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Assessing the Pedagogical Impact toward Interactive Game-Based Instruction on Improving Elementary Students' Integer Learning Concepts

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ABSTRACT

This study aims to describe the effectiveness of implementing a game method in learning integers. This study employs a quasi-experimental design with a posttest-only control group. The sampling technique was random, and the class equivalence test employed a one-way ANOVA. Sampling used a cluster random sampling technique. The data collection technique employed a test method consisting of essay questions in the high-level thinking category. These questions were found to be valid, with a reliability coefficient of 0.75, which falls in the high category. The data analysis employed an independent t-test at a significance level of 0.05, preceded by a prerequisite test of data normality and homogeneity of variance. The results of the study showed that the application of the interactive game method can improve learning outcomes in integer arithmetic operations, which is also indicated by: (1) students are enthusiastic and involved in following the lesson. (2) active student participation increases, (3) learning is more meaningful, and (4) building very positive team collaboration.

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1. INTRODUCTION

Significant academic achievement is the goal of every teacher, which means fostering impactful learning experiences that enhance student creativity. Elevated creativity can aid pupils in problem-solving and socio-emotional development, fostering substantial comprehension through various instructional methods, including games [1], [2], [3]. The effective use of media and teaching aids can enhance students' soft skills, namely in critical, analytical, logical, and systematic thinking [4], [5]. However, the evidence reveals numerous challenges in the teaching of mathematics at the basic level, indicating poor achievement, particularly in number theory. Observations of classroom activities and interviews with

teachers and learners at SDK Ruteng VI, Manggarai Regency, East Nusa Tenggara, indicated that pupils exhibited an inadequate level of enthusiasm and engagement during mathematics instruction. The educators' feedback at the school where this study was conducted indicated that the provided material lacked contextual relevance. This was confirmed by the students, who reported that their engagement with the numbers felt overly abstract, leading them to listen and transcribe rather than achieve a profound understanding primarily. This aligns with findings from Mandasari and Rosalina [6], who reported that students struggled to grasp integer concepts, primarily due to the absence of contextual media used by teachers, coupled with a notable lack of enthusiasm and drive in the study of mathematics among students [7]. Undoubtedly, this issue necessitates proactive measures to drive innovation by implementing diverse pedagogical approaches that elevate engagement and foster positive learning outcomes.

This research is of paramount importance, particularly given that numbers serve as a foundational element intricately linked to a multitude of advanced topics. Numerous misconceptions arise in the comprehension of numbers, as evidenced by the research conducted by Hamapinda et al. [8] reported that the primary challenge faced by students lies not in grasping the material itself, as evidenced by their mistakes in formulating mathematical models, their inability to execute mixed-number arithmetic operations correctly, and deficiencies in fundamental calculation skills, along with improper positioning of arithmetic operation symbols. Similarly, research by Maharani et al. [9] demonstrated that students' mistakes in addressing numerical story problems are shaped by various factors, including insufficient comprehension of fundamental concepts, inaccuracies in algorithms or procedures, and a lack of understanding of the mathematical steps required to resolve the problem. Consequently, employing game-based methods is highly pertinent for engaging with the abstract nature of mathematical concepts, thereby enhancing students' comprehension, motivation, and problem-solving skills [10]. Therefore, this study aims to describe improvements in learning outcomes in integer arithmetic operations through interactive game methods at the elementary school level.

The interactive game discussed in this study is the marching game, a traditional activity frequently engaged in by children, characterised by the formation of a line and stepping from one designated point to another. The marching game enhances children's motor skills; moreover, it features an appropriate playing step that aligns with the concept of calculating integers on a number line. The operational method resembles it, as it involves transitioning from one point to another, akin to jumping or walking between numbers [11], [12]. This game technique distinguishes itself from others by engaging students in psychomotor activities that involve moving forward, backward, and in reverse for subtraction, multiplication, and division operations. This method employs various rules to enhance students' understanding of the concept of integers [13], [14]. The in-depth understanding of educators is intrinsically linked to the capacity to implement knowledge, encompassing both subject matter and teaching methods in the context of elementary education [15].

Indeed, prior investigations into the use of games for understanding numbers have been undertaken; however, the emphasis diverges from that of the current study. For instance, Ali [16] asserted that the application of panpinbul enhances students'

comprehension of the cognitive dimension solely in integer arithmetic operations. Conversely, the findings of this study emphasise the fundamental nature of marching in rows, which can foster the comprehensive abilities of elementary school students across the cognitive, affective, and psychomotor domains in integer arithmetic. The research conducted by Harianti et al. [17] revealed that the Bobak Sodor game enhances students' comprehension of the cognitive dimensions of integer arithmetic operations. This contrasts with the current study's results, which demonstrated that the marching game method fosters a more holistic understanding among students. The research by Syafriadi [10] emphasised that the game method is highly effective in fostering learning motivation among elementary school students. However, research done by Syafriadi [10] exclusively assesses the efficacy of game methods in a broad sense, concentrating primarily on the affective dimension of learning motivation. However, it diverges from the present study, which focuses on the effectiveness of the marching game. The distinction in emphasis makes this research both crucial and relevant.

The core of the interactive marching game method's utility in teaching integers in primary school lies in enhancing conceptual understanding, fostering learning motivation, and promoting active student engagement through enjoyable and meaningful learning experiences. The interrelation of these three aspects is evident, as the fundamental principle posits that the Cognitive dimension underscores how the marching game facilitates students' comprehension of integers—encompassing positive and negative values, addition, subtraction, and comparison—through tangible visualisation and the simulation of real-world scenarios within instructional activities. The psychological aspect fosters an engaging educational environment that can enhance intrinsic motivation, confidence, and enthusiasm for mathematics, a subject frequently perceived as challenging by elementary school learners. From a physical engagement perspective, the marching game technique demonstrates that it serves as an avenue for developing collaboration, communication, critical thinking, and problem-solving skills among elementary school students, aligning with the core principles of a student-centred learning framework.

This study highlights the distinctive features of the marching line game, setting it apart from other game methods. Through this method, pupils engage both physically and mentally, actively participating in the exercise with either the depicted number line or the stretch of rope linked to the numbers, referred to as Marching Line. This interaction fosters an enjoyable and significant learning experience. This study aims to investigate the effectiveness of the Marching Line game method in enhancing the academic performance of sixth-grade elementary students in integer mathematics.

2. METHOD

This research is a quasi-experimental study using a posttest-only control group design [18]. Random sampling technique with class equivalence test using the one-way ANOVA technique. After implementing a class equivalency test based on the final grades from the odd semester of the 2024/2025 academic year for grade VI students across three study groups at SDK Ruteng VI East Nusa Tenggara, Eastern Indonesia, the One-Way ANOVA analysis revealed that all classes were equivalent. From the three classes, selection

was conducted through a cluster random sampling technique, specifically by drawing lots, whereby the first two classes drawn were designated as the sample classes. After conducting another round of random selection for the two sample classes, it was determined that class VI B comprised 24 individuals designated as the experimental group. In contrast, class VI A included 25 individuals serving as the control group. In the experimental class, the interactive game-based marching method was used, whereas in the control class, the conventional strategy was employed, specifically the method typically adopted by educators for instructing numerical arithmetic operations.

The technique for collecting data on learning outcomes employs a test technique characterised by descriptive questions at cognitive levels C3 and C4 [19], [20]. Before use, the questions were tested at SDK Ruteng II, and the analysis results showed that all five questions were valid, with an instrument reliability coefficient of 0.75, which falls in the high category. The data analysis technique employed a t-test at a significance level of 0.05, which first satisfied the prerequisite tests, namely the data normality test and the homogeneity of variance test.

3. RESULTS AND DISCUSSION

3.1 Results

This experimental study was conducted at SDK Ruteng VI, Level C, to investigate the enhancement of learning outcomes through the implementation of the interactive marching game method on numerical arithmetic operations. This study consisted of 8 sessions for both the experimental and control groups, focusing on the operations of addition, subtraction, multiplication, and division of integers. The content covered involved arithmetic operations and the resolution of integer problems through the marching game method in the experimental class, whereas the control class employed the traditional method that educators have utilised to date in teaching integers. Following treatment administration, a posttest was conducted. This document summarizes the posttest results for both the experimental and control groups. Based on descriptive data analysis, the mean count in the experimental class was higher than that in the control class. $\overline{X}$ = 81,23 while the mean count of the control class was $\overline{X}$ = 75, 36. This demonstrates that the marching line game method is effective in enhancing students' learning outcomes in level C integers.

Although descriptive analysis indicated that the class engaging with the marching game demonstrated a superior grasp of the concept compared to the class that did not utilise this medium, further testing is required to statistically and inferentially evaluate this research hypothesis. A prerequisite test was conducted to verify that the test data conformed to the requirements of a normal distribution and uniform data variance. According to the findings of this prerequisite test, the data met the specified criteria, demonstrating normality and homogeneity. The results of the normality test, as conducted using SPSS 23, are presented in Table 1.

Table 1. Normality Test with Shapiro-Wilk

	Group	Shapiro-Wilk		
		Statistic	df	Sig.
Results	Pretest Experimental.	.915	223	.276
	Posttest Experimental.	.937	23	.156
	Pretest control	.958	24	.119
	Posttest control	.927	24	.078

Furthermore, the homogeneity test using Levene's test indicates that the posttest data have homogeneous variance. By paying attention to the normally distributed data and homogeneous data variance, the following hypothesis test uses the t-test, which shows that the value $t_{observation} > t_{critical\ value}$, namely $11{,}4 > 1{,}7$, at the significance level $\alpha = 5\%$.

3.2 Discussion

The study found that students taught with game media achieve higher learning outcomes than those taught with conventional methods. This research finding is consistent with their scholarly work [21], [22], which demonstrates that the utilisation of media substantially enhances students' comprehension of integer arithmetic operations. Similarly, studies by Mailani et al. [2] demonstrate that the educational game method significantly enhances student learning outcomes in material on integer operations. Likewise, the study by Syafriadi [10] found that implementing traditional educational game methods has the potential to enhance learning outcomes and motivation, serving as a viable alternative for facilitating learning among elementary school students.

A recent study found that traditional educational games can enhance achievement and motivation in elementary school mathematics. This study presents several key arguments, highlighting that these games serve as contextual learning strategies that integrate local cultural elements with play activities, thereby fostering a learning experience that is enjoyable, essential, and engaging [23], [24]. In the context of elementary school mathematics instruction, this conventional game method can help transform abstract ideas into more concrete and comprehensible concepts. It promotes social interaction and collaboration among students, fosters intrinsic motivation as learning activities resemble play, and indirectly enhances academic outcomes by increasing enthusiasm, involvement, and conceptual clarity. This assertion aligns with the principles of Vygotsky's constructivist theory (1925), as cited by Toma et al. [25] and Syafriadi [26], demonstrated that learners are capable of developing understanding through direct observation and interpersonal engagement—two components prominently featured in these classic games. The conventional activities associated with games foster autonomy, enjoyment, and a sense of competence—similar to those found in educational games—thereby enhancing students' intrinsic motivation. Moreover, educational games rooted in local culture enhance the relevance of learning to students' experiences.

The success of this research is directly connected to the educator's creative strategy in implementing interactive educational game techniques (marching), which actively engage students, as illustrated in Figure 1.

Figure 1. Students demonstrate game techniques for learning arithmetic operations on whole numbers using number lines or number ropes.

The instruction facilitated by interactive game methods in this study was found that (1) Students were more motivated, as they felt more enthusiastic about following the lesson. Students did not just sit passively, but were actively involved in challenging and fun physical activities; (2) increasing the active participation of students, who were previously less active or shy, began to dare to appear and participate in the game. The Marching game created a competitive but still cooperative atmosphere, thus encouraging all students to get involved; (3) more meaningful learning, through game activities, students not only memorize mathematical concepts, but also apply them directly in interesting situations. This strengthens conceptual understanding and improves students' memory of the material; (4) teamwork, in the number rope game, students learn to work together in groups. This not only improves cognitive aspects but also their social skills, such as communication and leadership. The findings of this study align with Vygotsky's theory (1925), which posits that a person will be more successful in learning when supported by someone more capable [27], [28].

Vygotsky's theory (1925) is further strengthened by the essence of Piaget's theory (1947), as cited by Subba et al. [29] and Lightfoot et al. [30], which implies that an individual has the capacity to acquire knowledge autonomously through observation of their surroundings and others' behaviors. This study highlights that, within the field of elementary school mathematics instruction, learning is fundamentally a constructive endeavor, in which children actively build their own understanding through direct experiences and engagement with their environment. Knowledge is not merely transmitted from teacher to student; somewhat, it is actively shaped by students through their observations, experiments, and reflections on experiences encountered directly in the classroom. Elementary school children frequently struggle to grasp the concepts of positive and negative integers, as well as the notion of zero, because these ideas are inherently abstract. Piaget's theory (1947) suggests that learning is significantly enhanced by tangible experiences, indicating that children grasp the concept of integers more effectively when provided with real-world interactions or concrete visual representations, such as using objects, number lines, or contextual games. Furthermore, while Piaget underscored the significance of individual

cognitive construction, he concurrently acknowledged the vital role of social interaction and observational Learning [31], [32]. Children can also learn independently by observing and imitating how friends or people around them solve problems, then adapting it to their own understanding (assimilation and accommodation processes), and independence in thinking occurs where children learn independently to build cognitive schemes about integers — for example, understanding that "−3 is smaller than 2" — through the process of trial, error, and self-correction based on the results of their observations.

Consistent with findings from Siregar et al. [33], Studies indicate that the use of interactive games in mathematics instruction may significantly improve students' engagement and enthusiasm for the topic at hand. Moreover, learners exhibit heightened enthusiasm and active participation in the study of mathematics when their learning is facilitated by stimulating, enjoyable games. Engaging in games enhances students' self-confidence and cultivates enriching experiences that subsequently inspire a deeper interest in mathematics. The marching game method significantly enhances students' engagement, participation, and proficiency in mathematics. Students exhibit increased engagement, reduced anxiety, and increased motivation in their participation in mathematics learning, culminating in a more dynamic and pleasurable learning atmosphere.

The implementation of the interactive marching game technique in mathematics instruction, particularly in the context of integer arithmetic operations, fosters an engaging and dynamic learning environment. The marching game represents an innovative method of active learning that integrates physical activity and cognitive engagement. In this dynamic environment, students collaborate and engage in rapid problem-solving of mathematical challenges as they move around. Beyond fostering interest and enjoyment, implementing the marching game method offers significant advantages for students. It enhances their ability to tackle mathematical problems, particularly in integer arithmetic, through a concrete operational method that aligns with their cognitive development [34], [35]. This aligns with Wildaniati's (2015) view that the mathematical game method serves as an engaging activity that can facilitate the attainment of instructional objectives in mathematics teaching, encompassing cognitive, affective, and psychomotor dimensions.

This method of marching serves as a demonstration of Vygotsky's theory, in which students collaborate in groups to accomplish tasks through an interactive, mutually beneficial process, with less proficient students receiving support from their more capable peers [37]. This method fosters a cooperative atmosphere that enhances active engagement and enables students to assist one another throughout their educational journey [38]. This method refers to learning that integrates physical movement with the concepts or material being taught, so that students can understand the material through direct experience and fun activities.

According to Lev Vygotsky (1925), as cited by Salami et al. [39] and Wibowo et al. [40], learning is a social process that occurs through interactions between individuals and their social and cultural environments. Vygotsky emphasized that a child's cognitive development is greatly influenced by the Zone of Proximal Development (ZPD), which is the distance between a child's ability to complete tasks independently and the ability that can be achieved with the help of others, such as teachers or more capable peers. In the context of primary school, this notion can be effectively implemented through collaborative

endeavors and the strategic application of scaffolding—providing educators' incremental support—to facilitate students' comprehension of abstract ideas such as negative integers, the concept of zero, and various arithmetic operations. For instance, educators may employ visual aids, number lines, or pedagogical games to enhance interaction and discourse among learners, thereby fostering a collective comprehension. Thus, Vygotsky's theory asserts that learning about integers will be more effective if designed within an interactive social context, where students have the opportunity to engage in dialogue, collaborate, and receive support until they can construct knowledge independently.

Previous research has focused on the importance of interactive-educational exploring play and its implications for elementary school students' mathematics achievement [16], [17]. Their findings further demonstrate that the interactive marching game is a traditional game commonly played by elementary school children, which improves motor skills and enhances students' learning motivation. There are similarities between the results of previous studies Ali [16] and Harianti et al. [17] and the findings of this study, which confirm that the function of Interactive games rooted in local traditions serve as an integrated strategy to enhance students' educational outcomes comprehensively, encompassing conceptual understanding (cognitive), fostering learning motivation (affective), and promoting active student engagement through enjoyable and significant learning experiences (psychomotor). What distinguishes the findings of this study from those of previous ones?

This study proposes an alternative novelty—namely, the development and implementation of interactive educational game methods adapted to the socio-cultural context and learning characteristics of elementary school students in Indonesia. Rather than using imported digital games or universal models, this approach adapts traditional games and local activities as a medium for understanding integer concepts. This strengthens the relevance of learning to students' real-life experiences. The integration of three learning domains: cognitive (understanding number concepts), affective (motivation and attitudes toward mathematics), and social (cooperation and communication). This study evaluates academic learning outcomes while also exploring the influence of interactive games on the development of collaborative learning traits, aligned with the principles of the *Profil Pelajar Pancasila* [Pancasila Student Profile]. This study's findings underscore the learning process as a domain for dynamic student engagement. Interactive games serve not only as instruments but also as instructional methods that place students at the forefront of their mathematical learning. Moreover, this study offers valuable perspectives on the formulation of mathematical learning strategies that align with the *Kurikulum Merdeka* [Independent Curriculum], specifically emphasising essential, contextual learning that fosters student autonomy.

4. CONCLUSION

The study's results indicate that using the interactive marching game method enhances students' proficiency in solving integer problems, particularly in integer arithmetic. The implementation of the game technique demonstrates that: (1) pupils exhibit increased

motivation, leading to heightened enthusiasm during lessons; (2) Active student engagement escalates, as the marching game fosters a competitive yet collaborative environment, motivating all students to participate; (3) learning becomes more significant, and (4) teamwork is promoted. The use of the marching game approach can serve as an effective alternative to enhance the comprehension of complex mathematical concepts, aligning with the cognitive level of primary school students. This strategy provides favourable empirical outcomes in this study. It significantly enhances the quality of mathematics education in primary schools, facilitating its integration into the curriculum to optimize student learning.

This research suggests that applying game-based learning methods supports students' creativity in learning, enabling them to have meaningful experiences. Strong mathematical skills, particularly in solving integer problems, empower students to develop the capacity to meet 21st-century educational competencies that require creative problem-solving. The "Lines in Lines" game can create a learning environment that requires team collaboration and mutual support to build a comprehensive understanding of integers. Learning using the "Lines in Lines" game method not only facilitates the acquisition of subject-specific knowledge but also fosters critical thinking, communication, and collaboration skills necessary for interactive, meaningful learning, thereby increasing students' enjoyment of mathematics. This research concentrated on enhancing learning outcomes in mathematical operations at the C3 and C4 cognitive levels. This study aimed to enhance students' understanding of fundamental mathematical concepts by fostering a passion for the subject through game-based learning techniques. Consequently, further study may be conducted on the C5 and C6 levels of problem-solving skills to enhance higher-order thinking skills through the application of pertinent methods.

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