPSS Statistics 27, with decision-making based on the significance (Sig.) values as follows:

If Sig. < 0.05, then H_0 is rejected, indicating a significant influence.

If Sig. ≥ 0.05, then H_0 is accepted, indicating no significant effect.

Results and Discussions

Description of Mathematical Connection and Mathematical Problem-Solving Test Results

Evaluation tools, used before and after learning to assess math integration, have been tested for validity, reliability, difficulty, and differences, and the data have been analysed for validity, homogeneity, and linearity. The results of all tests were within good categories, indicating that the instrument was suitable for use and that the data could serve as a basis for concluding.

Table 1. Statistical Description of Experimental Class Mathematical Connection Ability Test Results

Statistics	**Experimental Classes**		**Control Class**	
	Pre-test	***Post-test***	***Pre-test***	***Post-test***
Maximum Value	30.00	95.00	35.00	75.00
Minimum Score	0	35.00	0	15.00
Average	16.97	69.74	18.29	40.66
Variance	54.78	237.77	72.00	236.72
Baku Junction	7.40	15.42	8.48	15.39

Based on Table 1, the pretest outcomes for learners' math linkage skills in the trial group ranged from 0 to 30, with a mean of 16.97, a variance of 54.78, and a standard deviation of 7.40. Meanwhile, the posttest scores indicated improvement, ranging from 35.00 to 95.00. The mean score increased to 69.74, with a variance of 237.77 and a standard deviation of 15.42.

The pretest results for students' mathematical connection skills in the control group showed the lowest score was 0, and the highest was 35.00. The average result was 18.29, with a variance of 72.00 and a standard deviation of 8.48. Meanwhile, the posttest results showed a lowest score of 15.00 and a highest of 75.00. The average score reached 40.66, with a variance of 236.72 and a standard deviation of 15.39.

Table 2. Statistical Description of Experimental Class Mathematical Problem-Solving Test Results

Statistics	**Experimental Classes**		**Control Class**	
	Pre-test	***Post-test***	***Pre-test***	***Post-test***
Maximum Value	21.25	83.75	22.50	77.50
Minimum Score	5.00	31.25	1.25	36.25

Average	12.30	65.59	12.60	58.62
Variance	17.36	129.45	32.80	128.11
Baku Junction	4.17	11.38	5.73	11.32

As shown in Table 2, the pretest results for students' mathematical problem-solving ability in the experimental group ranged from 5.00 to 21.25. The mean score was 12.30, with a variance of 17.36 and a standard deviation of 4.17. In contrast, the posttest results showed an increase, with the lowest score of 31.25 and the highest of 83.00. The average score rose to 65.59, with a variance of 129.45 and a standard deviation of 11.38.

The pretest outcomes for math reasoning competencies in the control group showed the lowest score was 1.25, the highest was 22.50, and the average was 12.60, with a variance of 32.80 and a standard deviation of 5.73. Meanwhile, the posttest results revealed an improvement, with scores ranging from 36.25 to 77.50. The average score increased to 58.62, with a variance of 128.11 and a standard deviation of 11.32.

ANCOVA Description of CORE Learning Towards Connection and Problem-Solving Skills

Table 3. Results of Testing the Influence of Subjects on Mathematical Connection Ability

Tests of Between-Subjects Effects

Dependent Variable	**Post-test of Mathematical Connections**					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	20203.838[a]	2	10251.919	57.050	0.000	0.610
Intercept	18225.285	1	18225.285	101.420	0.000	0.581
Pre-test of Mathematical Connections	4437.719	1	4437.719	24.695	0.000	0.253
Model	17389.467	1	10753.772	96.769	0.000	0.570
Error	13118.202	73	179.701			
Total	265175.000	76				
Corrected Total	33622.039	75				

a. R Squared = 0.610 (Adjusted R Squared = 0.599)

Based on Table 3, the p-value of 0.000 was below the significance threshold of 0.05, leading to the rejection of H_0 and acceptance of H_1. It indicates that students' initial ability had a statistically significant and linear influence on their mathematical connection skills. Practically, the contribution of 25.3% means that roughly one-quarter of the variation in students' posttest scores can be explained by differences in their prior knowledge. In other words, students who began with a stronger initial understanding tended to achieve higher outcomes, even before the learning model was considered.

In Table 3, the significance value of 0.0000 ($p < 0.05$) also led to the rejection of H_0 and acceptance of H_1, confirming that the CORE learning model had a significant effect on Grade 8 students' mathematical connection ability after controlling for prior ability. The effect size of 57.0% represents a substantial practical impact. Conceptually, this indicates that more than half of the improvement in students' posttest performance is attributable to the CORE learning model itself, beyond what can be explained by their initial ability alone. This level of contribution is typically interpreted as a significant educational effect, demonstrating that the CORE approach meaningfully enhances students' mathematical connection skills.

Table 4. *Estimate Marginal Means* Mathematical Connection Ability Test

Dependent Variable		Post-test of Mathematical Connections		
			95% Confidence Interval	
Model	**Mean**	**Std. Error**	**Lower Bound**	**Upper Bound**
Eksperimen	70.377[a]	2.178	66.035	74.718
Kontrol	40.018[a]	2.178	35.676	44.360

a. Covariates appearing in the model are evaluated at the following values: Pretest_Koneksi_Matematis = 17,6316.

Table 4 showed variation in average scores on math linkage skills across the treatment and comparison groups, after controlling for students' initial abilities. The adjusted mean score for the experimental group was 70.377, whereas the comparison class recorded an average of 40.018. It indicates a difference of 30.359 in favor of the experimental group.

Table 5. Percentage of Indicators of the Number of *Post-test* Answers of Students on the Mathematical Connection Ability of the Experiment Class

Post-test Score of Mathematical Connection Ability			
Indicators	**Sum**	**Average**	**Percentage**
Relationship between mathematical concepts	89	2.34	58.55%
The relationship between mathematics and other sciences	224	2.95	73.68%
The relationship between mathematics and everyday life	217	2.86	71.38%

Table 6. Percentage of Indicators of the Number of *Post-test* Answers of Students on the Mathematical Connection Ability of the Control Class

Post-test Score of Mathematical Connection Ability			
Indicators	**Sum**	**Average**	**Percentage**
Relationship between mathematical concepts	53	1.39	34.87%
The relationship between mathematics and other sciences	109	1.43	35.86%
The relationship between mathematics and everyday life	147	1.93	48.36%

Based on the data in Tables 5 and 6, it can be seen that students' achievement in mathematical connection ability in the experimental class is consistently higher than that in the control class across all indicators. The highest indicator in the experimental class was the relationship between mathematics and other sciences, with a percentage of 73.68%, followed by the relationship between mathematics and daily life (71.38%), and the relationship between mathematical concepts (58.55%). Meanwhile, in the control class, the indicator that had the highest percentage was the relationship between mathematics and daily life at 48.36%. In contrast, other indicators showed a relatively low percentage below 40%, indicating that using the instructional strategy in the tested group better enhances learners' mathematical connection skills compared to the control class.

These findings are consistent with the theoretical framework of mathematical connectivity proposed by Jerry Johnson (2000), which holds that deep mathematical understanding occurs when learners connect one idea to another in a coherent structure. The CORE model, with stages that encourage learners to associate, organize, reflect, and expand their understanding, aligns with those principles of connectivity. In addition, these findings align with Vygotsky's (1978) social constructivist approach, which emphasizes that cognitive development occurs through social interaction and cultural mediation. In the context of mathematics learning, the CORE model provides space for learners to actively build knowledge through discussion, reflection, and application of concepts in meaningful real-world contexts. Therefore, the significant improvement in learners' mathematical connection abilities in experimental classrooms can be explained through the synergy between effective learning models and underlying theoretical approaches.

Table 7. Results of the Influence of Subjects on Mathematical Problem-Solving Ability

Dependent Variable	**Post-test of Problem-Solving**					
Source	**Type III Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	6197,132a	2	3098.566	53.139	0.000	0.593
Intercept	17487.582	1	17487.58	299.906	0.000	0.804
Pre-test of Problem-Solving	5273.119	1	5273.119	90.432	0.000	0.553
Type	1060,034	1	1060.034	18,179	0.000	0.199
Error	4256.651	73	58.310			
Total	303590.625	76				
Corrected Total	10453,783	75				

a. R Squared = 0.593 (Adjusted R Squared = 0.582)

Based on the results presented in Table 7, the p-value of 0.000 was below the 0.05 threshold, leading to the rejection of H_0 and acceptance of H_1. This finding indicates that the prior ability covariate exerted a statistically significant, linear influence on students' mathematical problem-solving performance. Practically, the contribution of 55.3% demonstrates that more than half of the variance in post-test problem-solving scores was explained by differences in students' initial ability levels. It implies that students who entered the learning process with stronger prior competence tended to achieve higher problem-solving outcomes, reflecting a substantial and practically meaningful effect of the covariate.

Table 7 further reports a model significance value of 0.000, which is below the 0.05 critical level. Consequently, the null hypothesis (H_0) was rejected, confirming that the

CORE learning model had a statistically significant effect on students' mathematical problem-solving skills after controlling for prior ability. The model accounted for 19.9% of the variance in students' post-test performance, indicating that nearly one-fifth of the improvement can be explicitly attributed to the implementation of the CORE learning strategy, independent of students' initial achievement levels.

Following Cohen's guidelines, the obtained effect size of $\eta^2 = 0.199$ falls within the range of a medium effect. Conceptually, this suggests that the CORE model produced a meaningful and educationally relevant impact on students' problem-solving abilities—strong enough to be considered substantively important, yet not overpowering other contributing factors. Such a medium-sized effect underscores the pedagogical value of the CORE approach while acknowledging that additional variables beyond the instructional model also influence learning outcomes.

Table 8. *Estimate Marginal Means* Mathematical Problem-Solving Ability Test

Dependent Variable:		**Posttest_Pemecahan_Masalah**		
			95% Confidence Interval	
Type	**Mean**	**Std. Error**	**Lower Bound**	**Upper Bound**
Experiment	65.842a	1.239	63.372	68.311
Control	58.369a	1.239	55.900	60.838

a. *Covariates appearing in the model are evaluated at the following values: Pretest_Pemecahan_Masalah* = 12.4507.

Table 8 revealed a difference in the adjusted mean scores of mathematical problem-solving ability between the experimental and control groups, after accounting for students' initial skills. The adjusted mean score for the experimental group was 65.842, while that of the control group was 58.369, resulting in a mean difference of 7.437 in favor of the experimental group.

Table 9. Percentage of Indicator of the Number of *Posttest Answers* on the Mathematical Problem-Solving Ability of the Experimental Class

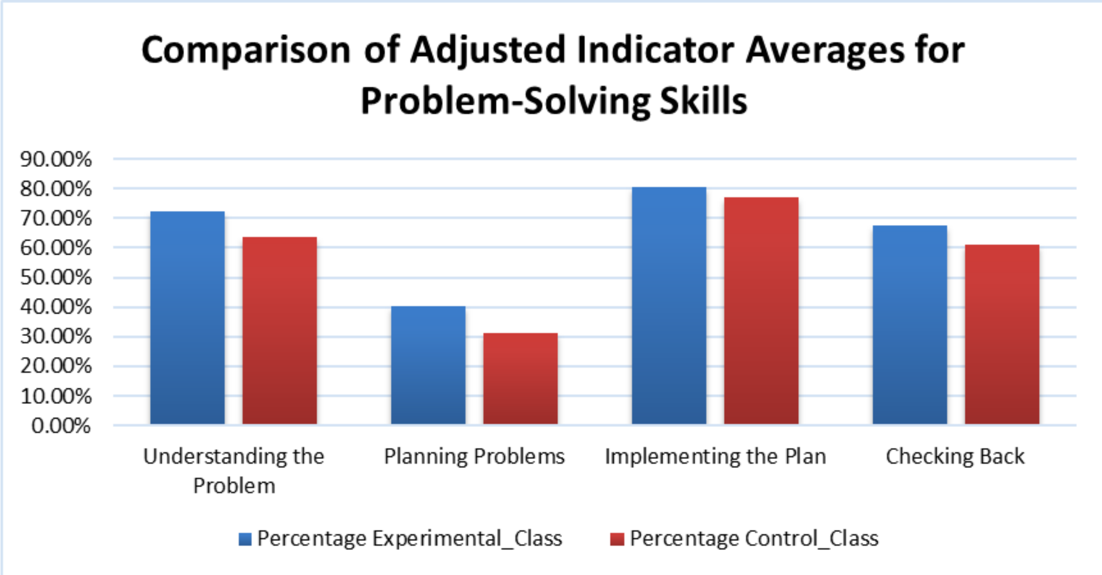
Problem-Solving Ability Pretest Score			
Indicators	**Sum**	**Average**	**Percentage**
Understanding the Problem	551	2.90	72.50%
Planning Problems	306	1.61	40.26%
Implementing the Plan	613	3.23	80.66%
Checking Back	514	2.71	67.63%

Table 10. Percentage of Posttest Answer Percentage Indicator on Mathematical Problem-Solving Ability Control Class

Problem-Solving Ability Pretest Score			
Indicators	**Sum**	**Average**	**Percentage**
Understanding the Problem	485	2.55	63.82%
Planning Problems	236	1.24	31.05%

Implementing the Plan	585	3.08	76.97%
Checking Back	465	2.45	61.18%

Based on the data presented in Tables 9 and 10, the experimental class taught using the CORE learning model demonstrated higher achievement in mathematical problem-solving across all indicators than the control class that received conventional instruction.



Picture 1. Comparison of the average percentage of mathematical problem-solving indicators between the experimental and control classes.

Picture 1 shows that the implementing of the plan indicator achieved the highest percentage in both groups, with the experimental class reaching 80.66% and the control class 76.97%. Although the difference on this indicator is relatively small, the experimental class demonstrated a more apparent advantage on the more cognitively demanding dimensions of problem-solving: understanding the problem (72.50% vs. 63.82%), planning the solution (40.26% vs. 31.05%), and checking back (67.63% vs. 61.18%). These patterns suggest that the CORE model strengthens not only procedural execution but also the strategic and metacognitive processes required for practical mathematical reasoning.

The observed differences indicate that CORE provides meaningful benefits for students' ability to interpret problems, construct coherent strategies, and reflect on their solutions. The structured phases Connecting, Organizing, Reflecting, and Extending—encourage learners to activate prior knowledge, reorganize information, justify their thinking, and generalize concepts. It aligns with constructivist perspectives, such as Vygotsky's view of guided internalization and Johnson's principles of cooperative interaction. It also reinforces Schoenfeld (1985) emphasis on strategic competence, Skemp (1976) relational understanding, and Flavell (1979) conceptualization of metacognition as central to problem-solving development.

The more substantial gains in the experimental group further indicate that the CORE model enhances both conceptual depth and reflective thinking. This finding is consistent with prior studies reporting positive effects of CORE-based instruction on higher-order mathematical performance, including Mardiana et al. (2020), Niarti et al. (2021), and Ayudia dan Mariani (2022). The present study extends these results by demonstrating that the CORE model yields substantial improvement in connection skills (η^2 = 0.57) but more moderate effects on problem-solving ability (η^2 = 0.199), suggesting that conceptual integration may respond more quickly to structured intervention compared to complex problem-solving processes that require sustained practice.

Limitations and Implications

This study relied solely on quantitative test data, limiting the depth of insight into students' cognitive processes during CORE implementation. Classroom observations, interviews, or think-aloud protocols would provide richer triangulation and capture how students navigate each phase of the model. Additionally, factors such as teacher differences, classroom dynamics, and instructional time allocation may have influenced outcomes. Future research should incorporate mixed-method designs to examine how students internalize each CORE phase and to explore long-term impacts on mathematical reasoning across different school contexts.

Conclusions and Suggestions

The findings of this study showed that the CORE learning model produced a significant improvement in students' mathematical connection abilities after controlling for prior achievement. A secondary but meaningful effect was also observed on students' mathematical problem-solving performance, indicating that the structured phases of connecting, organizing, reflecting, and extending strengthened students' strategic and reflective reasoning. Overall, these findings suggest that the CORE framework can be adopted as a reflective learning model to foster deeper conceptual integration in mathematics classrooms. This study was limited by its exclusive reliance on quantitative data, which did not capture the qualitative nuances of students' engagement with each phase of the CORE model. Future research is therefore recommended to incorporate classroom observations, student interviews, or learning journals to triangulate the results and provide a richer understanding of the cognitive processes that contribute to the effectiveness of CORE instruction.

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