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Research Article

Strategic Thinking and Reasoning in Integer Knowledge Enhancement (Strike): Manipulative Tool in Enhancing Integer Operations

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ABSTRACT

This study evaluated the effectiveness of the Strategic Thinking and Reasoning in Integer Knowledge Enhancement (STRIKE) manipulative tool in improving the integer operation skills of Grade 9 learners at Lantangan National High School. A quantitative pre-experimental one-group pretest–posttest design was employed involving 30 purposively selected Grade 9 learners who obtained the lowest scores in the Integer Test of Primary Operations (ITPO). Participants received a two-week intervention using the STRIKE manipulative tool before completing the posttest. Descriptive statistics were used to summarize learners' performance, while paired-samples and independent-samples *t*-tests determined significant differences in achievement. Results revealed significant improvements in both male learners ($t = -6.9099$, $p < .05$) and female learners ($t = -12.435$, $p < .05$) following the intervention. Although female learners obtained a slightly higher mean posttest score than male learners, no statistically significant difference was found between the two groups ($t = 1.9999$, $p = .0553$). The findings suggest that the STRIKE manipulative tool is an effective instructional intervention for improving Grade 9 learners' performance in integer operations by enhancing their conceptual understanding and computational proficiency while providing equitable learning opportunities regardless of sex. Future studies are recommended to employ larger samples and experimental or quasi-experimental designs with comparison groups to further validate its effectiveness.

Keywords: *Grade 9 learners, integer operations, manipulative-based instruction, mathematics achievement, STRIKE manipulative tool*

Introduction

Mathematics is widely recognized as a fundamental discipline that develops logical reasoning, critical thinking, and problem-solving skills essential for everyday life and national development. Its applications extend

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across science, technology, engineering, economics, and decision-making, making mathematical competence an indispensable component of quality education. Consequently, strengthening mathematics instruction has become a priority for educational systems seeking to prepare learners for the demands of the twenty-first century.

Despite its importance, mathematics achievement continues to be a significant concern worldwide. International large-scale assessments reveal substantial differences in students' mathematical proficiency across countries. Results from the Programme for International Student Assessment (PISA) 2022 showed that approximately three-fourths of participating learners attained at least the baseline level of mathematical literacy, although considerable disparities remained among education systems. High-performing countries such as Singapore and several East Asian economies consistently demonstrated strong performance, reflecting educational practices that emphasize conceptual understanding, reasoning, and problem-solving. Conversely, many countries continue to experience challenges in improving mathematics achievement among learners.

The Philippine education system likewise faces persistent challenges in mathematics education. According to the PISA 2022 results, Filipino learners remained among the lowest-performing participants in mathematics, with only a small proportion reaching the minimum proficiency level. National assessment results have similarly indicated declining mathematics performance over the years. These findings suggest that many learners continue to experience difficulties in understanding and applying fundamental mathematical concepts that serve as prerequisites for higher-order learning.

This concern is likewise evident in the Schools Division of Masbate Province. Results from the Albay Numeracy Assessment Tool (ALNAT) identified a large number of secondary learners requiring major instructional support in numeracy. At Lantangan National High School, previous National Achievement Test (NAT) results likewise reflected low performance in mathematics, particularly in problem solving, information literacy, and critical thinking. These outcomes indicate the need for instructional innovations that can strengthen students' conceptual understanding and computational skills, particularly in foundational mathematical topics.

One of the most challenging topics encountered by junior high school learners is integer operations. Although integers serve as the foundation for algebra and other advanced mathematical concepts, many students experience persistent misconceptions regarding positive and negative numbers. Learners frequently ignore negative signs, incorrectly apply operational rules, and rely on memorization rather than conceptual understanding. Such misconceptions hinder mathematical reasoning and often carry over to more advanced topics. Previous studies have emphasized that these difficulties may be addressed through instructional approaches that provide concrete representations of abstract mathematical ideas.

Manipulative materials have been recognized as effective instructional resources for improving students' mathematical understanding by providing opportunities for active participation and hands-on learning. Through concrete representations, learners are able to visualize mathematical relationships, construct meaning from abstract concepts, and develop deeper conceptual understanding. Research has consistently shown that manipulative-based instruction enhances student engagement, motivation, and academic achievement in mathematics.

In response to these instructional needs, the researcher developed the Strategic Thinking and Reasoning in Integer Knowledge Enhancement (STRIKE) manipulative tool. STRIKE is a hands-on instructional material specifically designed to strengthen junior high school students' understanding of the four fundamental operations involving integers. Inspired by the Keymatic manipulative used in elementary mathematics, STRIKE was modified to address the cognitive demands of secondary learners by emphasizing integer addition, subtraction, multiplication, and division through interactive learning activities. Its lightning-inspired design symbolizes directional movement similar to the movement along a number line, enabling learners to visualize integer operations more meaningfully.

Anchored on the principles of active learning and constructivism, STRIKE encourages

students to participate directly in the learning process rather than relying solely on rote memorization. Through repeated manipulation and guided practice, learners are expected to develop stronger conceptual understanding, procedural fluency, and confidence in performing integer operations. By transforming abstract mathematical ideas into concrete learning experiences, STRIKE aims to improve students' academic performance while promoting meaningful mathematical learning.

Accordingly, this study sought to determine the effectiveness of the Strategic Thinking and Reasoning in Integer Knowledge Enhancement (STRIKE) manipulative tool in improving the integer operation skills of Grade 9 learners at Lantangan National High School. Specifically, it examined students' pretest and posttest performance, determined whether significant improvements occurred following the intervention, and investigated whether differences existed in the posttest performance of male and female learners. The findings are expected to contribute to the growing body of evidence supporting the use of manipulative-based instruction in mathematics education and to provide practical guidance for teachers seeking effective strategies for teaching integer operations.

Statement of the Problem

This study aimed to determine the effectiveness of the Strategic Thinking and Reasoning in Integer Knowledge Enhancement (STRIKE) manipulative tool in improving the integer operation skills of Grade 9 learners at Lantangan National High School.

Specifically, it sought to answer the following questions:

1. What is the pretest performance of Grade 9 learners in integer operations?
2. What is the posttest performance after the implementation of the STRIKE manipulative tool?
3. Is there a significant difference between the pretest and posttest scores of male learners?
4. Is there a significant difference between the pretest and posttest scores of female learners?
5. Is there a significant difference between the posttest scores of male and female learners?

Significance of the Study

The findings of this study are expected to contribute to both mathematics education research and classroom practice by providing empirical evidence on the effectiveness of the Strategic Thinking and Reasoning in Integer Knowledge Enhancement (STRIKE) manipulative tool in improving Grade 9 learners' performance in integer operations. The study also seeks to enrich the growing body of literature on manipulative-based instruction by demonstrating the potential of contextualized instructional innovations in strengthening learners' conceptual understanding and computational proficiency in mathematics.:

Students. The findings may help students improve their conceptual understanding and computational skills in integer operations through a hands-on and interactive learning approach. The STRIKE manipulative tool is expected to enhance learners' engagement, confidence, and accuracy in solving integer-related problems.

Mathematics Teachers. The results of this study may provide teachers with an additional instructional intervention that can be integrated into mathematics lessons, particularly in teaching integer operations. The findings may also serve as a basis for improving classroom strategies that promote active learning and conceptual understanding.

School Administrators. The study may assist school heads and instructional leaders in identifying effective classroom interventions that can be incorporated into school-based mathematics improvement programs. The findings may also support professional development initiatives focusing on the use of manipulative materials in mathematics instruction.

Department of Education (DepEd). The findings may provide evidence that can support the development and adoption of contextualized instructional materials and intervention programs aimed at improving numeracy performance among junior high school learners.

Curriculum Developers. The study may contribute to the enhancement of mathematics

instructional materials by providing evidence on the effectiveness of manipulative-based learning strategies in teaching abstract mathematical concepts such as integer operations.

Future Researchers. This study may serve as a reference for future investigations involving manipulative tools, mathematics interventions, or instructional innovations. Researchers may replicate or extend this study using different mathematical topics, research designs, larger populations, or different educational settings.

Scope and Limitation of the Study

This study focused on determining the effectiveness of the Strategic Thinking and Reasoning in Integer Knowledge Enhancement (STRIKE) manipulative tool in improving the integer operations performance of Grade 9 learners in mathematics. Specifically, it examined the learners' pretest and posttest scores in integer operations and determined whether significant differences existed before and after the implementation of the STRIKE manipulative tool. The study also compared the posttest performance of male and female learners.

The study employed a quantitative pre-experimental one-group pretest–posttest design. The participants consisted of 30 Grade 9 learners from Lantangan National High School who were purposively selected based on their low pretest scores in integer operations. The Integer Test of Primary Operations (ITPO) served as the primary instrument for measuring learners' performance before and after the intervention. The STRIKE manipulative tool was implemented as the instructional intervention for a period of two weeks during the National Mathematics Program schedule.

The findings of this study are limited to the selected participants and the research setting; therefore, the results cannot be generalized to all junior high school learners. The study focused exclusively on integer operations, specifically the addition, subtraction, multiplication, and division of integers, and did not investigate other mathematics competencies. Furthermore, the study did not include a control group because of the one-group pretest–posttest design. Variables such as learners' motivation, attitudes toward mathematics, teacher effectiveness, socioeconomic status, and other external factors that may influence academic performance were not examined. In addition, the two-week intervention period may have limited the extent of learners' improvement and did not permit the assessment of long-term retention of integer operation skills. Therefore, the findings should be interpreted within the context of the STRIKE intervention, the two-week implementation period, and the limitations inherent in the pre-experimental one-group pretest–posttest research design.

Theoretical Framework

This study is anchored on Bruner's Theory of Representation (Bruner, 1966) and Constructivist Learning Theory (Piaget, 1972), which provide the theoretical foundation for the use of manipulative-based instruction in teaching integer operations.

Bruner's Theory of Representation explains that learning progresses through three interconnected modes of representation: enactive, iconic, and symbolic. The enactive mode emphasizes learning through direct manipulation of concrete objects and hands-on experiences. As learners gain understanding, they progress to the iconic mode, where knowledge is represented through visual images and diagrams. Finally, learners reach the symbolic mode, in which mathematical concepts are represented using symbols, numbers, and abstract reasoning (Bruner, 1966). This progression suggests that learners develop stronger conceptual understanding when they first experience mathematical concepts concretely before moving toward abstract computation.

The STRIKE manipulative tool was developed based on these principles by providing learners with a concrete instructional material that allows them to manipulate positive and negative integers before performing symbolic operations. Through repeated interaction with the manipulative, learners are expected to strengthen their conceptual understanding of integer operations, minimize misconceptions, and improve computational proficiency.

The study is likewise supported by Constructivist Learning Theory, particularly the work of Piaget (1972), which posits that learners actively construct knowledge by interacting with their environment and integrating new experiences with their existing cognitive

structures. Rather than passively receiving information, learners develop meaningful understanding through exploration, problem solving, and reflection. Manipulative-based instruction promotes this active construction of knowledge by allowing learners to discover mathematical relationships through concrete experiences.

The theoretical foundation is further supported by empirical evidence. Carbonneau et al. (2013) reported through a meta-analysis that concrete manipulatives have a positive effect on students' mathematics achievement when integrated with effective instructional strategies. Similarly, Moyer-Packenham and Westenskow (2013) found that manipulative-based instruction significantly enhances learners' conceptual understanding, engagement, and mathematical achievement.

Guided by these theoretical perspectives, this study assumes that providing learners with meaningful concrete learning experiences through the STRIKE manipulative tool facilitates conceptual understanding and contributes to improved performance in integer operations.

Conceptual Framework

Guided by Bruner's Theory of Representation (Bruner, 1966) and Constructivist Learning Theory (Piaget, 1972), the conceptual framework illustrates the relationship between the independent and dependent variables of the study. It explains how the implementation of the Strategic Thinking and Reasoning in Integer Knowledge Enhancement (STRIKE) manipulative tool is expected to influence learners' performance in integer operations.

The independent variable of the study is the Strategic Thinking and Reasoning in Integer Knowledge Enhancement (STRIKE) manipulative tool, which serves as the instructional intervention during the teaching of integer operations. Designed based on the principles of concrete and learner-centered instruction, the STRIKE manipulative tool provides learners with opportunities to visualize, manipulate, and perform integer operations through hands-on learning experiences before transitioning to symbolic computation. This instructional approach is consistent with research demonstrating that mathematical manipulatives strengthen conceptual understanding and computational proficiency (Carbonneau et al., 2013; Moyer-Packenham & Westenskow, 2013).

The dependent variable is the students' performance in integer operations. This variable is measured using learners' pretest and posttest scores obtained from the Integer Test of Primary Operations (ITPO). The effectiveness of the STRIKE manipulative tool is evaluated by comparing learners' performance before and after the intervention using descriptive statistics, specifically the mean and standard deviation, and inferential statistics through the paired-samples *t*-test. Furthermore, an independent-samples *t*-test is employed to determine whether significant differences exist between the posttest performance of male and female learners.

The conceptual framework assumes that the implementation of the STRIKE manipulative tool may contribute to improved learner performance in integer operations by strengthening conceptual understanding and computational proficiency through concrete learning experiences. Improvements in learners' posttest scores relative to their pretest scores serve as the basis for evaluating the effectiveness of the instructional intervention within the context and limitations of the present study.

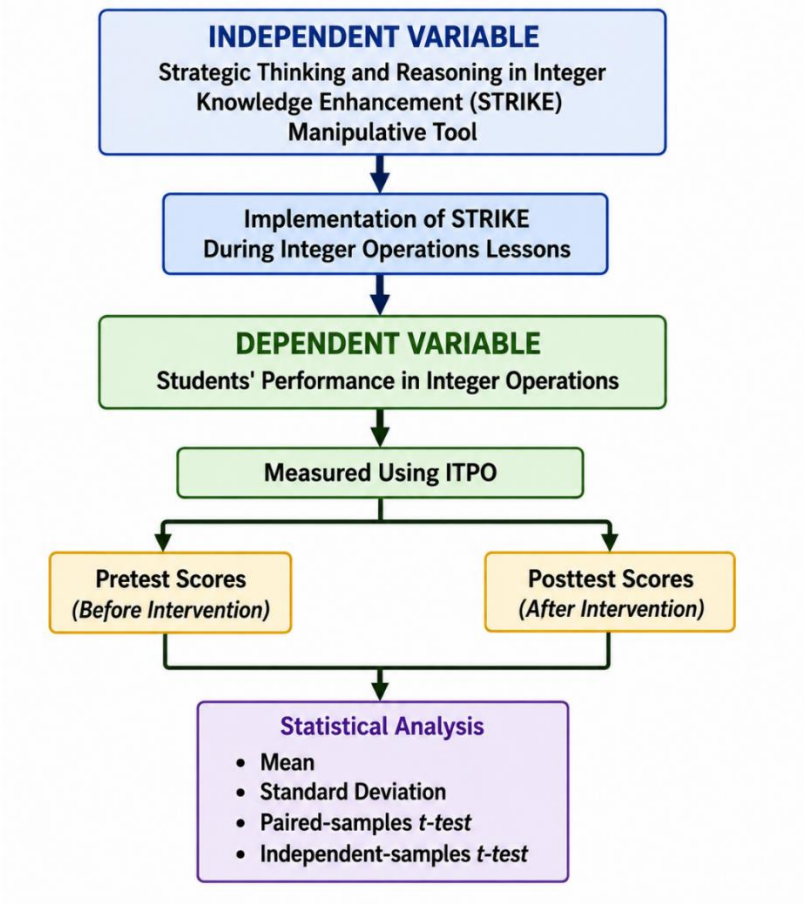

Figure 1. Conceptual Paradigm

Review Of Related Literature and Studies

The effectiveness of mathematics instruction depends largely on learners' conceptual understanding of fundamental mathematical ideas. Among these foundational concepts, integer operations remain one of the most challenging competencies for junior high school learners because they require students to move beyond whole-number reasoning and develop an understanding of positive and negative quantities. Numerous studies have examined the difficulties students encounter in learning integers and have proposed instructional strategies that improve conceptual understanding through meaningful learning experiences. This review synthesizes previous literature under five major themes: misconceptions about integers, pedagogical strategies for teaching integers, assessment of integer knowledge, effectiveness of manipulative tools, and contextual factors influencing mathematics learning.

Misconceptions about Integers. Research consistently demonstrates that misconceptions about integers remain a major obstacle to mathematics achievement among secondary learners. Many students incorrectly transfer their understanding of whole numbers to integer operations, resulting in systematic errors when working with positive and negative numbers. These misconceptions commonly involve misunderstanding the meaning of negative signs, misapplying operational rules, and treating all integers as if they were positive numbers. Such conceptual difficulties often prevent learners from developing flexible mathematical reasoning and hinder their success in more advanced mathematical topics.

Previous investigations have identified several sources of these misconceptions. Makonye and Fakude (2016) reported that learners frequently experience difficulties because instruction lacks meaningful representations such as number lines and contextual situations that illustrate integer concepts. Similarly, Bishop et al. (2014) explained that students encounter cognitive barriers when interpreting negative numbers because early mathematical

experiences emphasize counting and positive quantities. Sevim (2015) likewise documented frequent errors involving sign manipulation, ordering of integers, and incorrect application of operational procedures. These findings indicate that learners require instructional experiences that move beyond memorization and promote conceptual understanding.

Further evidence suggests that misconceptions developed during the early introduction of integers may persist throughout later mathematics learning. Kobak Demir, Azizoğlu, and Gür (2016) observed that inadequate understanding of negative integers negatively affects students' ability to perform subsequent integer operations. Likewise, Yürekli (2020) found that many students continued to compare integers solely according to their numerical value without considering their positive or negative signs. These persistent misconceptions demonstrate that learners need repeated opportunities to visualize and interpret integer relationships through meaningful instructional activities rather than relying solely on procedural rules.

Researchers have also emphasized that instructional practices contribute significantly to the development of these misconceptions. Khalid and Embong (2019) argued that students often memorize operational rules because classroom instruction tends to prioritize syllabus coverage over conceptual understanding. Similarly, Erdem et al. (2015) recommended connecting negative numbers with authentic real-life situations to help learners internalize their meaning. Collectively, these studies suggest that meaningful learning experiences supported by concrete representations are essential for improving students' understanding of integer operations.

Pedagogical Strategies for Teaching Integers. The literature emphasizes that effective instruction in integers requires learner-centered teaching approaches that actively engage students in constructing mathematical understanding. Rather than relying exclusively on lectures and procedural demonstrations, mathematics educators are encouraged to provide opportunities for learners to manipulate objects, explore mathematical relationships, collaborate with peers, and connect abstract concepts to authentic situations. Such instructional approaches enable students to develop deeper conceptual understanding while strengthening their problem-solving abilities.

Several researchers have identified instructional strategies that effectively improve students' understanding of integer operations. Acosta and Soliba (2024) highlighted the value of combining drill exercises with manipulative materials and technology-assisted learning to reinforce foundational concepts. Similarly, Almeida and Bruno (2014) emphasized the importance of using concrete representations that help learners visualize positive and negative quantities. Constructivist learning theory likewise supports the use of multiple representations because students develop stronger mathematical understanding when they actively construct knowledge from meaningful experiences.

Activity-based instruction has also demonstrated positive effects on mathematics learning. Rubin et al. (2014) reported that learners who actively participate in mathematical activities exhibit stronger conceptual understanding than those who rely solely on traditional instruction. Likewise, Çetin (2019) recommended the use of integer modeling activities that encourage learners to explore relationships among integers through meaningful contexts. These findings collectively indicate that instructional strategies promoting active participation are more likely to improve students' mastery of integer operations than approaches emphasizing memorization alone.

Assessment and Measurement of Integer Knowledge. Accurate assessment plays an important role in determining learners' conceptual understanding of integer operations and evaluating the effectiveness of instructional interventions. Reliable assessment instruments provide educators with evidence regarding students' strengths, misconceptions, and areas requiring additional instructional support. Such information allows teachers to design targeted interventions that address specific learning difficulties while monitoring students' progress over time.

One of the most widely recognized assessment tools for integer operations is the Integer Test of Primary Operations (ITPO), developed

and validated by Nurnberger-Haag and colleagues. The instrument measures learners' proficiency in addition, subtraction, multiplication, and division of integers and has demonstrated strong reliability and validity through Rasch analysis. Because of its comprehensive coverage of integer operations, the ITPO has become a useful instrument for evaluating instructional interventions and measuring conceptual understanding among middle school learners.

Researchers have further emphasized that assessment should extend beyond measuring procedural accuracy to include learners' conceptual reasoning. Nurnberger-Haag (2018) argued that long-term understanding of integers requires continuous assessment capable of identifying persistent misconceptions and monitoring conceptual growth. Consequently, valid and reliable assessment instruments remain essential for evaluating instructional innovations such as manipulative-based learning interventions.

Effectiveness of Manipulative Tools in Integer Learning. Manipulative materials have long been recognized as valuable instructional resources for improving students' understanding of mathematical concepts. Unlike traditional lecture-based instruction, manipulative-based learning enables students to interact directly with mathematical ideas through concrete objects, thereby facilitating the transition from concrete experiences to abstract reasoning. Such instructional approaches encourage active participation, enhance conceptual understanding, and increase learners' confidence in solving mathematical problems.

Research consistently demonstrates the positive impact of manipulatives on students' mathematics achievement. Student-centered instructional approaches that incorporate hands-on activities have been associated with higher levels of participation, motivation, and academic performance. By allowing learners to visualize mathematical relationships, manipulatives promote meaningful learning experiences that are often difficult to achieve through symbolic instruction alone. As learners manipulate concrete representations, they develop a deeper understanding of mathematical structures and become more capable of applying concepts to unfamiliar situations.

Several empirical studies support the effectiveness of manipulative-based instruction in teaching integer operations. Chong et al. (2022) reported that the use of a non-digital card game significantly improved students' performance in integer operations by promoting active engagement during classroom activities. Similarly, Bouck and Park (2020) found that virtual manipulatives enhanced students' understanding of integer addition, particularly among learners experiencing mathematical difficulties. These findings indicate that both physical and digital manipulatives can improve conceptual understanding when integrated appropriately into mathematics instruction.

Evidence from previous intervention studies further strengthens the use of manipulatives in mathematics education. Sahat, Tengah, and Prahmana (2018) reported a substantial increase in students' achievement after implementing manipulative-based lessons on integer computation, demonstrating a large instructional effect. Likewise, Kwakye et al. (2022) recommended the use of number-rule manipulatives in teaching integer addition and subtraction because they promote conceptual understanding while improving computational accuracy. Perez (2023) also observed that manipulative and interactive instructional materials encouraged learners to work more independently and accurately during mathematical tasks. Collectively, these findings provide strong evidence that carefully designed manipulative tools can significantly improve students' mathematical performance.

Other intervention studies have similarly highlighted the effectiveness of game-based and manipulative-centered instruction. Clarke et al. (2018) demonstrated positive learning outcomes through the ROOTS mathematics intervention program, while Furio, Fulay, and Janer (2022) found that the educational card game *Kwatro* significantly enhanced Grade 7 learners' computational skills in integer addition. Singh et al. (2021) likewise reported improvements in numeracy skills through the use of the Math Zap card game. Although these instructional materials differ in design and implementation, they consistently illustrate

that learner-centered manipulative activities contribute to improved mathematical understanding, greater engagement, and higher academic achievement.

The collective evidence from previous studies supports the use of manipulative materials as effective instructional interventions for mathematics education. However, relatively few studies have developed manipulative tools specifically designed to address all four fundamental operations involving integers among junior high school learners. This gap provided the rationale for developing the Strategic Thinking and Reasoning in Integer Knowledge Enhancement (STRIKE**)** manipulative tool, which aims to strengthen learners' conceptual understanding through structured, interactive, and hands-on learning experiences.

Cultural and Contextual Factors Affecting Integer Learning. Mathematics learning does not occur independently of learners' social and cultural experiences. Contemporary educational research emphasizes that students develop stronger conceptual understanding when mathematical ideas are presented within contexts that are meaningful and relevant to their daily lives. Contextualized instruction enables learners to connect abstract concepts with familiar experiences, thereby promoting deeper engagement, critical thinking, and long-term retention of knowledge.

Several studies have demonstrated the educational value of incorporating local contexts into mathematics instruction. Researchers have reported that contextualized learning using local wisdom enhances learners' cognitive development, encourages active classroom participation, and creates more enjoyable learning environments. In addition, instructional materials grounded in learners' cultural experiences promote greater interest in mathematics and improve academic achievement by making abstract concepts more understandable and relatable.

The integration of culturally relevant instructional materials also benefits teachers by providing opportunities to design learning activities that reflect the realities of their communities. Deda and Maifa (2021) found that student worksheets incorporating local contexts effectively improved junior high school learners' mathematical skills and learning outcomes. Such findings suggest that instructional materials become more meaningful when they reflect students' lived experiences and encourage active participation in the learning process.

In addition to cultural influences, researchers have explored the effects of socioeconomic factors on mathematics achievement. Although some studies reported that students from higher socioeconomic backgrounds generally perform better academically because of greater educational opportunities and learning resources, other investigations found minimal differences in mathematics proficiency across income groups. These mixed findings suggest that socioeconomic status alone cannot fully explain variations in students' mathematics achievement, highlighting the importance of instructional quality, learner engagement, and effective teaching strategies.

Overall, previous literature indicates that meaningful mathematics instruction results from the interaction of effective pedagogy, appropriate learning resources, and relevant learning contexts. While learner characteristics and environmental factors may influence achievement, classroom instruction remains one of the most significant determinants of students' mathematical success. Consequently, instructional innovations such as the STRIKE manipulative tool provide opportunities to create engaging learning environments that support conceptual understanding regardless of learners' backgrounds.

Research Design

This study employed a quantitative pre-experimental research design, specifically the one-group pretest–posttest design, to evaluate the effectiveness of the Strategic Thinking and Reasoning in Integer Knowledge Enhancement (STRIKE) manipulative tool in improving the integer operation skills of Grade 9 learners. In this design, participants completed a pretest before the implementation of the intervention and a posttest after the intervention. The comparison of pretest and posttest scores provided evidence regarding changes in students' performance following exposure to STRIKE. Since only one group of participants received the intervention, no control group was included in

the study. This design was considered appropriate because it allowed the researcher to measure learning gains associated with the implementation of the instructional material.

Research Locale

The study was conducted at Lantangan National High School, a public secondary school located in the Municipality of Mandaon, Province of Masbate, Philippines. The school serves learners from surrounding rural communities and offers Junior High School education. Grade 9 learners were selected because integer operations form an essential component of the Junior High School Mathematics curriculum and because these learners experienced disruptions in foundational mathematics instruction during the post-pandemic transition. The study was limited to this setting to ensure consistency in the implementation of the intervention and to facilitate data collection.

Respondents of the Study

The respondents consisted of 30 Grade 9 learners enrolled during School Year 2024–2025. They were selected from a population of 58 Grade 9 students after the administration of the pretest. Fifteen participants were male and fifteen were female, providing balanced representation for the comparison of learning outcomes according to sex. The selection focused on learners who obtained relatively low scores in the pretest, as these students were expected to benefit most from the intervention.

Sampling Technique

The study employed purposive sampling to identify the participants. Following the administration of the Integer Test of Primary Operations (ITPO), the researcher selected the thirty learners with the lowest pretest scores. This sampling technique was appropriate because it enabled the study to focus on learners demonstrating greater instructional needs in integer operations. Selecting participants based on predetermined criteria ensured that the intervention targeted students who required additional support in mastering the competencies under investigation.

Research Instruments

Two instruments were utilized in the conduct of the study. The first instrument was the **Integer Test of Primary Operations (ITPO)** developed by Nurnberger-Haag, which served as both the pretest and posttest. The ITPO consists of **30 items** covering the four fundamental operations involving integers: addition, subtraction, multiplication, and division. Previous validation studies have demonstrated that the instrument possesses satisfactory reliability and validity for measuring learners' proficiency in integer operations.

The second instrument was the **Strategic Thinking and Reasoning in Integer Knowledge Enhancement (STRIKE)** manipulative tool developed by the researcher. STRIKE is a hands-on instructional material specifically designed to strengthen learners' conceptual understanding of integer operations through guided manipulation and interactive learning activities. The instructional material emphasizes the four basic integer operations and provides learners with concrete representations that facilitate conceptual and procedural understanding.

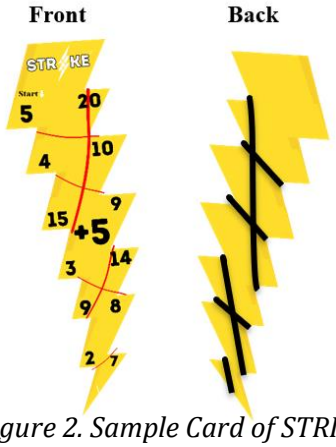

Figure 2. Sample Card of STRIKE

Data Gathering Procedure

Prior to data collection, the researcher secured all necessary approvals from the appropriate institutional and school authorities. Permission to conduct the study was obtained from the Graduate School, the Schools Division Office of Masbate Province, and the school administration of Lantangan National High School. Because the participants were minors, informed consent was likewise obtained from their parents or guardians before the implementation of the study.

The study began with the administration of the Integer Test of Primary Operations (ITPO) to all 58 Grade 9 learners. Based on the pretest results, the thirty learners who obtained the lowest scores were selected as participants through purposive sampling. These learners then participated in the STRIKE intervention conducted for 30 minutes each afternoon over a two-week period as part of the school's National Mathematics Program schedule. The intervention focused on strengthening learners' understanding of integer addition, subtraction, multiplication, and division through structured manipulative-based activities.

At the conclusion of the intervention period, the same assessment instrument was administered as a posttest to determine changes in students' performance. The collected data were subsequently organized, encoded, and analyzed to evaluate the effectiveness of the STRIKE manipulative tool in improving learners' proficiency in integer operations.

Statistical Treatment of Data

The study employed both descriptive and inferential statistical techniques to analyze the data. Descriptive statistics, including frequency counts, mean scores, and standard deviations, were used to summarize the participants' pretest and posttest performance. Learners' proficiency levels were interpreted using the proficiency descriptors prescribed in DepEd Order No. 73, s. 2012.

Table 1. Proficiency Level

Proficiency Level	Percentage Range	Score Range (Out of 30 items)
Advanced (A)	90% and above	27 – 30
Proficient (P)	85% – 89%	26
Approaching Proficiency (AP)	80% – 84%	24 – 25
Developing (D)	75% – 79%	23
Beginning	74 and below	0 – 22

Inferential statistics were applied to determine whether significant differences existed in students' performance. A **paired-samples t-test** was used to compare the pretest and posttest scores of male and female learners separately in order to determine the effectiveness of the intervention within each group. An **independent-samples t-test** was then employed to compare the posttest scores of male and female learners and determine whether significant differences existed between the two groups after the implementation of STRIKE. Microsoft Excel was used for descriptive analyses, while **RStudio** was utilized for inferential statistical computations.

Results And Discussion

Pretest Performance of Grade 9 Learners Before the STRIKE Intervention

The pretest findings revealed that both male and female Grade 9 learners demonstrated Beginning proficiency in integer operations prior to the implementation of the STRIKE manipulative tool. Male learners obtained a mean score of 11.00 (SD = 3.10), while female learners achieved a slightly higher mean score of 11.93 (SD = 3.66). Although female learners outperformed their male counterparts by less than one point, both groups remained within the Beginning proficiency level, indicating that learners had not yet mastered the competencies involving integer operations.

Table 2. Pre-test Score of Participant per Gender Before the Use of STRIKE

Participants	Pre-test Mean Score	Standard Deviation	Numerical Value	Interpretation
Male	11	3.098387	74% and below	Beginning
Female	11.93333333	3.659994	74% and below	Beginning

These findings suggest that learners entered the intervention with limited conceptual understanding of integers. The relatively low pretest scores indicate that many students had trouble interpreting positive and negative numbers, applying operational rules, and solving integer problems accurately. Such misconceptions may have originated from earlier learning experiences in which procedural memorization was emphasized more than conceptual reasoning. Consequently, learners may have developed operational strategies that were insufficient for solving more complex integer problems.

The observed performance is consistent with previous studies reporting that misconceptions involving negative numbers remain one of the most persistent learning difficulties in mathematics. Earlier researchers found that students frequently ignore negative signs, incorrectly apply operational rules, and transfer their understanding of whole numbers to integer operations. The present findings therefore reinforce existing evidence that many junior high school learners require additional instructional support before they can demonstrate proficiency in integer computation.

From an instructional perspective, the pretest results justified the implementation of the STRIKE manipulative tool. Since both groups exhibited comparable levels of prior knowledge, the intervention provided an appropriate opportunity to determine whether a hands-on instructional approach could improve learners' conceptual understanding and computational performance in integer operations.

Posttest Performance of Grade 9 Learners After the STRIKE Intervention

Following the implementation of the STRIKE manipulative tool, both male and female learners demonstrated improved performance in integer operations. Male learners achieved a mean posttest score of **14.27** (SD = 2.38), whereas female learners obtained a mean score of **15.53** (SD = 2.83). Although both groups remained within the Beginning proficiency category based on the adopted proficiency descriptors, the increase in mean scores indicates measurable improvement in students' understanding of integer operations after the intervention.

The improvement observed in both groups suggests that the STRIKE manipulative tool effectively facilitated conceptual learning by providing learners with concrete representations of otherwise abstract mathematical ideas. Through repeated manipulation and guided exploration, students were able to visualize relationships among integers and apply operational rules more confidently. The reduction in score variability after the intervention further indicates that improvements occurred across most participants rather than being limited to a few high-performing learners.

Table 3. Post-test Score of Participant per Gender Before the Use of STRIKE

Participants	Post-test Mean Score	Standard Deviation	Numerical Value	Interpretation
Male	14.26666667	2.379542	74% and below	Beginning
Female	15.53333333	2.825283	74% and below	Beginning

These findings support the growing body of literature emphasizing the effectiveness of manipulative-based instruction in mathematics education. Previous intervention studies have consistently shown that hands-on learning promotes active participation, enhances conceptual understanding, and improves students' mathematical achievement. The present study contributes additional evidence by demonstrating that STRIKE can effectively improve

learners' performance in all four fundamental integer operations among Grade 9 students.

Despite these gains, the posttest results also indicate that additional instructional support remains necessary. While students improved considerably, their performance did not yet reach the Developing proficiency level. This finding suggests that the two-week intervention successfully strengthened foundational understanding but may not have provided sufficient time for learners to attain mastery of integer operations. Future implementations of STRIKE may therefore benefit from longer intervention periods and integration into regular classroom instruction rather than serving solely as a remediation activity.

Difference Between the Pretest and Posttest Scores of Male Learners

The paired-samples t-test revealed a statistically significant improvement in the performance of male learners following the implementation of STRIKE (t = -6.9099, p = 0.000007209). The mean score increased from **11.00** during the pretest to **14.27** during the posttest, indicating that the observed improvement was unlikely to have occurred by chance. These findings provide statistical evidence supporting the effectiveness of the intervention in improving the integer operation skills of male learners.

The significant improvement may be attributed to the instructional features of STRIKE, which transformed abstract integer concepts into concrete learning experiences. Rather than relying exclusively on memorized rules, learners actively manipulated the instructional material while solving mathematical problems. Such experiences likely promoted stronger conceptual understanding and enabled students to construct more meaningful relationships among integer operations.

Table 4. Paired t-test Results of Pre-test and Post-test Scores for Male Learners

Statistic	Pre-test Mean	Post-test Mean	t-value	Mean Difference	Df	p-value	Decision Rule	Interpretation
Values	11.0	14.26667	-6.9099	-3.266667	14	0.000007209	Reject Null Hypothesis	Significant Difference

The findings are consistent with previous studies demonstrating that manipulative-based instruction increases learners' mathematical achievement by encouraging active engagement and improving conceptual understanding. The present study therefore supports the growing evidence that carefully designed instructional materials can effectively address persistent misconceptions in mathematics and strengthen learners' computational competence.

Difference Between the Pretest and Posttest Scores of Female Learners

The paired-samples t-test revealed a statistically significant improvement in the performance of female learners following the implementation of the STRIKE manipulative tool (t = -12.435, p = 0.000000005912). The mean score increased from **11.93** during the pretest to **15.53** in the posttest, indicating a mean gain of **3.60 points**. Since the obtained p-value was considerably lower than the 0.05 level of significance, the null hypothesis was rejected, confirming that the observed improvement was statistically significant.

Table 5. Paired t-test Results of Pre-test and Post-test Scores for Female Learners

Statistic	Pre-test Mean	Post-test Mean	t-value	Mean Difference	Df	p-value	Decision Rule	Interpretation
Values	11.93	15.53	-12.435	-3.6	14	0.000000005912	Reject Null Hypothesis	Significant Difference

The results indicate that STRIKE effectively strengthened female learners' conceptual understanding of integer operations. The intervention enabled students to engage actively with mathematical concepts through concrete manipulation rather than relying

solely on memorized computational rules. This hands-on approach likely facilitated deeper cognitive processing by allowing learners to visualize relationships among integers before performing symbolic operations. Such experiences are consistent with constructivist learning principles, which emphasize active knowledge construction through meaningful interaction with instructional materials.

The magnitude of improvement observed among female learners also suggests that manipulative-based instruction promotes active participation and sustained engagement during mathematics learning. Previous studies have consistently reported that learners benefit from instructional materials that transform abstract mathematical ideas into tangible experiences. The findings of the present study therefore reinforce existing evidence that manipulative tools serve as effective instructional interventions for improving students' conceptual understanding and computational proficiency in mathematics.

Although female learners obtained slightly higher posttest scores than male learners, the improvement observed in both groups demonstrates that STRIKE functions as an inclusive instructional resource capable of supporting learners regardless of sex. These findings further suggest that instructional strategies emphasizing active learning may be more influential than learner characteristics in improving mathematics achievement.

Difference Between the Posttest Scores of Male and Female Learners

An independent-samples *t*-test was conducted to determine whether significant differences existed between the posttest performance of male and female learners following the implementation of the STRIKE manipulative tool. The analysis yielded a *t*-value of **1.9999** with a corresponding *p*-value of **0.0553**, which exceeded the 0.05 level of significance. Consequently, the null hypothesis was not rejected, indicating that no statistically significant difference existed between the posttest scores of male and female learners. Although female participants obtained a slightly higher mean score (15.53) than male participants (14.27), the observed difference was not sufficient to establish a statistically meaningful distinction between the two groups.

Table 6. Independent Samples t-test Results for Post-test Scores of Male and Female Learneres

Statistic	t-value	df	p-value	95% Confidence Interval	Mean (Male)	Mean (Female)	Decision Rule	Interpretation
Values	1.9999	28	0.0553	[-0.05661434,4.72328101]	14.2667	15.533	Failed Reject Null Hypothesis	Not Significant Difference

These findings suggest that the effectiveness of STRIKE was not influenced by the sex of the learners. Instead, the manipulative tool provided comparable learning opportunities for both male and female students, enabling them to improve their understanding of integer operations regardless of demographic differences. This result supports the premise that instructional interventions emphasizing conceptual understanding and active engagement benefit learners equitably when implemented effectively.

The findings are likewise consistent with previous research reporting minimal or no significant differences in mathematics achievement based on sex when learners are exposed to similar instructional conditions. Rather than attributing differences in performance to biological or demographic characteristics, the present study highlights the importance of instructional quality, learner engagement, and access to appropriate learning resources. These factors appear to exert greater influence on students' mathematical achievement than sex alone.

From an educational perspective, the results indicate that STRIKE may be implemented confidently in mixed-gender classrooms without requiring modifications based on learner sex. This characteristic enhances its practicality for classroom instruction because teachers can employ the manipulative tool as a universal

instructional resource that promotes equitable learning opportunities for all students.

Conclusion

The findings of this study demonstrate that the Strategic Thinking and Reasoning in Integer Knowledge Enhancement (STRIKE) manipulative tool is an effective instructional intervention for improving Grade 9 learners' proficiency in integer operations. Prior to the intervention, both male and female learners demonstrated Beginning-level proficiency, indicating limited conceptual understanding of integer operations. Following the implementation of STRIKE, both groups exhibited measurable improvements in their posttest performance, and the paired-samples *t*-tests confirmed that these gains were statistically significant.

Furthermore, the independent-samples *t*-test revealed no statistically significant difference between the posttest performance of male and female learners. This finding suggests that STRIKE provides equitable learning opportunities and effectively supports students regardless of sex. The improvement observed across both groups indicates that manipulative-based instruction enhances conceptual understanding by enabling learners to interact actively with mathematical ideas through concrete learning experiences.

Overall, the study provides empirical evidence supporting the integration of STRIKE into mathematics instruction as a supplementary learning resource for teaching integer operations. The findings reinforce the value of learner-centered instructional approaches that promote conceptual understanding, active engagement, and meaningful learning experiences. Consequently, STRIKE has the potential to serve as an effective classroom intervention for improving students' mathematical proficiency while addressing persistent misconceptions regarding integer operations.

Recommendations

Based on the findings of the study, the following recommendations are offered:

1. **Mathematics teachers** are encouraged to integrate the STRIKE manipulative tool into classroom instruction, remediation activities, and enrichment programs to strengthen students' conceptual understanding of integer operations.
2. **School administrators** should support the production and classroom utilization of STRIKE by providing instructional resources and professional development opportunities that promote manipulative-based teaching strategies.
3. **The Department of Education** may consider validating the STRIKE manipulative tool for broader implementation across schools and incorporating manipulative-based approaches into Mathematics teacher training and instructional support programs.
4. **Curriculum developers** are encouraged to incorporate contextualized manipulative activities similar to STRIKE into mathematics learning resources, lesson exemplars, and teacher guides to enhance conceptual learning.
5. **Future researchers** should conduct quasi-experimental or true experimental studies involving larger and more diverse samples to further establish the effectiveness of STRIKE. Future investigations may also explore its application to other mathematical topics, evaluate its long-term effects on knowledge retention, and examine additional factors such as learner motivation, engagement, and mathematical self-efficacy.

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