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Teaching two-digit multiplication with the colour group–lattice approach

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ABSTRACT

This study aims to enhance students' understanding of two-digit multiplication through the application of the Colour Group learning model combined with the Lattice method. A quasi-experimental design Matching Pretest–Post-Test Control Group was employed, involving 68 fourth-grade students from SD Negeri Gunungsari 01. Data were collected using a validated cognitive test and analyzed through normality testing, homogeneity testing, t-test, and N-Gain calculations. The findings reveal that students in the experimental group exhibited significantly higher improvement compared to the control group. The N-Gain results showed a moderate-to-high category for the experimental group, while the control group fell into the low category. These results demonstrate that integrating the Colour Group model with the Lattice method can effectively improve students' mastery of two-digit multiplication.

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INTRODUCTION

Mathematics serves as a core foundation in primary education, yet students commonly face persistent difficulties in mastering essential arithmetic concepts, particularly two-digit multiplication. These difficulties have been documented across various international studies, which highlight that young learners often experience cognitive overload when required to perform multi-step computations without conceptual scaffolding (Sweller, 2011; Rahman & Lee, 2020; Geary, 2013). A lack of conceptual understanding and overreliance on memorization-based approaches are frequently associated with long-term weaknesses in numerical reasoning (Baroody, 2003; Heirdsfield & Cooper, 2004).

Indonesian classrooms often employ teacher-centered instructional methods, which emphasize direct explanation and repetitive drills (Munifah et al, 2019a; Sumarni et al, 2019a; Sumarni et al, 2019b; Huda et al, 2019). This approach tends to limit student engagement and restrict opportunities for collaborative meaning-making (Dimyati & Mudjiono, 2009; Suryani, 2018). Research consistently indicates that student-centered pedagogies, visual representations, and cooperative interaction significantly improve mathematical performance and retention (Boaler, 2015; Arcavi, 2003; Freeman et al., 2014).

Visual strategies such as the Lattice method have been shown to reduce cognitive demands by breaking complex procedures into manageable, visually structured steps (Carter, 2017; Nur et al., 2019; Chen, 2015). These representations help students identify place values, digit interactions, and summation flow more clearly than traditional algorithms (Yasin et al, 2020; Sunyono et al, 2022). Meanwhile, cooperative learning models such as the Colour Group model, which organizes students into color-coded collaborative groups enhance motivation, peer tutoring, and shared problem solving (Gillies, 2016; Johnson & Johnson, 2018; Slavin, 2014). Empirical studies show that cooperative structures significantly improve mathematical reasoning, communication skills, and confidence (Kagan, 2017; Hattie, 2009).

However, although research on visual multiplication methods is well-established internationally, studies that integrate the Lattice method with a cooperative, color-coded grouping strategy remain scarce, particularly in the Indonesian elementary-school context (Diani et al, 2019; Munifah et al, 2019b; Huda et al, 2020a; Huda et al, 2020b). The majority of previous research has examined the methods independently, without exploring how their synergy may combine cognitive and social learning benefits (Rahman & Lee, 2020; Suryani, 2018; Kagan, 2017). Therefore, this study fills the identified research gap by evaluating the combined use of the Colour Group learning model and the Lattice method in improving students' mastery of two-digit multiplication.

METHOD

This study employed a Matching Pretest–Post-Test Control Group Design, which is suitable for comparing the effects of instructional interventions while ensuring equivalence between groups (Creswell, 2014; Fraenkel & Wallen, 2009). Participants consisted of 68 fourth-grade students from SD Negeri Gunungsari 01, divided equally into experimental and control groups. Group equivalence was verified through pre-test comparison. The instrument was a 20-item cognitive test developed based on curriculum competencies. Items were validated through expert judgment and piloted to determine reliability, following recommendations by Crocker & Algina (2008) and DeVellis (2016). The research procedure followed four major stages:

1. Pre-test administration to assess baseline multiplication capability.
2. Implementation of Colour Group + Lattice method in the experimental class.
3. Conventional instruction in the control class.
4. Post-test administration to measure improvement.

Figure 1 give visual procedure aligns with standard quasi-experimental process flows (Creswell, 2014). Data analysis included normality testing, homogeneity testing, independent-sample t-tests, and N-Gain analysis (Hake, 1999). Statistical interpretation followed principles from Field (2013) and Howell (2012).

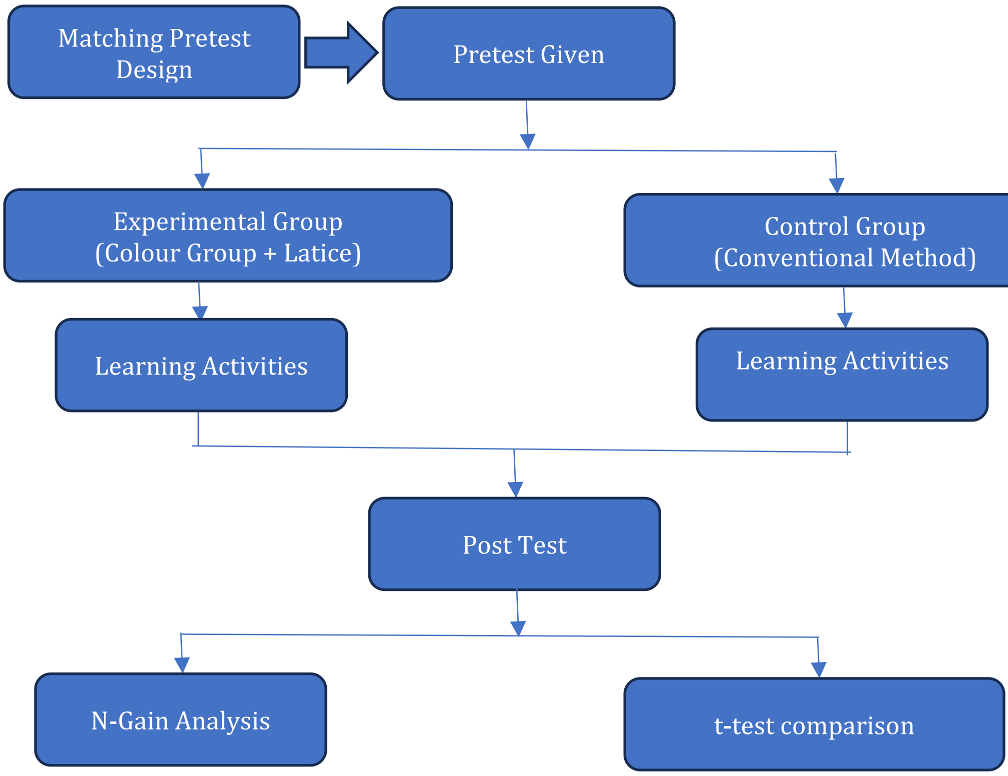

Figure 1. Design Method

RESULTS AND DISCUSSION

Before conducting the experiment, a pre-test was given to the sample to determine the extent of students' understanding of mathematics in the material on multiplying two numbers, and the pre-test results are presented in Table 1.

Table 1. Pre-Test Scores for the Experimental Class and Control Class.

Pre-Test	Experiment	Control
P-Value	0,25	0,62
Mean	54,85	65,12
Median	54	65,5
Modus	54	68
Max	60	70
Min	50	60
Range	10	10
Variance	9,52	9,38
Standard Deviation	3,09	3,06

Based on Table 1 Pre-test analysis indicated no significant difference between the experimental and control groups ($p > 0.05$). This confirms group equivalence and supports the validity of comparing treatments (Creswell, 2014).

After conducting a pre-test, the experimental class was given a stimulus using the Lattice Model Color Group technique to learn two-digit multiplication. The steps taken in providing the stimulus to the experimental class are shown in Figure 2.

Step-1

The Atmosphere in the Experimental Classroom. Then the students were given colored paper to write down the two numbers they wanted.

Step-2

Students write down 2 numbers, After the students wrote down two numbers of their choice, they were tested on the Lattice board that the researcher had created to calculate the results according to the method used by the researcher. Next, to help students better understand the material, they were divided into groups based on the colors they obtained. In this study, there were six groups, each of which was given the task of creating a Lattice table. Students then wrote down the numbers they had on colored paper to work on with their groupmates.

Step-3

Students draw lattice boxes on cardboard paper.

Step-4

Students enter the numbers written on colored paper to be counted.

Figure 2. Illustration of learning with the Color Group–Lattice Approach

After completing the first day of experiments, a post-test was conducted on the second day to determine the difference between the pre-test and post-test scores. Post-test scores of the experimental group showed significant improvement compared to the control group ($p < 0.05$). These findings align with evidence that visual-based strategies enhance computational accuracy and reduce cognitive burden (Sweller, 2011; Carter, 2017; Arcavi, 2003). N-Gain results indicated moderate-to-high improvement for the experimental group and low improvement for the control group. This reflects the effectiveness of combining structured visual supports with cooperative interactions (Gillies, 2016; Johnson & Johnson, 2018).

The synergy between the Colour Group model and the Lattice method created a learning environment that maximized cognitive clarity and social engagement. Cooperative structures enabled peer-assisted explanation, collaborative problem solving, and distributed cognitive workload processes shown to significantly strengthen mathematical reasoning (Slavin, 2014; Kagan, 2017). The Lattice method's structured digit-grid representation minimized common multiplication errors, supporting findings from visual numeracy research emphasizing the power of graphical scaffolds (Arcavi, 2003; Boaler, 2015). The integration of these two complementary approaches visual conceptualization and collaborative learning constitutes the novelty of this study and demonstrates a promising instructional model for primary mathematics (Ridwanulloh et al, 2022; Bumi et al, 2025: Usman et al, 2025). The results also contribute to literature on cognitive load theory (Sweller, 2011), cooperative learning frameworks (Johnson & Johnson, 2018), and visual mathematics education (Arcavi, 2003), positioning this study within a strong theoretical lineage.

CONCLUSIONS AND SUGGESTIONS

The Colour Group learning model combined with the Lattice method effectively enhanced students' learning outcomes in two-digit multiplication. Students in the experimental group showed significantly higher post-test scores and greater learning gains compared to those in the control group.

Teachers are encouraged to adopt this integrated model, particularly for mathematics topics that require structured computation and strong visual support. Future researchers may also consider examining the model's effectiveness across various grade levels or different subject areas to broaden its applicability. Additionally, incorporating digital Lattice tools into the Colour Group model has the potential to further enhance student engagement and deepen conceptual understanding, making the approach even more effective in diverse learning environments.

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CONFLICT OF INTEREST

The authors declare that there are no potential conflicts of interest related to the research, writing, or publication of this article.

AUTHOR CONTRIBUTIONS

The authors contributed equally to the formulation of the research concept, data collection, data analysis, manuscript writing, and approval of the final manuscript for publication.

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