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Jigsaw cooperative learning with puzzle media: Improving fraction mastery in primary school students

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ABSTRACT

This study addresses the low conceptual understanding of fractions among elementary students and examines the effectiveness of the Jigsaw cooperative learning model supported by puzzle media. A quantitative descriptive design was employed involving two third-grade classes from SDN Sanja 01 and SDN Leuwinutug 05. Learning outcomes were measured through pretest and posttest assessments in both the experimental and control classes. Data were analyzed using normality, homogeneity, and t-tests. The results show a substantial improvement in students' learning performance, with mastery increasing from 3.33% in the pretest to 86.66% after the implementation of the Jigsaw model with puzzle media. The findings indicate that this approach enhances students' understanding of fractions while also strengthening collaboration, communication, and responsibility within group learning.

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INTRODUCTION

Mathematics is a fundamental discipline that underpins the development of modern technology and serves as a foundation for cultivating critical thinking, analytical reasoning, creativity, and problem-solving skills from the elementary level (Atmoko et al., 2017; NCTM, 2020). Despite its importance, numerous studies report that mathematics continues to be perceived as a difficult, abstract, and less engaging subject by many elementary students (Suryani & Ningsih, 2018; Yusuf et al., 2021; Wijaya, 2017). This condition requires teachers to design learning approaches that are more concrete, meaningful, and appealing to young learners (Munifah et al, 2019a; Sumarni et al, 2019a; Sumarni et al, 2019b; Huda et al, 2019).

Fractions, in particular, present considerable challenges for students because the concept involves part–whole relationships that demand strong visual representation. Many students struggle to conceptualize fractions due to limited use of concrete learning media and insufficient conceptual scaffolding (Charalambous & Pitta-Pantazi, 2007; Siegler et al., 2013; Widodo & Kartikasari, 2020). Preliminary observations at SDN Sanja 01 and SDN Leuwinutug 05 revealed that third-grade students' achievement ranged between 40–70, falling short of the minimum proficiency standard (KKM) of 70. These findings align with previous studies showing that elementary students often experience misconceptions and limited conceptual understanding of fractions (Lestari & Purnomo, 2020; Rahmawati et al., 2021). Therefore, an innovative instructional design that facilitates concrete visualization is urgently needed.

The Jigsaw cooperative learning model is widely recognized for fostering student engagement, interaction, responsibility, and collaborative learning (Yasin et al, 2020; Sunyono et al, 2022). Several studies have demonstrated that the Jigsaw model enhances students' academic achievement and communication skills (Slavin, 2015; Huda, 2016; Kahar et al., 2020; Anitra, 2021; Tarigan et al., 2022). However, most studies emphasize the social-collaborative dimension of Jigsaw and do not incorporate concrete learning media that are essential for teaching abstract mathematical concepts such as fractions.

Conversely, puzzle-based learning media have been shown to improve motivation, cognitive development, spatial reasoning, and problem-solving skills among elementary students (Elan et al., 2017; Sari et al., 2020; Fitrah & Arifin, 2021; Anggraeni, 2020; Pratiwi, 2022). Puzzles help students visualize part–whole relationships through hands-on manipulation and engaging visual stimuli. However, existing studies generally examine puzzles in early childhood or for general cognitive purposes, and only a few focus specifically on mathematical content such as fractions.

Research on fraction learning consistently highlights that fractions are among the most difficult mathematical topics for elementary students due to their abstract nature (Siegler et al., 2013; Pitta-Pantazi, 2018; Ramadhani & Ningsih, 2021; Wahyuni et al., 2020; Ball, 2008). Nevertheless, most prior studies focus on diagnosing misconceptions, exploring simple manipulatives, or adopting single instructional models, without integrating cooperative learning with concrete visual media.

A comprehensive review of existing literature identifies several gaps as follows:

1. Studies on the Jigsaw model largely emphasize collaboration skills, yet rarely integrate concrete media to support conceptual understanding in mathematics learning (Slavin, 2015; Huda, 2016; Kahar et al., 2020; Anitra, 2021; Tarigan et al., 2022).
2. Research on puzzle-based media focuses more on general cognitive and motivational outcomes, with limited attention to their potential for enhancing specific mathematical concepts such as fractions (Elan et al., 2017; Sari et al., 2020; Fitrah & Arifin, 2021; Anggraeni, 2020; Pratiwi, 2022).
3. Fractions are well-documented as challenging for elementary learners, yet few studies combine cooperative learning with manipulative puzzle media to address these conceptual difficulties (Siegler et al., 2013; Pitta-Pantazi, 2018; Widodo & Kartikasari, 2020; Ramadhani & Ningsih, 2021; Ball, 2008).
4. Integrated approaches that combine Jigsaw and puzzle media remain scarce, despite their complementary strengths—Jigsaw supports collaborative

knowledge construction, while puzzles strengthen visual-conceptual understanding.
5. There is a lack of empirical studies in the Indonesian context, including SDN Sanja 01 and SDN Leuwinutug 05, particularly within third-grade classrooms where students are in the concrete-operational stage and require hands-on learning tools.

Based on these gaps, this study aims to examine the effectiveness of the Jigsaw cooperative learning model assisted by puzzle media in improving third-grade students' mathematics achievement on fraction concepts in elementary school.

METHOD

This study employed a quantitative research approach using a quasi-experimental method with a *pretest–posttest control group design*. Two groups were assigned: an experimental group that received instruction using the Jigsaw cooperative learning model assisted by puzzle media, and a control group that received conventional instruction. Both groups were administered a pretest prior to the intervention and a posttest afterward to measure changes in learning outcomes.

The study was conducted in two public elementary schools in Bogor Regency, namely SDN Sanja 01 and SDN Leuwinutug 05. The sample consisted of two intact third-grade classes selected through purposive sampling. SDN Sanja 01 served as the experimental group, while SDN Leuwinutug 05 served as the control group.

The primary instrument used in this study was a mathematics achievement test on fraction concepts, administered as both the pretest and the posttest. The test measured students' conceptual understanding, computational accuracy, and ability to compare and represent fractions. Supporting instruments included lesson plans, learning media (fraction puzzles made of styrofoam and origami paper), and observation sheets used to monitor classroom activities.

The experimental group followed the Jigsaw cooperative learning model integrated with puzzle media, while the control group received direct instruction. The implementation steps for the experimental group included:

1. The teacher initiates the lesson by showing a song video related to fractions to build interest and activate prior knowledge.
2. The teacher introduces the fraction puzzle media and explains its components, including:
    a. Identifying fractional parts,
    b. adding fractions with like denominators,
    c. comparing shaded and unshaded regions.
3. Students observe the demonstration and ask questions regarding the puzzle-based explanation of fractions.
4. Selected students manipulate the puzzle to practice solving fraction problems.
5. The teacher forms small Jigsaw groups consisting of 3–5 students.
6. Each student in a group is assigned a different subtopic (expertise area).
7. Students meet with peers from other groups who have the same subtopic to form an "expert group."
8. Expert groups discuss, analyze, and prepare to teach the material to their original groups.

9. Students return to their home groups and teach their assigned subtopics to their peers.
10. Groups share their overall understanding and present their results to the class.
11. The teacher administers a posttest to measure students' individual learning outcomes.
12. Students complete the evaluation individually.

The control group received instruction through conventional teaching methods using teacher explanation and textbook-based exercises, without the use of Jigsaw strategies or puzzle media.

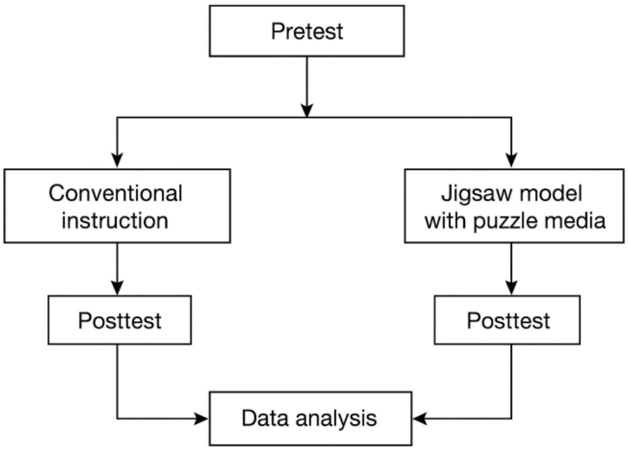

Figure 1. Research Design

Data were analyzed using descriptive and inferential statistics. Descriptive analysis included mean, standard deviation, and percentage of learning achievement. Inferential tests consisted of normality tests, homogeneity tests, and an independent samples *t*-test to determine whether there was a statistically significant difference in learning outcomes between the experimental and control groups.

RESULTS AND DISCUSSION

The study involved two third-grade classes from two elementary schools in Bogor Regency. SDN Leuwinutug 05 served as the control group with 40 students, while SDN Sanja 01 functioned as the experimental group with 30 students. Data were collected through a 10-item multiple-choice test assessing students' understanding of fraction concepts, administered as both pretest and posttest.

Before the learning intervention, both groups completed a pretest to determine their initial conceptual understanding. After the intervention which used conventional teaching in the control group and the Jigsaw–Puzzle method in the experimental group students completed the posttest. The descriptive statistics for both groups are presented in Table 1 and Table 2.

Table 1. Pretest and Posttest Scores – Control Group

Statistic	Pretest	Posttest
Mean	48.75	73.75
Median	50	70
Mode	50	70
Maximum	70	80
Minimum	40	60
Range	30	20

Variance	65.94	38.44
SD	8.12	6.20

The control group showed an improvement of 25.02 points, indicating that conventional instruction helped enhance learning outcomes, although the gain was moderate.

Table 2. Pretest and Posttest Scores – Experimental Group

Statistic	Pretest	Posttest
Mean	58.00	84.67
Median	60	80
Mode	50	80
Maximum	80	100
Minimum	40	70
Range	40	30
Variance	89.33	78.22
SD	9.45	8.84

The experimental group experienced a 28.67-point increase, surpassing the control group's improvement and indicating stronger conceptual gains through the Jigsaw–Puzzle learning model.

Narratively, these findings show that the experimental group started with higher pretest scores than the control group and ended with a substantially higher posttest average. Students' active engagement, collaborative learning, and direct manipulation of puzzle media seemed to support deeper understanding of the fraction concepts.

Normality testing using Kolmogorov–Smirnov revealed that both groups' data were not normally distributed. Therefore, non-parametric tests were used for hypothesis testing.

Table 3. Normality Test Results (Kolmogorov–Smirnov)

Test Type	Experimental	Control	α	Conclusion
Pretest	$p = 0.00005$	$p = 0.00005$	0.05	Not normal
Posttest	$p < 0.00001$	$p < 0.00001$	0.05	Not normal

Despite the non-normality, the homogeneity test indicated that the variance between groups was comparable.

Table 4. Homogeneity Test (Levene's Test)

Statistic	Value
F-ratio	0.67387
p-value	0.414573

Because $p > 0.05$, the data variances were homogeneous, allowing a valid comparison across groups.

Given the non-normal distribution of data, the Mann–Whitney U test was used to examine differences in posttest scores.

Tabel 5. Mann–Whitney U Test (Posttest)

Test	p-value	α	Conclusion
Mann–Whitney U	0.00001	0.05	Significant difference

The significance level below 0.05 confirms that the experimental group outperformed the control group significantly.

The findings of this study demonstrate that students who received instruction through the Jigsaw cooperative learning model assisted by puzzle media showed significantly higher improvement in their understanding of fraction concepts compared to those who learned through conventional methods. The experimental group achieved a mean gain of 28.67 points, exceeding the control group's 25.02-point improvement. This suggests that the integrated instructional approach effectively supported students' conceptual development.

The effectiveness of the Jigsaw–Puzzle model can be better understood by examining how the instructional steps unfolded during the learning process. At the beginning of the lesson, students were introduced to puzzle media representing fractional parts, allowing them to explore, manipulate, and visualize abstract concepts in a concrete manner. This immediate engagement provided a meaningful entry point for understanding part–whole relationships, addition of fractions with like denominators, and comparison of fractional quantities. Students were able to interpret the puzzle pieces physically, giving them a stronger foundation for the subsequent collaborative activities. The structured Jigsaw sequence further strengthened learning. Students were first placed into heterogeneous home groups and then assigned different subtopics related to fraction concepts. They later met in expert groups to discuss, analyze, and master their assigned segment. After completing these expert discussions, students returned to their home groups to teach their peers, ensuring that each student became both a learner and an instructor. The process concluded with group sharing and class presentations, enabling students to reinforce their understanding through explanation, questioning, and reflection. This systematic movement from puzzle manipulation, to expert-group collaboration, to home-group integration created an active and supportive learning environment that promoted deeper comprehension.

This flow of activities aligns with the findings of Fratiwi et al. (2021), who emphasize that the Jigsaw model's collaborative mechanisms encourage responsibility, communication, and mastery of learning content. The addition of puzzle media amplified these benefits by providing students with a visual anchor that made abstract mathematical ideas more accessible. As students engaged in each stage of the process, they showed increased enthusiasm, asked more questions, and participated actively in both group and class discussions. Their engagement was noticeably higher than that of the control group, which largely relied on teacher-centered instruction.

The combined approach's effectiveness is further explained by cognitive theory, which states that children at the elementary level are still in the concrete operational stage. At this stage, learners benefit greatly from visual and tactile materials. The puzzle media fulfilled this need by providing direct manipulation of concrete fraction representations, while the Jigsaw model ensured purposeful interaction, peer teaching, and collaborative problem-solving (Diani et al, 2019; Munifah et al, 2019b; Huda et al, 2020a; Huda et al, 2020b). This dual support system visual reinforcement through puzzles and social reinforcement through Jigsaw played a crucial role in enhancing learning outcomes. The implementation of the jigsaw cooperative learning model used in this study can be seen in Figure 2.

1. Divide students into jigsaw groups of 5-6 people and Assign one student from each group as leader

2. Divide the lesson to be discussed into 5 segments.

3. Assign each student to study one segment and master it, and give students the opportunity to quickly read their segment twice so that they get used to it and don't have time to memorize it.

4. Form expert groups with one person from each jigsaw group joining other students who have the same segment to discuss the main points of their segment and practice presenting to their jigsaw group.

5. Each student from the expert group returns to their jigsaw group and shares the knowledge gained from the expert group with their original group members.

6. Presentation of discussion results

Figure 2. learning activities in the experimental class

These findings are consistent with previous studies, such as those by Asis (2013) and Maryati et al. (2014), who reported that Jigsaw improves academic achievement and student engagement. The present study extends this understanding by demonstrating that integrating puzzle media with the Jigsaw model further increases effectiveness, particularly when teaching abstract mathematical concepts like fractions (Ridwanulloh et al, 2022; Bumi et al, 2025: Usman et al, 2025).

In conclusion, the inclusion of puzzle media within the Jigsaw cooperative learning model provided both cognitive and social benefits. Students were enthusiastic at every step of the learning sequence, and this enthusiasm was reflected in their strong posttest performance. The structured Jigsaw syntax, supported by concrete materials, enabled students to build a deeper and more meaningful understanding of fractions. Therefore, the Jigsaw–Puzzle learning model is not only effective but also highly suitable for third-grade mathematics instruction.

CONCLUSIONS AND SUGGESTIONS

The findings of this study demonstrate that the implementation of the Jigsaw cooperative learning model supported by puzzle media effectively enhances students' learning outcomes and engagement in the topic of fractions among third-grade elementary students. A significant improvement was observed, with students' mastery increasing from 3.33% in the pretest to 86.66% in the posttest. Beyond academic achievement, the integration of Jigsaw and puzzle media also fostered meaningful interaction, collaboration, and individual responsibility, making mathematics learning more concrete, engaging, and conceptually accessible for young learners.

It is recommended that teachers adopt the Jigsaw model combined with puzzle media, particularly for mathematical concepts that require concrete visualization, as this approach has proven effective in enhancing student understanding and participation. Schools should provide adequate learning aids to support such innovative practices, while future researchers may expand this study by exploring different grade levels, mathematical topics, or technology-based puzzle media to strengthen the generalizability of the findings. Curriculum developers may also consider incorporating collaborative and visual learning strategies inspired by this study into elementary mathematics instruction.

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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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