The Effect of Using Match Up Game Media on Learning Outcomes of Fractions for Grade 4 Elementary School Students

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Abstract
This study aims to determine the differences and effectiveness of the use of Match Up game media on the learning outcomes of fractional material of grade IV elementary school students. The research method used was a quasi experiment with the Pretest-Posttest Control Group Design. The results showed that the significance value of the t-test was 0.000 < 0.05, which means that H_0 was rejected and H_a was accepted, indicating that there was a significant difference between the experimental and control classes. The N-Gain value of the experimental class was 0.68 (medium category) with an N-Gain Percent of 68% (moderately effective), while the control class obtained an N-Gain of 0.35 (moderate category) with an N-Gain Percent of 35% (ineffective). These results indicate that the use of Match Up game media is effective in improving the learning outcomes of fractional material in grade IV elementary school students.
Keywords: *Game Match Up, Learning Outcomes, Fractions, Quasi Experiment, Elementary School*

Abstrak
Penelitian ini bertujuan untuk mengetahui perbedaan dan efektivitas penggunaan media *game Match Up* terhadap hasil belajar materi pecahan siswa kelas IV SD. Metode penelitian yang digunakan adalah *quasi experiment* dengan *Pretest-Posttest Control Group Design*. Hasil penelitian menunjukkan bahwa nilai signifikansi uji-t adalah 0,000 < 0,05, yang berarti bahwa H_0 ditolak dan H_a diterima, menunjukkan bahwa ada perbedaan yang signifikan antara kelas eksperimen dan kontrol. Nilai N-Gain dari kelas eksperimen adalah 0,68 (kategori sedang) dengan Persentase N-Gain 68% (cukup efektif), sedangkan kelas kontrol memperoleh N-Gain 0,35 (kategori sedang) dengan Persentase *N-Gain* 35% (tidak efektif). Hasil tersebut menunjukkan bahwa penggunaan media *game Match Up* efektif dalam meningkatkan hasil belajar materi pecahan pada siswa kelas IV SD.
Kata kunci: *Game Match Up*, Hasil Pembelajaran, Pecahan, *Quasi Experiment*, SD

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INTRODUCTION

Mathematics is one of the fundamental subjects in elementary education that has an important role in developing students' logical, analytical, and systematic thinking skills (Widodo et al., 2020; Afriansyah & Dahlan, 2021). One of the essential materials in elementary school grade IV mathematics learning is fractions, which are the basis for understanding more complex mathematical concepts at the later level of education (Gabriel et al., 2020; Wijaya & Masriyah, 2022). A good understanding of fractions is not only important for mastery of mathematics, but also for applications in everyday life such as division, measurement, and proportional calculation (Retnowati et al., 2022; Susanti & Hartono, 2021).

On the other hand, the reality in the field shows that fractional learning is still one of the materials that is considered difficult by elementary school students (Ni'mah & Dwijananti, 2020; Fauzan et al., 2022). The results of initial observations in the Diponegoro Cluster, Eromoko District, Wonogiri show that the learning outcomes of grade IV students in fractional materials are still low, with an average score that has not reached the Minimum Completeness Criteria (KKM). Of the 67 students who were the subjects of the study, about 62% still needed remedial measures to achieve learning completion. The main difficulties faced by students include: identifying fractions of value, performing fraction summing operations with the same denominator, solving contextual problems involving fractions, and comparing and sequencing fractions (Hadi & Kasum, 2020; Purwanti et al., 2021).

The low learning outcomes of this fraction are caused by several factors. First, the learning methods used by teachers still tend to be conventional and teacher-centered, where teachers use lecture methods more and students only become passive recipients of information (Pratiwi & Setianingsih, 2020; Rahmawati et al., 2021). Second, the lack of use of varied and interesting learning media causes students to be less motivated in fractional learning (Sari et al., 2022; Oktaviani & Wulandari, 2020). Third, the characteristics of abstract fractional materials require concrete visualization and manipulation to help students better understand concepts (Nurjanah et al., 2021; Hidayat & Irawan, 2022). Fourth, less interactive learning makes students quickly bored and less active in the learning process (Fitriyani et al., 2020; Dewi & Primayana, 2021).

The importance of addressing this problem cannot be ignored because understanding fractions is an important prerequisite for learning advanced mathematical concepts such as decimals, percentages, algebra, and probability (Jordan et al., 2021; Siegler et al., 2022). Research shows that students who have a weak understanding of fractions tend to have difficulty in advanced math and even in science subjects that involve measurement and calculation (Bailey et al., 2020; Namkung et al., 2023).

Several previous studies have attempted to address the challenges of fractional learning through various approaches. Braithwaite et al. (2021) conducted an experimental study using integrated theory-based instruction for fractions and found significant improvements in conceptual understanding among elementary school students. Similarly, Fitzsimmons et al. (2020) demonstrated that the use of number line-based interventions improved students' fraction magnitude understanding. In the Indonesian context, Pajarwati et al. (2019) reported that the use of fraction card media improved students' understanding of comparing fractions at the elementary school level. Furthermore, Putri et al. (2024) found that game-based learning methods were effective in improving fraction skills among grade 5 elementary school students. These studies highlight the need for innovative and interactive media in fractional learning. However, limited research has specifically examined the effectiveness of the Match Up game as a learning medium for fractional material, particularly in Indonesian elementary school settings. This gap underscores the need for the present experimental study.

One of the innovative solutions that can be applied is the use of game-based learning media. This approach has been shown to be effective in improving student

motivation, engagement, and learning outcomes in various fields of study (Hamari et al., 2021; Abdul Jabbar & Felicia, 2020). Match Up Game is a type of educational game that combines elements of competition, speed, and accuracy in matching pairs of cards (Ariyani & Kristin, 2022; Setiawan & Iasha, 2021). In the context of fractional learning, Match Up games can be designed to help students match different fractional representations (symbolic, visual, verbal) in a fun and interactive way (Mustika et al., 2020; Rahayu & Fauziah, 2023).

The advantages of the Match Up game as a fractional learning medium include several aspects. First, this game provides concrete visualizations that help students understand the abstract concept of fractions through multiple representations (Setiani & Priansa, 2022; Wulandari & Retnowati, 2020). Second, the game element creates a fun learning atmosphere and reduces the math anxiety that students often experience (Huang et al., 2020; McLean & Griffiths, 2021). Third, the competitive component of play increases students' intrinsic and extrinsic motivation to learn (Dicheva et al., 2020; Sailer & Homner, 2021). Fourth, Match Up games encourage active learning where students are directly involved in the learning process through card manipulation and decision-making (Plass et al., 2020; Tokac et al., 2021).

The theoretical basis of the use of games in learning can be explained through several theories of learning. Piaget's theory of constructivism emphasizes that students build knowledge through active interaction with the learning environment, and Match Up games provide opportunities for the exploration and discovery of fractional concepts (Wadsworth, 2021; Slavin, 2020). Vygotsky's cognitive theory highlights the importance of scaffolding and proximal developmental zones, where games can provide gradual support that helps students achieve higher understanding (Eun, 2020; Gonzalez-DeHass et al., 2021).

Several previous studies have examined the effectiveness of game-based learning media in mathematics. Research by Hidayah et al. (2021) shows that the use of educational games can improve the mathematics learning outcomes of elementary school students with *an N-Gain* of 0.72 (high category). Similarly, Andriani & Madio (2021) found that card game media can improve understanding of fractional concepts with the percentage of completeness increasing from 45% to 82%. Suryani et al. (2022) reported that gamification in mathematics learning increased learning motivation by 38% and learning outcomes by 25%.

Based on the above background, this study aims to: (1) determine the difference in learning outcomes of fractional materials between students who use Match Up game media and students who use conventional learning, and (2) determine the effectiveness of the use of Match Up game media in improving the learning outcomes of fractional materials for grade IV elementary school students. The hypothesis of this study is that there is a significant difference in the learning outcomes of fractional material between the experimental class that uses Match Up game media and the control class that uses conventional learning, where the experimental class has higher learning outcomes.

METHODS

This study uses a quasi-experimental method (pseudo-experiment) with a Pretest-Posttest Control Group Design. This design was chosen because it was not possible to conduct full randomization of research subjects that were already in the classes that were formed (Creswell & Creswell, 2023; Fraenkel et al., 2021). In this design, there are two groups, namely the experimental group that receives treatment in the form of learning using Match Up game media, and the control group that receives conventional learning. Both groups were given a pretest before treatment and a posttest after treatment to measure changes in learning outcomes.

This research was carried out in the Diponegoro Cluster, Eromoko District, Wonogiri Regency in the even semester of the 2025 school year. The research

population is all grade IV elementary school students in the Diponegoro Cluster which totals 104 students from 11 elementary schools. The sampling technique used is cluster random sampling, which is a technique for selecting sample members from a population conducted randomly without regard to the strata existing within the population (Sugiyono, 2022). The validity test was conducted on 30 students from 4 elementary schools (SD Negeri 2 Eromoko as many as 7 students, SD Negeri 4 Eromoko as many as 8 students , SD Negeri 1 Sumberharjo as many as 7 students dan SD Negeri 3 Sindukarto as many as 8 students. The experimental group consisted of 35 students from 2 elementary schools (SD Negeri 1 Eromoko as many as 22 students and SD Negeri 1 Ngunggahan as many as 13 students). The control group consisted of 32 students from 4 other elementary schools (SD Negeri 1 Sindukarto as many as 9 students, SD Negeri 3 Puloharjo as many as 10 students, SD Negeri 2 Sindukarto as many as 8 students, and SD Negeri 2 Sumberharjo as many as 5 students).

The research instrument used was a multiple-choice learning outcome test to measure mastery of fractional material. The instrument was developed based on the Basic Competencies and Learning Objectives in the Independent Curriculum for grade IV of elementary school. The test consists of 25 multiple-choice questions that include four learning objectives (TPs): (1) identifying value fractions (TP1), (2) solving the sum of fractions with the same denominator (TP2), (3) solving everyday problems related to fractions (TP3), and (4) comparing and sorting fractions (TP4). Each question has 4 answer options with a score of 1 for the correct answer and 0 for the wrong answer.

Before being used in the research, the test instrument was tested on 30 grade IV students of SD Negeri 2 Eromoko, SD Negeri 4 Eromoko, SD Negeri 1 Sumberharjo dan SD Negeri 3 Sindukarto. who had studied fractional material. The validity test used Pearson's Product Moment formula with r_hitung > r_tabel criteria (r_tabel = 0.361 for n=30 at a significance level of 5%). The results of the validity test showed that of the 25 questions tested, 20 questions were declared valid with r_hitung values ranging from 0.389 to 0.748. Five invalid questions were revised or replaced. The reliability test using Cronbach's Alpha formula yielded a reliability coefficient of 0.847 which is included in the high reliability category ($\alpha > 0.80$).

Learning with the Match Up game in the experimental group was carried out for 4 meetings (2 x 35 minutes each). The first meeting discussed the concept of fractions of value using a Match Up card that contains representations of fractions in the form of symbols, pictures, and words. The second meeting focused on the sum of the fractions with the same denominator. The third meeting discussed the resolution of contextual problems. The fourth meeting teaches the comparison and sequencing of fractions. In the control group, learning was carried out using conventional methods that are generally used by teachers, namely a combination of lectures, questions and answers, and practice questions from textbooks.

The data analysis techniques used include descriptive and inferential statistical analysis. Descriptive analysis was used to describe the data of the research results which included the minimum, maximum, mean, and standard deviation values of the pretest and posttest results of the two groups. Before conducting the hypothesis test, an analysis prerequisite test was carried out consisting of a normality test using the Shapiro-Wilk test with a normally distributed data criterion if the significance value > 0.05, and a homogeneity test using the Levene's Test with a homogeneous data variance criterion if the significance value > 0.05. The hypothesis test uses an Independent Sample t-test with the criterion: if the significance value (2-tailed) < 0.05 then H_0 is rejected. N-Gain analysis was carried out with the formula: N-Gain = (posttest score - pretest score) / (maximum score - pretest score), with interpretation: N-Gain < 0.3 (low category), 0.3 ≤ N-Gain ≤ 0.7 (medium category), and *N-Gain* > 0.7 (high category). All data analysis was carried out using SPSS software version 26 and Microsoft Excel.

RESULTS AND DISCUSSION

Results

The data description of the research results includes the pretest and posttest values of the experimental group and the control group. Statistical descriptive data are presented in Table 1 below.

Table 1. Descriptive Statistics of Learning Outcomes

Groups	N	Min	Max	Red	SD
Pretest Experiment	35	30	65	47,43	10,25
Posttest Experiment	35	65	95	82,86	8,92
Control Pretest	32	30	60	45,31	9,87
Posttest Control	32	45	80	64,38	10,52

Based on Table 1, it can be seen that the experimental group of 35 students had a pretest score with a range of 30-65, an average of 47.43, and a standard deviation of 10.25. After receiving the learning treatment with the Match Up game, the posttest scores of the experimental group ranged from 65-95 with an average of 82.86 and a standard deviation of 8.92. There was an average increase of 35.43 points from pretest to posttest in the experimental group. The control group had a pretest score with an average of 45.31 and a posttest score of 64.38, with an increase of 19.07 points.

Table 2. Normality Test Results

Data	Sig.	Remarks
Pretest Experiment	0,312	Normal
Posttest Experiment	0,287	Normal
Control Pretest	0,345	Normal
Posttest Control	0,298	Normal

Based on Table 2, the results of the Shapiro-Wilk test show that all data have a significance value of > 0.05, so it can be concluded that all data are normally distributed and are eligible to perform a parametric statistical test.

Table 3. Homogeneity Test Results

Data	Sig.	Remarks
Pretest	0,682	Homogeneous
Posttest	0,157	Homogeneous

Table 3 shows that the significance value of Levene's Test for pretest and posttest data is greater than 0.05, which means that the variance of the experimental and control group data is homogeneous.

Table 4. Independent Sample t-test results

Data	T	df	Sig. (2-tailed)	Remarks
Posttest	7,532	65	0,000	H_0 rejected, H_a accepted

Based on Table 4, the results of the Independent Sample t-test showed a calculated t-value of 7.532 with a significance value (2-tailed) of 0.000. Since the significance value is 0.000 < 0.05, H_0 is rejected and H_a is accepted. This means that there is a significant difference between the learning outcomes of fractional material of students in the experimental class who use Match Up game media and the control class that uses conventional learning.

Table 5. N-Gain Analysis Results

Groups	Red Pretest	Mean Posttest	N-Gain Score	Categories
Experiments	47,43	82,86	0,68	Medium
Controls	45,31	64,38	0,35	Medium

Table 5 shows that the N-Gain Score of the experimental group was 0.68 which was in the medium category, while the control group had an N-Gain Score of 0.35 which was also in the medium category. Although both groups were in the same category, the N-Gain value of the experimental group was almost twice as high as that of the control group.

Table 6. N-Gain Percent Analysis Results

Groups	N-Gain Percent	Effectiveness Category
Experiments	68%	Quite Effective
Controls	35%	Ineffective

Based on Table 6, the N-Gain Percent of the experimental group was 68% which was included in the category of moderately effective, while the control group had an N-Gain Percent of 35% which was included in the category of ineffective. These results indicate that the use of Match Up game media is quite effective in improving the learning outcomes of fractional material for grade IV elementary school students.

Table 7. Average Posttest Score per Learning Objective

Learning Objectives	Experiments (%)	Control (%)
TP1: Identifying a fraction of a value	85,71	68,75
TP2: Sum of equal denominator fractions	82,86	65,63
TP3: Everyday problems (about stories)	78,29	58,13
TP4: Comparing and sorting	84,57	65,00
Average	**82,86**	**64,38**

Based on Table 7, it can be seen that in all learning objectives, the experimental group showed higher achievement than the control group. The largest difference occurred in TP3 (daily problems) which was 20.16%, where the experiment reached 78.29% and the control 58.13%.

Discussion

The results showed that there was a significant difference between the learning outcomes of fractional material of grade IV students who used Match Up game media and students who used conventional learning. This difference can be seen from the results of the Independent Sample t-test which produces a significance value of 0.000 < 0.05. The average posttest score of the experimental group (82.86) was much higher than that of the control group (64.38) with a difference of 18.48 points. This difference indicates that the use of Match Up game media has a greater positive impact on student learning outcomes compared to conventional methods.

The effectiveness of learning with the Match Up game is also shown by the results of the N-Gain analysis. The experimental group had an N-Gain Score of 0.68 (medium category near high) with an N-Gain Percent of 68% (moderately effective), while the control group had an N-Gain Score of 0.35 (low moderate category) with an N-Gain Percent of 35% (ineffective). These results confirm that the Match Up game media not

only improves learning outcomes, but is also effective in facilitating a change in understanding from the initial level to the higher level.

The superiority of the Match Up game in fractional learning can be explained through several pedagogical mechanisms. First, the Match Up game provides multiple representations of fractional concepts in the form of symbols, visuals, and verbal that facilitate a deeper conceptual understanding (Ainsworth, 2020; Rau et al., 2021). Research shows that students who learn with multiple representations have more flexible understanding and can transfer to different contexts (Hubber et al., 2020). Second, the game element creates positive emotional engagement, reduces math anxiety, and increases students' persistence in facing difficulties (Attard & Holmes, 2022; Ke & Clark, 2020).

Third, card matching activities in the Match Up game involve active cognitive processes such as remembering, comparing, analyzing, and making connections between concepts, which are in accordance with the principles of active learning (Freeman et al., 2021; - Theobald et al., 2020). Fourth, the competitive and collaborative component of group play enhances social learning where students teach each other, explain strategies, and provide feedback to peers (Johnson & Johnson, 2020; Lou et al., 2021). Fifth, the immediate feedback students get when matching cards facilitates corrective learning and strengthens correct understanding (Hattie & Clarke, 2021; Wisniewski et al., 2020).

The analysis per learning objective shows an interesting pattern. The experimental group showed superiority in all TPs, with the largest gap in TP3 (daily problems) where the difference reached 20.16%. This indicates that the Match Up game is very effective for improving the app's capabilities and knowledge transfer to real-world situations. These findings are consistent with research that shows that game-based learning is more effective for higher-order thinking skills than conventional learning (Hung et al., 2022; Tsai & Tsai, 2020). Game Match Up facilitates situated learning where students apply fractional concepts in a meaningful context through story questions packaged in the game (Lave & Wenger, 2021; Greeno, 2020).

The results of this study are in line with the findings of previous research on the effectiveness of game-based learning in mathematics. Hidayah et al. (2021) found an N-Gain of 0.72 for math educational games, which is slightly higher than this study (0.68). This difference may be due to differences in game types, implementation duration, and subject characteristics. Andriani & Madio (2021) reported an increase in completeness from 45% to 82% with fractional card games, which is comparable to this study where completeness increased from 38% (pretest) to 89% (posttest) in the experimental group. Suryani et al. (2022) found a 25% increase in learning outcomes with gamification, while this study showed a greater increase (35.43 points or 75% relative increase), likely due to the use of physical games that are more engaging than digital gamification.

From a theoretical perspective, the results of this study support Vygotsky's theory of social constructivism which emphasizes the importance of social interaction and scaffolding in learning (Vygotsky, 2021; Wertsch, 2020). Game Match Up provides a zone of proximal development where students with higher abilities can help other students through peer tutoring during group play. These results also confirm Mayer's Cognitive Load theory which states that well-designed multimedia learning can reduce extraneous cognitive load and increase germane cognitive load (Mayer, 2021; Sweller, 2020). The simple yet engaging design of the Match Up game helps students focus on learning fractional concepts without the overload of complex interfaces.

This research also provides empirical support for Self-Determination Theory in the context of mathematics learning (Ryan & Deci, 2020; Vasconcellos et al., 2020). Game Match Up meets three basic psychological needs: autonomy (students can choose their own strategies and pace), competence (direct feedback and visible progress), and

relatedness (social interaction in groups). Fulfilling these three needs increases intrinsic motivation which in turn increases engagement and learning outcomes.

Although the results of the study show significant effectiveness, there are some limitations to consider. First, the relatively short duration of the study (4 meetings) limited understanding of the long-term effects of the use of Match Up games. Longitudinal research is needed to evaluate the retention of understanding and transfer of learning over a longer period of time. Second, this study only measures cognitive learning outcomes without exploring the impact on affective aspects such as attitude toward mathematics, mathematical anxiety, or self-efficacy. Third, the implementation of the Match Up game requires quite intensive preparation including card making and teacher training, which may be a barrier to adoption in schools with limited resources.

The practical implication of this study is that elementary math teachers can use the game Match Up as an alternative or supplement to conventional methods of teaching fractions. This game is relatively easy to create and can be adapted for a variety of other math topics. For optimal implementation, teachers need to: (1) provide explanations of basic concepts before the game, (2) facilitate reflective discussions after the game to consolidate learning, (3) vary the difficulty level of the cards according to the student's ability, and (4) integrate the game with formative assessments for monitoring progress.

This research makes a theoretical contribution by confirming and expanding the understanding of the pedagogical mechanism of game-based learning in the context of fractional learning in Indonesia. Methodologically, this study demonstrates the use of a rigorous quasi-experimental design with multiple measures (pretest-posttest, N-Gain, per-TP analysis) that provides convergent evidence on the effectiveness of the intervention. Practically, this study provides evidence-based interventions that can be implemented by education practitioners to improve fractional learning outcomes.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that: (1) there is a significant difference between the learning outcomes of fractional material of grade IV students who use Match Up game media and students who use conventional learning, with a significance value of 0.000 < 0.05 and the average posttest of the experimental group (82.86) is higher than that of the control group (64.38); and (2) the use of Match Up game media was quite effective in improving the learning outcomes of fractional material, as shown by an N-Gain Score of 0.68 and an N-Gain Percent of 68% (the category of quite effective) in the experimental group, compared to the control group that had an N-Gain Score of 0.35 and an N-Gain Percent of 35% (the ineffective category). The experimental group showed superiority in all learning objectives, with the highest effectiveness in solving contextual problems.

This study recommends that elementary mathematics teachers use the Match Up game as an alternative or complementary learning medium for fractional materials. For further research, it is recommended to: (1) conduct longitudinal research to evaluate the long-term effects and retention of learning, (2) explore the impact of Match Up games on affective variables such as motivation and attitudes towards mathematics, (3) develop and test Match Up games for other math topics, and (4) examine factors that moderate the effectiveness of Match Up games such as students' initial abilities, learning style, or teacher characteristics.

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