The Application of a Domino Train Game-Based Learning System in Improving Middle School Students' Understanding of Algebraic Operations

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Article Info	ABSTRACT
	This study examines the effectiveness of using domino train games in teaching algebraic operations and how it improves students' understanding. The research employed Classroom Action Research (CAR) with both experimental and control groups. The experimental group was taught using the domino train game method, while the control group followed traditional teaching methods. The study was conducted at SMP Uswatun Hasanah during the 2019-2020 academic year, involving 64 seventh-grade students divided into two classes: class VII A (32 students) as the experimental group and class VII B (32 students) as the control group. Data were collected using pre-tests and post-tests to assess students' understanding of algebra, along with questionnaires to measure student engagement. The tests consisted of 10 essay questions on algebra. Validated closed-ended questionnaires were used to gather data on students' involvement in the learning process. Data analysis included normality tests, Mann-Whitney tests, and N-Gain calculations. Results showed that the experimental group experienced significant improvement, with an N-Gain of 0.493, while the control group had an N-Gain of -0.322. The findings indicate that the domino train game method is effective in enhancing students' understanding and participation in mathematics learning, providing an innovative alternative in teaching algebra.

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1. INTRODUCTION

Mathematics is fundamental in shaping students' logic and critical thinking skills. These skills and abilities are crucial not only in education but also in practical ventures like making rational decisions in economics, science, and engineering[1]. As a fundamental part of primary education, a solid grasp of mathematics is likely to enhance a student's cognitive development, which is expected to be beneficial across multiple career paths and aspects of life[2]. Unfortunately, a lack of deep understanding of mathematical concepts is often a challenge in the education sector, with many students feeling that mathematics is a difficult and confusing subject[3]. Data from SMP Uswatun Hasanah shows that between 2017 and 2019, around 75% of students did not achieve the minimum passing grade (KKM) in algebraic operations. This achievement reflects the low level of students' understanding of basic concepts that should serve as the foundation for learning more complex mathematical concepts[4]. One of the main obstacles faced by students in mathematics learning is their lack of active participation in the learning process. In many cases,

teaching methods dominated by lectures cause students to feel bored and disengaged, which in turn makes it difficult for them to delve deeper into the material presented[5]. A study shows that monotonous teaching methods tend to make students passive and reduce their motivation to understand concepts[6]. As a result, students' understanding of various mathematical concepts becomes superficial, they memorize formulas rather than understanding the meaning behind them[7]. This problem is exacerbated by the use of learning media that is not diverse and does not always accommodate the various learning styles of students. This is where the urgent need for a new approach in mathematics education arises, one that can enhance students' engagement and interest in the subject. One method that has been widely proposed is the use of game-based learning media. Research conducted by Kesumawati et al. (2015) shows that game-based methods can increase students' motivation and interest in learning mathematics, proving that a fun and interactive learning environment can make a significant difference in student engagement[8].

In this context, domino train games were chosen as an alternative method that is not only entertaining but also allows for more active interaction with learning materials. Domino games enable students to learn various mathematical concepts, including algebraic operations, in a more concrete and practical way[9]. Although there have been several studies on the use of games in mathematics education, the focus on the application of domino train games for algebraic operations at the secondary school level is still very limited, making this study important to fill the gap in the literature on mathematics education[10]. This study aims to introduce the application of domino train games in teaching algebraic operations and evaluate their impact on students' understanding at SMP Uswatun Hasanah during the 2019-2020 academic year. The method used in this study was Classroom Action Research (CAR), which involved an experimental and control design. In this study, the experimental group was provided with the use of the domino train game, while the control group followed conventional learning through traditional lectures[11]. The sample population was drawn from a cohort of 64 seventh-grade students, formed into an experimental group of 32 students and a control group of 32 students. Collection of data was performed using a pre-test and post-test method aligned with the objective of assessing the participants' comprehension in relation to the treatment they received; these particular measures were aimed toward achieving the reliable data on the enhancement of students' understanding[12]. Along with the tests, questionnaires were given to record the level of students' participation and involvement through activities during the learning session. The construct validity and reliability of the methods were critical to the study to ensure the assessment was aligned with students' understanding of the concepts taught and the learning activities. The results of the research showed that the implementation of the domino train game enhanced the students' understanding to a greater extent. The results based on the post-test showed that the experimental group performed better than the control group. The experimental group had an N-Gain value of 0.493 which means there was an enhancement in understanding while the control group had a negative value of -0.322[13], [14].

This study has positive implications, not only in improving students' understanding but also in increasing their motivation and engagement in the classroom. Implementing the domino train game in learning allows students to become more active and participate, which directly influences their learning outcomes[15]. The innovation of using this game is an important step in creating more engaging and innovative teaching methods, which can serve as an alternative for teachers in addressing the issue of student inactivity in mathematics learning[16]. Thus, it can be concluded that this study shows that integrating domino-based learning into mathematics teaching can have a significant impact on student engagement and understanding. With this new approach, it is hoped that students will not only perceive mathematics as a frightening subject, but also as a field full of opportunities and challenges[17]. The use of game-based media not only creates a more engaging learning environment but also facilitates the development of critical and logical thinking skills among students, which are essential for preparing a competent future generation.

2. RESEARCH METHOD

This research aims to assess how the domino train game is integrated into mathematics instruction concerning algebraic operations, as well as to assess the degree to which students' understanding is enhanced through this more interactive approach. The use of games in teaching mathematics has been found to facilitate understanding of the concepts taught as well as a higher level of interest among students. Research has demonstrated that the application of games, even traditional ones, not only enhances students' participation but also alleviates monotony and allows learning in a more enjoyable manner[18], [19]. Domino train games are expected to create a more interactive and engaging learning experience for students.

This study employed Classroom Action Research (CAR) which includes both an experimental group and a control group. The control group received instruction through traditional lectures, while the experimental group was engaged with the domino train game. This design not only enables a balanced comparison of the two approaches, but also provides additional empirical proof on the effectiveness of game-based learning techniques on enhancing the learning outcomes of mathematics [20], [21]. Earlier work

demonstrated that more participative and stimulating methods of instruction, like game-based learning, improve students' conceptual understanding [22], [23]. This study was conducted at SMP Uswatun Hasanah in the 2019-2020 academic year. The following is a research process diagram illustrating the steps taken in this study:
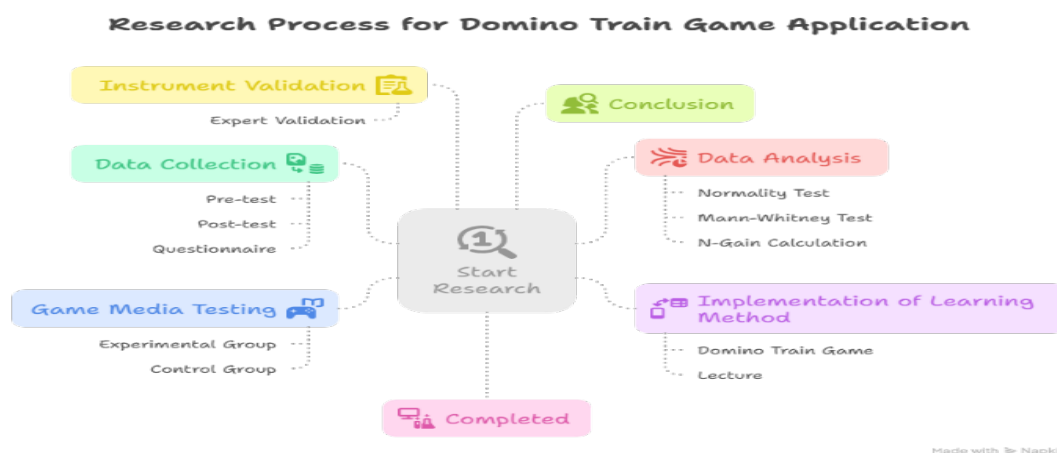

Figure 1. Research process of the application of the domino train game

The participants in this study were 64 seventh grade students from SMP Uswatun Hasanah in the academic year 2019-2020, split into two classes, with class VII A (experimental group) consisting of 32 students, and class VII B (control group) also with 32 students. The consideration for the selection of Grade VII stemmed from the suitability of the algebraic operations material to be taught, as well as the students' age readiness to be taught using interactive methods. [24]. Furthermore, algebraic operations are basic mathematical skills that are important for the development of students' abilities in the future, so improving their understanding in this area is very important[25].

Data collection for this research began with using two instruments: a test administered before the process began (pre-test) and a test given afterward (post-test), alongside a questionnaire. The pre-test provided baseline data for assessment and was conducted prior to the application of the domino train game. This was followed by a post-test to evaluate the treatment provided[26]. Questionnaires were used to measure the level of student engagement and activity in learning, which are important indicators of the effectiveness of the learning method used[27]. Through the use of qualitative questionnaires, researchers obtain valuable insights through qualitative data collected about students' experiences while learning. The alignment of the tests and questionnaires to the learning outcomes to be achieved was subject matter expert validated, which was especially critical to the instructional objectives of the tests and questionnaires. This procedure is vital to ensure the instruments produced valuable and trustworthy results[28]. In addition, the reliability of the instruments is also tested to ensure consistency in measuring students' understanding and activities, which is an important step[29].

After validation, the next stage is media testing, where the experimental group uses a domino train game as the learning medium, while the control group uses the lecture method as the conventional learning medium. This testing aims to investigate the impact of the game method on students' understanding and learning activities[30]. Other studies also emphasize that games as teaching aids not only improve problem-solving skills but also enhance social skills and teamwork among students[31], [32], [33]. The implementation of the learning method was carried out by encouraging students to actively interact with the material through the domino train game in the experimental group, while the control group focused more on lectures as the traditional method. In the context of interactive learning, students do not merely learn passively but are encouraged to collaborate with their peers in solving problems, which is an essential aspect of meaningful learning[34], [35]. This approach is expected not only to enhance students' understanding of mathematical concepts but also to reduce the anxiety often experienced by students when learning mathematics, which is perceived as challenging[36], [37].

After the learning process is complete, the results are collected by administering a post-test to measure changes in students' understanding and a questionnaire to assess the level of student engagement in the learning process. Data analysis is conducted through several stages, including data reduction, normality tests to determine data distribution, and N-Gain calculations to measure improvements in students' understanding[37], [38], [39]. The Mann-Whitney test is used to analyze significant differences between the experimental and control groups if the data is not normally distributed, which is an important step to ensure that the analysis results truly reflect the existing differences[40]. Consequently, the effectiveness of

incorporating domino train games within the context of students' comprehension of mathematical concepts determines the conclusions formulated following data analysis. The findings of this study are designed to illustrate the impact of the domino train game learning strategy on students' mathematical understanding, as well as to present a more engaging and interactive alternative to traditional, instructional techniques [41]. With this structured design and methodology, this study aims to make a significant contribution to the development of more innovative mathematics learning methods that can enhance students' understanding of the taught material[42], [43].

3.   RESULTS AND ANALYSIS

This study's findings suggest that the use of domino train games in learning algebra markedly enhances the understanding of mathematical concepts among students at SMP Uswatun Hasanah. Analysis of the pre-tests and post-tests indicated remarkable differences between the experimental and control groups. The experimental group that utilized domino train games as a learning technique posted an average post-test score of 71.56, while the control group that was taught through the conventional lecture method only reached an average post-test score of 54.84. This suggests that the use of game-based learning enhances understanding among students.

Improvement in Mathematical Concept Understanding

This increase in understanding was indicated by the N-Gain scores obtained by both groups. The experimental group recorded an N-Gain of 0.493, indicating that students in this group experienced a significant increase in their understanding of algebra after using the domino train game. In contrast, the control group experienced a negative N-Gain of -0.322. These data indicate that game-based learning is more effective in improving understanding of algebraic concepts than traditional lecture methods, which tend to be passive and monotonous[44], [45], [46]. Consistent with previous research, Lestary et al. (2022) stated that the application of interactive learning methods such as games can significantly improve students' understanding of mathematical concepts. In this context, the domino train game used not only made students more actively engaged but also provided them with opportunities to practice applying theories in an enjoyable setting[44] . In other words, learning that involves games successfully creates a more dynamic and enjoyable learning environment for students, which in turn positively impacts learning outcomes[47], [48], [49]. The implementation of domino train games significantly improved students' understanding of algebra. The experimental group showed a substantial increase in post-test scores compared to the control group.

Table 1. Pre-Test and Post-Test Scores for Both Groups

Group	Pre-Test Score	Post-Test Score	N-Gain
Experimental Group	45.32	71.56	0.493
Control Group	45.14	54.84	-0.322

The comparison of the pre-test and post-test scores for the experimental and control groups is shown in the table above. While employing the domino train game as a learning technique, the experimental group attained an average post-test score of 71.56, demonstrating considerable gain, unlike the control group which suffered from low average post-test score of 54.84 using the passively delivered lecture format. The experimental group's algebra understanding N-Gain of 0.493 reflects considerable improvement, while the control group's understanding suffered as indicated by a negative N-Gain of -0.322.

Student Involvement in the Learning Process

The results of the questionnaire on student engagement showed that there was an increase in student participation and engagement during learning. Student engagement in the experimental group increased significantly from 31.6% in the first cycle to 89.8% in the third cycle. This drastic increase indicates that students feel more interested and engaged in learning when using the domino train game method, which is in line with the research discussed by Ranti and Kurniati (2020) that interactive learning models encourage students to be more active[45]. Game-based activities such as domino trains allow students to not only be passive listeners but also participate in discussions and interact with their peers in solving algebra problems. This active involvement gives students the opportunity to exchange ideas, discuss possible solutions, and receive direct feedback from their peers and teachers. The social interaction that occurs during the game can strengthen their understanding of algebraic concepts[44], [48]. The game-based learning approach resulted in a significant increase in student participation and engagement.

Table 2. Student Engagement in Experimental Group

Cycle	Engagement Percentage
Cycle 1	31.60%
Cycle 3	89.80%

This table demonstrates the significant increase in student engagement within the experimental group that used the domino train game. In the first cycle, only 31.6% of students were actively involved in the learning process, but this number increased drastically to 89.8% by the third cycle. This sharp rise indicates that students felt more engaged and interested in learning when the domino train game method was used, supporting the notion that interactive learning models encourage greater student involvement.

1. Comparison with the Lecture Method

Lecture-based learning is often considered uninteresting for students, limiting their participation and contributing to a monotonous learning experience. In the control group that followed traditional lectures, students listened more without direct interaction with the material. These results are in line with the research by Rahim et al. (2022), which shows that lecture-based methods have limitations in improving students' understanding of complex concepts such as algebra[50] . In contrast, domino train-based learning provides a real-world context for students to learn. They are not only focused on theory but also engaged in applying concepts in a fun and challenging game. Research by Novianti et al. (2024) aligns with these findings, indicating that the use of game-based methods in teaching significantly improves students' conceptual understanding in algebraic mathematics, as students learn through direct experience[48]. In the control group, students were exposed to traditional lectures, which tend to limit engagement and active participation.

Table 3. Average Post-Test Scores and N-Gain of Both Groups

Group	Post-Test Score	N-Gain
Experimental Group	71.56	0.493
Control Group	54.84	-0.322

This table compares the post-test scores and N-Gain values of the experimental group using the domino train game and the control group following traditional lectures. The experimental group recorded a higher average post-test score (71.56) and a positive N-Gain (0.493), indicating a significant improvement in their understanding. Conversely, the control group had a lower post-test score (54.84) and a negative N-Gain (-0.322), highlighting the limitations of lecture-based learning in improving students' understanding of algebraic concepts.

2. Implications for Learning Development

From the results of the study, the practical implications are quite clear: game-based learning such as domino trains not only improves conceptual understanding but also creates a more dynamic and engaging learning environment for students. These findings support the idea that innovation in teaching methods, especially in mathematics education, is essential for creating more effective learning experiences for students

at all levels. Games should be utilized as teaching aids that not only promote conceptual understanding but also enhance student motivation and engagement[51] . Therefore, recommending the use of domino train games as part of the learning approach in schools is a valuable step. Training for teachers on how to integrate games into the curriculum and learning process should be a priority in efforts to improve the quality of mathematics education. By giving students the opportunity to learn in a more interactive way, it is hoped that they will not only understand mathematical concepts better but also increase their interest in studying the subject[44], [52].

Thus, it can be concluded that the results of this study confirm that the application of domino train games in algebra learning at SMP Uswatun Hasanah significantly improves students' mathematical concept understanding. Increased student engagement, higher post-test scores in the experimental group, and positive N-Gain values prove that game-based learning methods are highly effective. These results align with other studies indicating that interactive learning can have a significant impact on students' learning experiences. Therefore, the implementation of the domino train game-based learning method is worth considering and integrating into teaching strategies to facilitate better conceptual understanding in schools. For future development, further research can be conducted to explore various types of games and innovative approaches that can support mathematics learning and improve learning outcomes for students at all levels of education. The findings clearly demonstrate that game-based learning, specifically through domino train games, not only improves students' understanding of algebra but also creates a dynamic and engaging learning environment.

Table 4. Impact of Game-Based Learning on Student Engagement

Group	Engagement Increase	Post-Test Score Improvement
Experimental Group	Significant	71.56 (N-Gain: 0.493)
Control Group	Minimal	54.84 (N-Gain: -0.322)

This table highlights the impact of game-based learning on both student engagement and post-test scores. The experimental group saw significant increases in engagement and a marked improvement in post-test scores, with a final post-test score of 71.56 and an N-Gain of 0.493. In contrast, the control group exhibited minimal engagement and a negative N-Gain of -0.322, demonstrating the higher effectiveness of interactive, game-based learning compared to traditional methods. This suggests that game-based learning not only improves conceptual understanding but also fosters a more dynamic and engaging learning environment.

4. CONCLUSION

In conclusion, this study highlights the significant impact of using domino train-based games on enhancing students' understanding of algebraic operations and promoting active participation in the learning process. The experimental group, which engaged in the game-based approach, showed considerable improvement, with an average post-test score of 71.56 compared to the control group's score of 54.84. The N-Gain analysis reinforced these results, revealing a positive N-Gain of 0.493 for the experimental group, indicating a moderate improvement, while the control group exhibited a negative N-Gain of -0.322, suggesting a decline in understanding. Furthermore, student engagement in the experimental group increased dramatically from 31.6% in the first cycle to 89.8% by the third cycle, demonstrating the effectiveness of the game-based learning method in encouraging student involvement. The findings underscore the importance of adopting innovative, interactive teaching strategies in mathematics education to enhance both academic performance and student engagement. The study advocates for the widespread use of game-based learning methods, particularly the domino train game, as a valuable alternative to traditional teaching approaches. For future research, it would be beneficial to explore the long-term effects of game-based learning on students' academic achievement and motivation in mathematics. Additionally, investigating the potential of combining different game-based strategies or applying this approach in other subjects could provide further insights into the broader applicability of these methods in education.

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