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The Effect of the ECIRR Model on Elementary Students' Numeracy Skills through Active and Critical Thinking-Oriented Learning

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Abstract

Numeracy skills are an essential competence for elementary school students. However, teacher-centred teaching practices mean that these skills have not yet developed to their full potential. This study aims to investigate the effect of the Elicit, Confront, Identify, Resolve, Reinforce (ECIRR) model on the numeracy skills of 4th grade of elementary school students. This study employed a quantitative approach using a quasi-experimental nonequivalent control-group design involving 62 pupils in the experimental and control groups. The instrument was a numeracy test comprising 10 items, with 7 valid items and a Cronbach's Alpha reliability of 0.703. The results indicate that the data are normally distributed and homogeneous, and the t-test revealed a significant difference between the two groups with a significance level of 0.025 (< 0.05). The mean score of the experimental class increased from 33.17 to 61.52, which is higher than that of the control class, which increased from 24.88 to 48.38. This indicates that the ECIRR model is more effective at improving 4th-grade students' numeracy skills, particularly in reasoning (analysis, interpretation, and drawing conclusions). The implications of this study suggest that the ECIRR model can be used as an effective active learning strategy to enhance critical reasoning-based numeracy. Teachers are advised to emphasise the 'confront' and 'identify' stages to trigger cognitive conflict and to integrate differentiated learning to accommodate differences in students' abilities.

Keywords: ECIRR Model, Elementary School Students, Numeracy Skill

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Abstrak

Kemampuan numerasi merupakan kompetensi penting bagi siswa sekolah dasar. Namun praktik pembelajaran yang masih berpusat pada guru menyebabkan kemampuan ini belum berkembang secara optimal. Penelitian ini bertujuan untuk mengetahui pengaruh model Elicit, Confront, Identify, Resolve, Reinforce (ECIRR) terhadap kemampuan numerasi siswa kelas IV sekolah dasar. Penelitian ini menggunakan pendekatan kuantitatif dengan desain quasi experiment nonequivalent control group design yang melibatkan 62 siswa pada kelas eksperimen dan kontrol. Instrumen berupa tes numerasi terdiri dari 10 soal, dengan 7 soal valid dan reliabilitas Cronbach's Alpha sebesar 0,703. Hasil penelitian menunjukkan bahwa data berdistribusi normal dan homogen, serta uji t menunjukkan adanya perbedaan signifikan antara kedua kelompok dengan nilai signifikansi 0,025 (< 0,05). Rata-rata skor kelas eksperimen meningkat dari 33,17 menjadi 61,52, lebih tinggi dibandingkan kelas kontrol yang meningkat dari 24,88 menjadi 48,38. Hal ini menunjukkan bahwa model ECIRR lebih efektif dalam meningkatkan kemampuan numerasi siswa kelas IV sekolah dasar, khususnya dalam aspek bernalar (analisis, interpretasi, dan penarikan Kesimpulan). Implikasi penelitian ini menunjukkan bahwa model ECIRR dapat digunakan sebagai strategi pembelajaran aktif yang efektif untuk meningkatkan numerasi berbasis penalaran kritis. Guru disarankan menekankan tahap confront dan identify untuk memicu konflik kognitif serta mengintegrasikan pembelajaran diferensiasi guna mengakomodasi perbedaan kemampuan siswa.

Kata Kunci: Model ECIRR, Siswa Sekolah Dasar, Keterampilan Numerasi

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INTRODUCTION

The rapid development of science and technology in the era of globalisation has significantly transformed people's lives while also introducing new challenges in education. Digital transformation, the rapid flow of information, and the complexity of global issues require students to possess advanced reasoning skills to adapt and actively participate in these changes (Mahrunnisya, 2023). In line with these demands, 21st-century education emphasises the mastery of 4C skills (critical thinking, creativity, collaboration, and communication) alongside subject knowledge (Prajapati et al., 2025). Therefore, learning models are needed that not only deliver content but also systematically facilitate students' thinking processes.

Various innovative learning models, such as Problem-Based Learning (PBL) and inquiry-based learning, have been widely implemented to enhance student engagement and critical thinking skills. PBL emphasises contextual problem-solving in authentic, real-world situations, while inquiry-based learning focuses on exploration and knowledge construction through discovery. Recent studies indicate that these student-centered approaches significantly contribute to the development of higher-order thinking skills and critical reasoning, particularly when learning involves structured collaboration and guided problem-solving activities (Loyens et al., 2023). However, these models do not explicitly integrate the systematic identification of misconceptions and the resolution of cognitive conflict in mathematics learning.

The Elicit, Confront, Identify, Resolve, Reinforce (ECIRR) model developed by Wenning & Vieyra (2020) offers a more structured approach through prior knowledge activation, cognitive conflict, misconception identification, problem resolution, and concept reinforcement. This approach has been shown to promote deeper conceptual understanding (Griantari & Wati, 2023). In mathematics learning, numeracy, defined as the ability to apply mathematical concepts in real-life contexts, is a key competency that can be developed through such approaches (Muliantara & Suarni, 2022).

However, preliminary data from fourth-grade students at SDN 1 Sigar Penjalin indicate that numeracy skills remain suboptimal and inconsistent across learning materials.

Table 1. Initial Student Numeracy Skill Data

Indicator	Data 1 (2024/2025)			Data 2 (2025/2026)		
	Arithmetic Operations	Number Patterns	Fractions	Arithmetic Operations	Data Analysis	Number Patterns
Number of Students	26	26	26	31	31	31
Highest Score	100	90	80	100	100	100
Lowest Score	60	50	30	30	30	30
Average Score	80	74	55	72	68	72
Number of Students Who Met the Standard (≥ 75)	22	15	8	21	13	17
Percentage of Students Who Met the Standard	85%	58%	31%	68%	42%	55%
Number of Students Who Did Not Meet the Standard (<75)	4	11	18	10	18	14
Percentage Not Meeting Standards	15%	42%	69%	32%	58%	45%

Based on Table 1, students' learning outcomes show fluctuations. In the first dataset (26 students), mastery in arithmetic operations reached 85% (average score 80), but declined in number patterns

to 58% (average 74), and further dropped in fractions to 31% (average 55), with 69% of students not meeting the minimum standard. In the second dataset (31 students), mastery in arithmetic operations reached 68% (average 72), decreased in data analysis to 42% (average 68), and increased again in number patterns to 55% (average 72). These results indicate that students' numeracy skills are inconsistent and have not yet met expected standards.

These findings are consistent with international studies showing that Indonesian students' numeracy skills remain relatively low. TIMSS 2015 results indicate that Indonesian students' mathematics scores are below the international average, with most students at a low proficiency level (Mullis et al., 2016). Similar trends are also reported in elementary-level assessments, where students demonstrate difficulties in understanding fundamental mathematical concepts and applying them to problem-solving contexts (Nafi'ah & Hartonoa, 2022). However, such macro-level data do not fully reflect classroom conditions. Therefore, local data in this study serve as the primary basis for identifying contextual problems. These issues are related to teacher-centered learning practices, which limit students' active engagement (Rediani, 2024). As a result, students tend to receive information rather than construct knowledge independently, leading to suboptimal conceptual understanding (Suyato et al., 2024).

Prior empirical research has consistently validated the effectiveness of the Elicit, Confront, Identify, Resolve, Reinforce (ECIRR) model in mitigating misconceptions and enhancing students' higher-order mathematical competencies (Ardiansyah et al., 2019; Kurniawati et al., 2020; Pahrudin et al., 2020; Sari et al., 2022; Septianingsih et al., 2022; Warsito et al., 2020). In secondary and higher education contexts, the implementation of ECIRR has proven successful in improving students' mathematical reasoning (Pahrudin et al., 2020), sharpening their mathematical problem-solving skills (Septianingsih et al., 2022), and optimising their critical thinking abilities in mathematics (Kurniawati et al., 2020). This body of literature emphasises that the cognitive conflict confrontation (confront) and clarification (identify) stages serve as the primary stimuli that compel students to articulate logical arguments and reconstruct their conceptual understanding (Ardiansyah et al., 2019; Kurniawati et al., 2020).

Nonetheless, a significant research gap persists in the existing literature. To date, the majority of ECIRR investigations have heavily focused on secondary and university students dealing with theoretical and abstract mathematics or science content (Kurniawati et al., 2020; Pahrudin et al., 2020; Sari et al., 2022; Septianingsih et al., 2022; Warsito et al., 2020). Conversely, explorations of this model within the domain of contextual numeracy among elementary school students remain remarkably scarce. This is despite large-scale studies proving that children's numerical reasoning skills at the primary level heavily rely on their proficiency in critically interpreting real-world data (Chang, 2023; Cintyawati & Suniasih, 2024). Low numeracy performance among elementary students is typically driven by mechanical routines in conventional learning that fail to address the deconstruction of children's numerical misconceptions (Rediani, 2024).

Based on these conditions, the ECIRR model has the potential to improve students' numeracy skills through active engagement and systematic thinking. However, previous studies on the ECIRR model have primarily focused on conceptual understanding and general mathematical reasoning. Studies specifically examining its effect on elementary students' numeracy skills remain limited, indicating a research gap. Therefore, this study aims to analyse the effect of the ECIRR model on elementary students' numeracy skills. The research hypothesis is that the ECIRR model has a significant effect on students' numeracy skills.

METHODS

This study employed a quantitative, quasi-experimental design. The study was conducted in intact classrooms without full randomisation, allowing comparison of treatment effects using pre-test and post-test scores in both the experimental and control groups. The research was conducted at SDN 1 Sigar Penjalin during the 2025/2026 academic year, involving 62 fourth-grade students: 31 in the experimental group and 31 in the control group. Grouping was based on comparable initial abilities determined by prior scores and/or pre-test results. Sampling used a saturated sampling technique, where all population members were included.

The research procedure was carried out over 8 meetings, each lasting 2 × 35 minutes. In the experimental class, learning was conducted using the ECIRR model, consisting of the stages of Elicit, Confront, Identify, Resolve, and Reinforce. Meanwhile, the control class used conventional teacher-centered learning. To minimise external variables, the same teacher taught both classes, used the same learning materials, and had equal instructional time. The research instrument was a numeracy test consisting of 10 essay items, developed based on the numeracy indicator of the Indonesian National Test of Minimum Assessment (AKM) in understanding, application, and reasoning domains of sense of number, geometry, algebra, data and uncertainty materials.

The validity test results were evaluated by experts to ensure content and construct validity. Subsequently, the instrument was pilot-tested with students with characteristics similar to those of the study participants to assess its empirical validity and reliability. The result showed that 7 items were valid, while 3 items were excluded based on Pearson's Product-Moment correlation. The reliability test yielded a Cronbach's Alpha value of 0.703, which is categorised as high, indicating that the instrument is reliable. Data analysis was conducted using descriptive and inferential statistics in IBM SPSS Statistics 25. Prerequisite tests included normality and homogeneity tests, and hypothesis testing used an independent-samples t-test to examine the effect of the ECIRR model on students' numeracy skills.

RESULTS AND DISCUSSION

Treatment Description

This study employed a quasi-experimental design with fourth-grade students in an elementary school. The research activities focused on two classes with relatively equivalent academic ability levels. The ECIRR model was implemented through structured stages (Elicit, Confront, Identify, Resolve, and Reinforce) to promote conceptual change in students' numeracy understanding. In the Elicit stage, the teacher activates students' prior knowledge using open-ended contextual scenarios. In the Confront & Identify stage, students are presented with paradoxical numeracy questions to trigger cognitive conflict, which they then clarify in group discussions. In the Resolve stage, students actively reconstruct their mathematical reasoning and test new conceptual hypotheses through collaborative worksheets. In the Reinforce stage, the teacher reviews alternative conceptions across varied everyday life conditions to strengthen long-term concept retention. The cooperative learning in small groups (4–5 students) with peer dialogue

While the experimental group received the ECIRR model, the control group was taught using a structured Direct Instruction (DI) approach to ensure a clear pedagogical contrast. Over the 8-meeting intervention, the instructional sequence in the control class strictly followed a traditional three-step procedure: presentation, guided practice, and independent practice. In each 2 × 35-minute session, the teacher began by delivering the numeracy concepts, then led practice,

during which the teacher solved sample problems on the board and asked the students to replicate the steps. Finally, during the independent practice stage, students completed computational worksheets containing procedural exercises from their textbooks individually, without peer discussion, cognitive conflict simulation, or structured scaffolding.

The Effect of the ECIRR Model on Students' Numeracy Skills

After confirming the instrument's validity and reliability, pre- and post-tests were administered to both the experimental and control groups to collect research data. The descriptive statistical results are presented in Table 2.

Table 2. Descriptive Statistics

	N	Range	Min.	Max.	Mean	Std. Dev.
Pre-test Control	31	50.00	0.00	50.00	24.8845	13.41006
Post-test Control	31	78.57	7.14	85.71	48.3861	22.56533
Pre-test Experiment	31	64.29	7.14	71.43	33.1797	18.40156
Post-test Experiment	31	92.86	7.14	100.00	61.5210	22.33645
Valid N (listwise)	31					

Based on Table 2, numeracy skills increased in both groups, though the magnitude differed. In the control group, the mean score increased from 24.88 in the pre-test to 48.38 in the post-test, representing an increase of 23.50 points. Meanwhile, in the experimental group, the mean score increased from 33.17 to 61.52, with a higher gain of 28.35 points. This difference indicates that the improvement in numeracy skills in the experimental group is greater than in the control group. Furthermore, the experimental group achieved a maximum score of 100, suggesting that some students reached full mastery of the material. Overall, these findings indicate that the ECIRR model has a greater impact on improving students' numeracy skills than conventional learning. To enhance clarity, these results can be visualised using a bar chart comparing the mean pre-test and post-test scores of both groups.

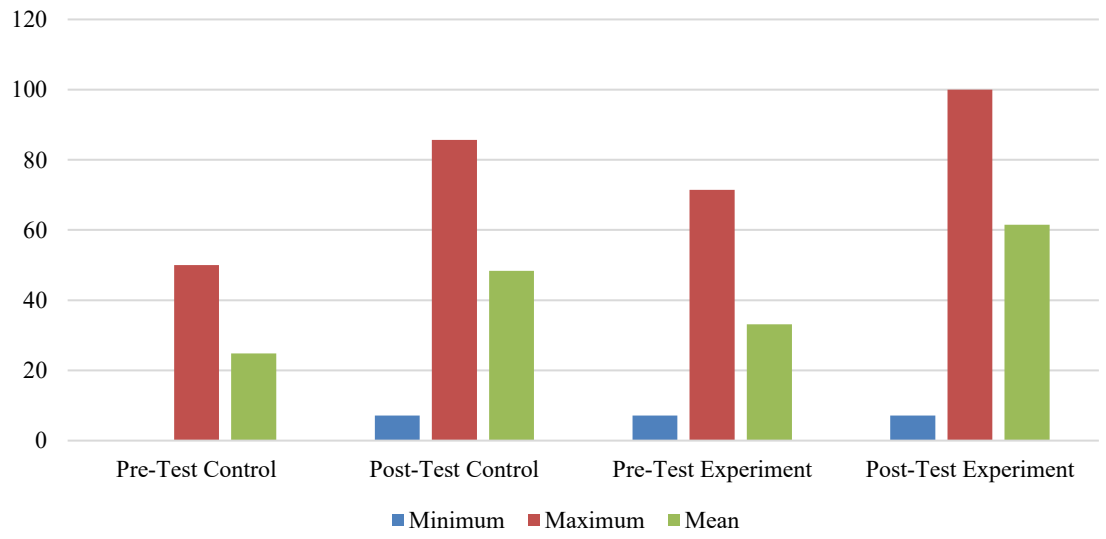


Figure 1. Descriptive Statistics Data Visualization

The experimental group shows a steeper upward trend compared to the control group, indicating not only higher improvement but also greater learning effectiveness. This visualisation illustrates that the ECIRR model has a stronger impact on students' numeracy development. Next, prerequisite tests were conducted prior to hypothesis testing. The normality test results are presented in Table 3.

Table 3. Normality Test for Numeracy Skills

Data Tested	Group	Sig.	Interpretation
Numeracy Ability Pre-test	Control	0.095	Normal
	Experimental	0.085	Normal
Numeracy Ability Post-test	Control	0.078	Normal
	Experimental	0.115	Normal

Statistical analysis of the numeracy ability variable confirmed that the data met the assumption of normality. This was evidenced by the significance values (Sig.) across all sample groups, which consistently exceeded the 0.05 level. Specifically, the control class recorded values of 0.095 (pre-test) and 0.078 (post-test), while the experimental class recorded values of 0.085 (ppre-test) and 0.115 (post-test). Since all probability values are > 0.05, the data distribution is deemed normal. The next step is to conduct a homogeneity test. This confirms that the data distribution for both groups is normal. Substantively, this suggests that students' abilities are distributed proportionally and not dominated by extreme values.

Table 4. Homogeneity Test for Numeracy Skills

Test of Homogeneity of Variance				
Data	**Levene statistic**	**df1**	**df2**	**Sig.**
Numeracy Skills	0.000	1	60	0.996

The significance value of 0.996 (> 0.05) indicates that the variances between the experimental and control groups are homogeneous. This means that both groups have comparable variability characteristics. Interpretatively, this strengthens the conclusion that the observed differences are due to the treatment rather than variance differences. After fulfilling the assumptions, hypothesis testing was conducted using the Independent Sample t-test. The results are shown in Table 5.

Table 5. Independent Samples T-Test

Independent Samples Test			
Data	**t**	**df**	**Sig. (2-tailed)**
Numeracy Skills	-2.303	60	0.025

The comparative test calculations yielded a significance level (Sig. 2-tailed) of 0.025. Since this probability value is lower than the established alpha level of 0.05 (0.025 < 0.05), the null hypothesis (H_0) is statistically rejected, while the alternative hypothesis (H_a) is accepted. This indicates a significant difference in numeracy skills between the experimental and control groups. When interpreted alongside the descriptive data and graphical visualisation, it can be concluded

that the ECIRR model not only produces quantitative improvements but also demonstrates greater effectiveness in enhancing students' numeracy skills compared to conventional learning. Thus, the ECIRR model has been proven to make a significant positive contribution to elementary students' numeracy development.

Discussions

The findings of this study indicate a significant difference in numeracy skills between the experimental and control groups, as evidenced by a p-value of 0.025 (< 0.05). Furthermore, the increase in the experimental group's mean score (from 33.17 to 61.52) was greater than that in the control group (from 24.88 to 48.38). Based on Table 2, the gain in the experimental group (28.35 points) exceeded that of the control group (23.50 points), indicating that the ECIRR model not only improves learning outcomes but also accelerates the development of students' numeracy skills. This quantitative acceleration strongly corroborates prior literature that established ECIRR's capacity to optimise high-level mathematical performance in secondary and higher education, such as mathematical reasoning (Pahrudin et al., 2020) and critical thinking skills (Kurniawati et al., 2020). Beyond quantitative improvement, the data indicate a qualitative transformation in students' thinking processes. The maximum score of 100 suggests deep conceptual mastery among some students. However, very low scores, even close to zero, indicate that the ECIRR model's effectiveness is not uniform across all students. This finding aligns with recent studies suggesting that constructivist interventions produce varied outcomes depending on students' prior knowledge and engagement (Darling-Hammond et al., 2020; OECD, 2023).

Mechanistically, the effectiveness of the ECIRR model can be explained through its stages. The elicit stage activates prior knowledge, serving as the foundation for learning. The observed improvement supports Ausubel's (1968) Meaningful Learning Theory and is reinforced by recent findings that prior knowledge activation is a key factor in meaningful mathematics learning (Hattie & Zierer, 2025). During this stage, students are asked how to determine which fraction is larger between $\frac{1}{2}$ and $\frac{1}{4}$ without using any aids. Students provide various responses, including comparing denominators and recalling visual representations. This activation serves as a foundation for subsequent learning, enabling students to connect new concepts with existing cognitive structures. This finding aligns with Rozy (2025), who argues that activating prior knowledge enhances engagement and motivation. However, in this study, the elicit stage functions more as a prerequisite than as a primary driver of conceptual change.

Next, the confront stage emerges as the most critical component in transforming students' numerical reasoning. Cognitive conflict encourages students to reconstruct their understanding, as reflected in the higher gains in the experimental group. This finding aligns with Piaget's (1952) statement in The Origins of Intelligence in Children and is supported by recent studies demonstrating that cognitive conflict significantly enhances higher-order thinking and mathematical problem-solving (Capraro et al., 2021; Karomah & Kismiantini, 2025). For example, the teacher presents several fractions with the same numerator, such as $\frac{1}{3}, \frac{1}{4},$ and $\frac{1}{6}$, and then asks students to order them from smallest to largest. The confusion arising from this task encourages students to reevaluate their initial understanding. Unlike the control group, where the teacher directly provides rules, students in the experimental group engage in more active and reflective thinking. Research by Rittle-Johnson et al. (2021) and Stull et al. (2022) confirms that well-designed cognitive conflict can significantly promote conceptual restructuring. Therefore, this stage serves as the primary driver of cognitive change. This micro-level breakthrough

validates the large-scale assessment patterns analysed by Chang (2023), which revealed that children's fundamental numerical reasoning is particularly pronounced when they are forced to go beyond rote computation toward strategy-driven data analysis.

The identify and resolve stages address misconceptions through collaborative discussion. However, not all students benefited equally, as evidenced by very low scores. This suggests that the effectiveness of these stages depends on the quality of scaffolding and student participation. This finding aligns with Vygotsky (1985) in *Mind in Society* and is supported by recent research emphasising the importance of structured guidance and active engagement in collaborative learning (Gillies, 2016; Hamidah et al., 2025).

The reinforce stage strengthens understanding through real-life applications. High-achieving students demonstrated the ability to transfer concepts to everyday contexts. This aligns with OECD (2023), which defines numeracy as the ability to interpret, represent, and make decisions using mathematical information. Recent studies also highlight the effectiveness of contextual learning in enhancing numeracy (Boaler, 2022; Kartikasari et al., 2025; Rahima et al., 2025). By demonstrating empirical success in an elementary setting, this study directly bridges a crucial research gap, expanding the deployment of the ECIRR framework from abstract science and secondary mathematical tasks (Ardiansyah et al., 2019; Sari et al., 2022; Septianingsih et al., 2022; Warsito et al., 2020) into the vital territory of primary school contextual numeracy. Compared to conventional learning, the key difference lies in cognitive engagement. Conventional instruction tends to emphasise procedures rather than conceptual understanding, which explains the lower gains in the control group. This is consistent with recent PISA findings showing that students struggle with contextual problems due to procedural learning approaches (OECD, 2023).

Critically, the presence of students scoring zero despite the intervention indicates that the ECIRR model is not fully inclusive. Factors such as low prior ability, limited participation, and short intervention duration contribute to this issue. This aligns with recent research emphasising the importance of differentiated instruction and individualised support. This operational reality echoes the pedagogical warnings of Rediani (2024) and Cintyawati & Suniasih (2024), who remarked that elementary numeracy crises cannot be resolved by open-ended or constructivist strategies alone unless teachers purposefully intertwine these methods with concrete teaching materials and differentiated support to accommodate low-baseline learners. This study contributes both theoretically and practically. Theoretically, it reinforces the role of cognitive conflict as a key mechanism in the development of numerical reasoning. Practically, it provides concrete guidance for teachers to emphasise the confront stage, strengthen the identify stage through structured scaffolding, and integrate real-life contexts in the reinforce stage. Thus, the study offers not only empirical evidence but also practical implications for improving mathematics instruction in elementary education.

CONCLUSION

Based on the research objective to determine the effect of the ECIRR model on the numeracy skills of fourth-grade elementary school students, it can be concluded that the ECIRR model has a positive and significant impact compared to conventional learning. The analysis results indicate that the data met the statistical assumptions, allowing the hypothesis to be tested appropriately, and it was proven that there is a significant difference in numeracy skills between the experimental and control classes. Substantively, the ECIRR stages encourage students to activate prior knowledge, experience cognitive conflict, discuss to improve understanding, and

reinforce concepts in real-world contexts, thereby fostering deeper and more meaningful numerical understanding. Based on these findings, the ECIRR model is recommended as an alternative to mathematics instruction for developing students' numeracy skills.

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