Chapter # 20

EXPLORING THE EFFECTIVENESS OF INTEGRATING DIDACTIC GAMES IN ARITHMETIC LESSONS:
A case study at the rudimentary level in South Africa

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ABSTRACT
Primary school learners' consistent underperformance in arithmetic, mainly attributed to ineffective instructional approaches employed in mathematics classrooms in South Africa, is the impetus for conducting this study. This quantitative case study examined the efficacy of incorporating a didactic game - Magic Square - in tandem with the Gurteen Knowledge Café approach for arithmetic instructions. Participants (n = 31) were Grade 3 learners from a primary school in the Northern Cape Province. Initially, learners were taught arithmetic using the traditional approach, followed by a pre-test. The intervention involved collaborative groups of 3-4 learners engaging with the new pedagogy, followed by a post-test. Kolb's experiential learning cycle served as the theoretical framework. Data collection methods included classroom observations, a pre-test and a post-test. Learners' pre-test and post-test scores were statistically analysed using the Bayesian Random-Effect Negative Binomial Model, which revealed a significant difference between the mean marks of the pre-test and post-test. The findings suggest that Magic Square is a more effective pedagogical tool for conducting arithmetic lessons at a rudimentary level compared to the traditional approach. Consequently, the researchers recommend incorporating the Magic Square as a didactic game into arithmetic instructions in South African primary schools to improve learners' performance and engagements.

Keywords: arithmetic, didactic games, experiential learning, magic square, rudimentary level.

1. INTRODUCTION

Arithmetic is a fundamental mathematical concept taught at the rudimentary level. However, learners' persistent underperformance in arithmetic operations and properties has intensified scrutiny on how those concepts are taught in mathematics classrooms (DoBE, 2024). The limitations of abstract instruction via traditional methods have prompted a shift toward practical approaches, notably through the integration of didactic games in early arithmetic lessons (Vankúš, 2021; Rabbimov, 2020).

Gamification has emerged as an effective pedagogical strategy for primary mathematics, grounded in the premise that children learn best through thoughtful play, making lessons demonstrable, engaging and enjoyable (Liu, Wang, & Lee, 2021; Vankúš, 2021). Didactic games promote learning through play-based activities that foster social interaction, motivation and healthy competition (Zhelal & Kaymak, 2023). Rooted in progressivist epistemology, these games bridge the gap between abstract theory and practical understanding (Hui & Mahmud, 2023). Games like Magic Square make mathematics playful and joyful, enhancing learners' interest and motivating them to solve both familiar and novel problems.

Incorporating appropriate didactic games and scaffolded activities can enable learners to attain conceptual understanding. These games can be implemented individually or in groups. Vankúš (2013) identifies key components of effective game-based instructions: game environment, objectives, rules and assessment. Didactic games deepen conceptual understanding; they also enhance engagement, teamwork and critical thinking. They cultivate spatial reasoning, improve mathematical achievement, and support sensory-motor development (Zhelal & Kaymak, 2023). Examples include Math Bingo, Math Jeopardy, Domino, Snakes and Ladders, and Magic Square-the focus of this study. Incorporating didactic games involves creative, play-based activities, often competitive, that stimulate learners' interest and motivation (Zhelal & Kaymak, 2023). However, relevant didactic games must be carefully selected to align with specific mathematical concepts, and their incorporated lessons have to be delivered in an enabling environment.

This study tested the effectiveness of Magic Square for teaching Grade 3 learners' arithmetic. A Bayesian Random-Effect Negative Binomial Model was used to analyze participants' pre- and post-test scores. This statistical method of evaluating the effectiveness of incorporating Magic squares in arithmetic lessons at the rudimentary level is limited in literature, adding to the novelty of conducting this study. Arithmetic involves numerical computations using operations such as addition, subtraction, multiplication, and division (Wang, 2015). Yet, instructional challenges often lead to learning and problem-solving difficulties. The researchers assert that developing effective pedagogical strategies for arithmetic at the rudimentary level would be essential in addressing those gaps. Thus, this study investigated the appropriateness of Magic Square as a reliable instructional tool for conducting arithmetic lessons.

Kolb's experiential learning theory underpinned the study, emphasizing four stages: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 1984). Children learn best through hands-on activities which allow them to manipulate concrete materials on their own. Participants engaged with Magic Square through direct experience, observed its application in solving arithmetic problems, internalized its use, and formed abstract representations. Finally, they actively experimented with solving both related and unrelated problems using the didactic game. The study aimed to establish a rationale for using Magic Square as a didactic game for teaching arithmetic in Grade 3. The central research question was: *How did the utilization of Magic Square as a didactic game impact participants' performance when solving arithmetic problems*?

2. LITERATURE REVIEW

Primary school learners often face significant challenges in grasping foundational mathematical concepts, necessitating timely and targeted pedagogical interventions (Suriya & Premalatha, 2024). Schoenfeld (2016) advocates mathematics to be taught as an exploratory and evolving discipline, emphasizing pattern recognition, conjecture formulation and reasoning over rote memorization. This perspective underscores the importance of fostering creativity and problem-solving in mathematics education. Within this framework, didactic games offer a promising strategy for cultivating learners' conceptual understanding and mitigating arithmetic-related difficulties (Bragg, 2012). By engaging learners in playful yet purposeful activities, such games align with constructivist principles and support intuitive learning through exploration and discovery.

Building on this theoretical foundation, didactic games can be understood as structured analogues of spontaneous children's activities designed to achieve specific educational objectives. Vankúš (2013) describes didactic games as stimulating tools that enhance engagement, creativity, spontaneity, cooperation, and competitiveness. Their student-centered nature encourages learners to construct knowledge through active participation rather than passive memorization. When applied to arithmetic instruction, didactic games can foster meaningful classroom interactions and support effective facilitation.

Arithmetic problems, as outlined by Demosthenous and Stylianides (2014) involve algebraic symbols, equations, generalizations and numerical relationships. These authors categorize algebra-related tasks into arithmetically situated relations, rule-based relations, and known-unknown relations. Didactic games provide learners with practical opportunities to develop arithmetic skills-particularly addition and subtraction-and to generalize their understanding using mathematical representations.

Bragg (2012) notes that didactic games can be used for drills, warm-up activities, and rewards, but cautions that their application requires careful consideration. Teachers must evaluate the appropriateness of each game for the targeted concept. When thoughtfully implemented, didactic games can enhance learners' creative and critical thinking, thereby improving learners' logical reasoning and problem-solving skills (Zhelal & Kaymak, 2023). Beyond cognitive benefits, didactic games influence learning across multiple dimensions which can be emotional, motivational, social, recreational and therapeutic (Vankúš, 2013). These dimensions suggest that didactic games do not only improve learners' mathematical achievements, but also, those games contribute to learners' holistic development, including sensory, emotional and physical well-being. By engaging learners in concrete experiences and personal reflection, didactic games promote deeper understanding and autonomy in the learning process (Zhelal & Kaymak, 2023).

Given the diversity and complexity of didactic games, selecting an appropriate game requires alignment with learners' developmental levels and instructional goals. Vankúš (2013,) proposes key evaluative questions: (1) How many learners will the game involve, and at what cognitive level? (2) What knowledge, skills, and traits does it develop? (3) What is its impact on instructional effectiveness? (4) How does it influence learners' attitudes? (5) What motivational effects does it produce? Importantly, Vankúš emphasizes that learners should be credited for making effort rather than performance alone. Examples of didactic games suitable for arithmetic instruction include Spot the Mistake, Pyramid Construction, Relay, Mathematical Memory, and Magic Square (Zhelal & Kaymak, 2023). This study focuses on Magic Square, a puzzle-based game designed to teach addition and subtraction. Its structure, a 3×3 grid requiring equal sums across rows, columns, and diagonals, makes it ideal for cultivating deductive reasoning and arithmetic fluency among primary school learners.

Effective implementation of a didactic game should address its thematic area, educational targets, environment, procedure, and assessment strategy (Vankúš, 2021). The thematic area refers to the mathematical content the game is designed to teach. In this study, Magic Square was used to support Grade 3 learners' understanding of arithmetic operations. The educational targets included enabling learners to solve problems involving addition, subtraction, and related expressions through scaffolded and sequential activities.

3. THEORETICAL FRAMEWORK

To evaluate the efficacy of the Magic Square in teaching Grade 3 arithmetic, this study adopted Kolb's experiential learning model as its theoretical framework (Kolb, 1984). Widely applied in educational psychology, Kolb's model outlines a cyclical process comprising four stages: concrete experience, reflective observation, abstract conceptualization and active experimentation. This structure facilitates deep, transferable learning through iterative engagements.

The concrete experience phase encompasses learners interacting directly with the instructional material in this case, Magic Square. This hands-on engagement allows learners to construct new knowledge by drawing on their prior experiences, creativity and feedback. Zhelal and Kaymak (2023) noted that didactic games like Magic Square enable learners to manipulate mathematical structures in playful, low-stakes environments, fostering curiosity and intrinsic motivation. The game's tactile and visual nature supports exploration of number relationships and arithmetic operations, aligning with progressivist and learner-centered pedagogies (Hui & Mahmud, 2023).

The reflective observation stage involves learners analyzing and making sense of their prior experiences. Learners reflect on their interactions with Magic Square, identifying patterns, errors and strategies. This metacognitive process enhances arithmetic fluency and problem-solving, as learners connect procedural actions with conceptual insights (Liu, Wang, & Lee, 2021). Reflection also supports personal meaning-making, a key component of sustained mathematical understanding.

In the abstract conceptualization phase, learners generalize their observations into coherent mental models. They begin to formulate hypotheses about mathematical logic underpinning Magic Square, transitioning from intuitive gameplay to structured reasoning. Vankúš (2021) emphasizes that didactic games serve as a bridge between concrete manipulation and abstract thinking, enabling learners to internalize arithmetic properties and operations.

The final stage, active experimentation, mandates learners to apply their conceptual understanding in new contexts. They solve novel problems, adjust game parameters, or design their own puzzles extending learning beyond the original activity. This phase promotes transfer of knowledge and adaptive problem-solving, especially when learners are encouraged to iterate and explore (Rabbimov, 2020).

Kolb's model provided a robust framework for structuring the instructional use of the Magic Square, guiding learners through a full cycle of experiential learning. By aligning each stage with targeted pedagogical strategies and game-based tasks, the study fostered deeper understanding, sustained engagement, and measurable gains in arithmetic performance. Integrating experiential learning theory with didactic game design offers a compelling approach to addressing persistent challenges in early mathematics education.

4. METHODOLOGY

4.1. Research Design

To ascertain the appropriateness of the didactic game- Magic Square - for primary school arithmetic lessons, the researchers found a case study research design to be appropriate for this study. A case study research design accorded the researchers the leeway to extensively observe and monitor participants in their natural classroom settings. This sufficiently guided the researchers to meaningfully measure the impact the Magic Square had on participants' problem-solving and performance in arithmetic. According to Creswell and

Poth (2018) a case study provides detailed and unabridged account of proceedings at the research field which provides researchers enough evidence to thoroughly answer the research questions being investigated.

4.2. Participants

This study investigated 31 purposively sampled learners from Grade 3 in a primary school in the Northern Cape Province in South Africa. According to Cohen, Manion and Morrison (2007) in purposive sampling, the researcher makes specific choices about which people to include in a study. These learners were from the same school, and they had the same mathematics teacher. They served as participants for this study after they agreed to do so in writing with any form of indemnity involved irrespective of their gender, race, ethnicity and social orientations.

4.3. Ethical Considerations

Informed consent, voluntary participation and confidentiality as ethical procedures were duly adhered to before, during and after conducting this study. On informed consent, the researchers sought for learners' and their parents and/or guardians, as well as the department of educations' permission in writing prior to conducting this study. Consent letters were signed by prospective participants together with their parent/guardian and ethical clearance approval letter with reference number: L2.10.2.4.3 was obtained from the Northern Cape Department of Education. On voluntary participation, only self-willing and self-motivated learners were considered as participants in this study. On confidentiality, participants' names and any form of identification of participants were kept anonymous from any third party.

4.4. Explication and Implementation of Magic Square for Solving Arithmetic Problems

The instructional process was partitioned into four stages based on Kolb's experiential learning theory. Each stage is described below with corresponding activities and pedagogical guidelines. This intervention lasted 3 weeks and 12 lessons were conducted - each lesson had a duration of 30 minutes.

Step 1: Classroom setting - Collaborative Learning - Gurteen Knowledge Café Approach

Objective: Enhance engagement and peer learning through structured group interaction.

Pedagogical Intent: This approach supports social constructivism, encouraging learners to co-construct knowledge through dialogue and shared inquiry. It complements the experiential cycle by embedding reflection and experimentation in a collaborative setting.

Guidelines:

- Organize learners into small groups of 3 – 4 participants per group.
- Facilitate brainstorming sessions where learners discuss strategies and solve problems collaboratively.
- Rotate roles (e.g., facilitator, recorder, presenter) to ensure active participation.

Step 2: Concrete Experience (Getting Acquainted with the Magic Square)

Objective: Introduce learners to the structure, rules and procedures of the Magic Square game.

Pedagogical Intent: This stage provides learners with hands-on exposure to the game, allowing them to manipulate numbers and observe patterns. It activates prior knowledge and sets the foundation for deeper learning.

Guidelines:

- Present a 3×3 Magic Square grid with some numbers filled in and others left blank.
- Explain the goal: to complete the grid so that the sums of each row, column, and diagonal are equal.
- Introduce basic arithmetic operations (addition and subtraction) used in the game.
- Demonstrate how the game can be used to solve arithmetic problems.

Suggested Visual: An image of a partially completed Magic Square is illustrated below:

		2
3	5	7
	1	

Step 3: Reflective Observation (Observing and Discussing Strategies)

Objective: Encourage learners to reflect on their experiences and observe how the Magic Square is used to solve arithmetic problems.

Pedagogical Intent: This stage promotes metacognitive awareness and helps learners make sense of their experiences. It supports the development of reasoning and analytical skills.

Guidelines:

- Ask learners to observe completed examples and discuss strategies used to arrive at the solution.
- Facilitate a class discussion or group reflection on patterns, symmetry and arithmetic relationships.

Use guiding questions such as:

- "What do you notice about the sums?"
- "How does changing one number affect the rest of the grid?"

Suggested Visual: A completed Magic Square with equal sums:

4	9	2
3	5	7
8	1	6

Step 4: Abstract Conceptualization (Forming Mental Models)

Objective: Enable learners to internalize and generalize the rules and logic of the Magic Square.

Pedagogical Intent: This stage fosters abstract reasoning and helps learners connect concrete experiences to formal mathematical concepts. It supports the transition from intuitive play to structured problem-solving.

Guidelines:

- Guide learners to **formulate rules** for completing a Magic Square.
- Introduce **arithmetic expressions** and relationships such as central symmetry, multiples, etc.
- Explain the logic behind the central box:

(a) The sum of numbers symmetrically opposite to the central box should be equal to **twice** the central number.
(b) Each row or column should be equal to **three times** the central number.

Suggested Visual: A diagram showing central symmetry and arithmetic relationships:

A	B	C
D	X	E
F	G	H

Where:

A + H = 2X
B + G = 2X
C + F = 2X
D + E = 2X
Row sums = 3X
Column sums = 3X

Step 5: Active Experimentation – Solving and Creating Magic Squares

Objective: Allow learners to apply their understanding by solving new problems and creating their own Magic Squares.

Pedagogical Intent: This stage emphasizes application and transfer of learning. Learners test their hypotheses, refine strategies, and engage in creative problem-solving

Guidelines:

- Provide learners with Activity 1 - Section A (numerical tasks) and Section B (non-numerical tasks)
- Ask learners to fill in missing values to complete the Magic Square.
- Encourage learners to create their own puzzles using given constraints.
- Use individual and group work formats to promote collaboration.

Suggested Visuals: Activity 1 (See Appendix 1)

- Section A: Completed Magic Square with numerical arithmetic tasks
- Section B: Completed Magic Square with non-numerical arithmetic task

4.5. Bayesian Negative Binomial Random-Effect Model for Assessing the Impact of a Didactic Game

The marks obtained by students (pre-test and post-test, each out of 50 marks) were recorded on a count scale, thus normality assumption may not hold which makes it inappropriate to use the traditional Analysis of Variance model to test for differences between the marks of the two groups. A more appropriate model for testing for differences in the marks for the two groups is the negative Binomial Random-effect model (Jiang, 2007). This model accounts for differences between participants as a result of variations in learning barriers and abilities and over-dispersion which are common for count data. In estimating the parameters of the model, one has the option of using traditional methods (frequentist approach) or the Bayesian approach. The frequentist approach however turns to produce inaccurate standard errors for small samples, thus may lead to spurious conclusions and generalizations. The Bayesian approach on the other hand is more useful in stabilizing the estimates, especially in small samples in the case of this study with a sample size of 31 (Follett & Vander Naald, 2020). Thus, it can produce a more accurate result. The Bayesian approach also allows one to incorporate prior information into the model. Although the marks obtained by the participants are within bounds, Hardin and Hilbe (2015) argue that standard negative Binomial models often remain preferable unless counts frequency hit the upper bound, which is not the case in this study. Thus, although our data is bounded, the negative binomial model is still a good and preferable choice. Due to these advantages of the Bayesian framework over the traditional estimation approach, the Bayesian Random-effect negative Binomial model was used in modelling the differences between the marks for the two groups. Here we are interested in testing the following hypothesis:

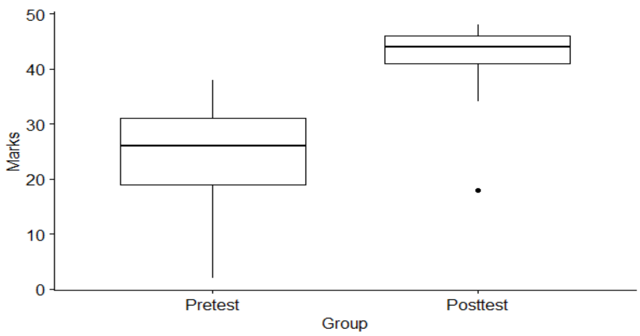
- H_O: Magic Square is an effective teaching method compared to the traditional approach.
- H_1: Magic Square is not an effective teaching method compared to the traditional approach.

5. RESULTS AND DISCUSSIONS

5.1. Preliminary Data Analysis

When testing for differences between two populations or samples, a box plot becomes more useful. Although it does not provide a formal test to assess the significance of the differences between the population means or samples, it provides a graphical means to pre-assess if there exist differences in the means of two or more groups. A box plot of the marks for the two tests is presented in Figure 1. It is evident from the plot that the marks of the control group (denoted pre-test) are lower than the marks of the experimental group (denoted post-test). This observation provides a possible indication that the didactic game for conducting arithmetic lessons at the rudimentary level is more effective.

Figure 1.
Box plot of aggregated marks.



5.2. Normality and Over-Dispersion Tests

In this section, the normality and over-dispersion test are presented. The Shapiro wilk's method was used for the normality test. If the data is normally distributed or over-dispersed, the p-value of the test should be less than the conventional 5% level of significance. The results are presented in Table 1.

Table 1.
Over dispersion test.

Test	**Test**	**P-value**
Shapiro-Wilk	0.9325	0.00209
Over-dispersion	1.6891	0.04560

It is clear from Table 1 that the data is not normally distributed, but it is over-dispersed. This is because the associated p-values are less than the 5% level of significance. These conclusions suggest the appropriateness of the Bayesian negative Binomial mixed- effect model for modelling the data.

5.3. Model Output and Discussions

Table 2 presents the estimated parameters of the Bayesian model, including the mean estimates, 95% credible intervals (LCI and UCI), and key convergence diagnostics such as Rhat, Bulk_ESS, and Tail_ESS. These diagnostics are essential for assessing the reliability of posterior estimates. For a well-fitted Bayesian model, the Rhat statistic should be close to 1, indicating that the Markov chains have mixed well and converged to the target distribution. Similarly, Bulk_ESS and Tail_ESS values should ideally exceed 1,000, reflecting sufficient effective sample size for both the bulk and tail of the posterior distribution, which ensures stable and accurate estimates. Observations from Table 2 confirm that the model meets these criteria because all Rhat values equal 1, and both Bulk_ESS and Tail_ESS are well above 1,000. This indicates strong convergence and suggests that valid inferences can be drawn from the posterior distributions for both groups.

Table 2.
Estimated parameters.

Parameter	Estimate	LCI-95% CI	UCI -95%	Rhat	Bulk_ES	Tail_ESS
Intercept	3.151	2.9846	3.3081	1	3252	3109
Random effect	0.004	-0.0041	0.0128	1	2984	2969
Treatment	0.5140	0.4249	0.6012	1	6160	2765

To determine if our proposed instructional method significantly improved participants' performance, we assess the estimated parameters and their credible intervals as presented in Table 2. The intercept estimate (3.151) with a narrow credible interval (2.9846–3.3081) reflects stability in the baseline performance. The treatment effect estimate (0.5140) is positive and its credible interval (0.4249–0.6012) excludes zero, providing strong evidence of a treatment effect. This confirms a statistically significant improvement in the post-test scores compared to the pre-test scores. Before attributing this improvement solely to the intervention, it is important to rule out random effects. Since the random effect is not significant because it has a credible interval that includes zero (–0.0041 to 0.0128). This depicts a random variation in students' performances due to negligible individual differences. Hence, we conclude that the observed improvement in the treatment (post-test marks) is due to the efficacy of the new teaching method rather than uncontrolled variability. Therefore, the evidence strongly ascertains the effectiveness of the intervention approach in enhancing learners' performance in solving basic arithmetic problems.

6. CONCLUSION, RECOMMENDATION AND LIMITATIONS

Conclusions: This study aimed to empirically assess the pedagogical efficacy of the didactic game - Magic Square - as an instructional strategy for foundational arithmetic education. To evaluate the impact of the game-based approach, the study employed a Bayesian negative binomial random-effect model. The analysis revealed that learners exposed to the Magic Square intervention achieved significantly higher post-test scores than those instructed through the traditional approach. These findings are congruent with prior research by Russo, Bragg, and Russo (2021) which underscores the role of mathematical games in cultivating learners' fluency, strategic reasoning, and problem-solving competencies. Similarly, Bragg (2012) emphasizes that non-digital mathematical games, when systematically embedded within structured instructional routines, foster deeper cognitive engagement and promote robust conceptual development. The Magic Square game builds key principles of experiential learning and collaborative inquiry, drawing on the Gurteen Knowledge Café framework to create a dynamic, socially mediated learning environment. Through interactive gameplay, learners engage with arithmetic operations in a concrete and contextually meaningful manner, thereby enhancing mathematical literacy, logical reasoning, and intrinsic motivation (Rahmonkulova, 2024; Booker, 2000).

Recommendations: The empirical validation of the Magic Square as an effective pedagogical tool for teaching arithmetic at the rudimentary level in South Africa has been established in this study. In the studied classroom context, the following recommendations are proposed for similar South African primary school settings**.** Firstly, schools with comparable learner profiles and curriculum requirements should consider formally integrating the Magic Square game into the foundational phase arithmetic lessons. This integration can be implemented either as a supplementary activity to reinforce core concepts or as part of structured teaching routines where experiential learning is emphasized.

This case study demonstrated that the didactic game aligns well with experiential learning principles and significantly improved learners' fluency, reasoning and problem-solving skills. Therefore, in contexts where rote-based approaches dominate and learner engagement is low, adopting the Magic Square game offers a practical alternative. It's interactive and socially enriched format modelled on the Gurteen Knowledge Café framework proved effective in promoting collaboration and active participation among learners. This suggests that schools aiming to practice differentiated instructions and learner-cantered approaches could benefit from incorporating this mode of pedagogy in their lessons.

Secondly, teacher professional development programmes may include training in design, facilitation and assessment of incorporating didactic games in arithmetic lessons such as Magic Square. Educators must be equipped to align game mechanics with specific learning outcomes, manage classroom dynamics effectively, and evaluate learners' progress using both formative and summative tools. This will ensure that the pedagogical benefits of game-based instructions are maximized and sustained across diverse learning contexts.

Thirdly, curriculum developers and policymakers may consider the broader adoption of culturally responsive didactic games in mathematics education. The Magic Square game, adaptable to local contexts and learner needs, aligns with the Department of Basic Education's emphasis on interactive and indigenous pedagogies. Its implementation can contribute meaningfully to national efforts aimed at improving foundational numeracy and reducing learning disparities. In conclusion, the study affirms that the Magic Square game is not merely an engaging instructional tool but a pedagogical interventional approach with demonstrable impact on arithmetic learning. Its adoption within South African schools may represents a strategic step towards more inclusive, effective, and learner-centered mathematics education.

Limitations: The integration of didactic games into arithmetic teaching is not without challenges. Time constraints often limit their use within rigid curricular schedules, and classroom management issues such as noise and off-task behavior can undermine instructional focus. Additionally, disparities in learner participation, misalignment between game mechanics and learning objectives, and difficulties in assessing learning outcomes pose significant barriers. Resource limitations, including access to materials and teacher training, further hinder widespread adoption, particularly in under-resourced educational contexts. To address these limitations, strategic interventions are essential. Time-efficient game formats, structured facilitation protocols, and inclusive design principles can mitigate logistical and equity concerns. Aligning games with specific arithmetic objectives and embedding assessment tools such as observation checklists and learner reflections enhances instructional coherence and evaluative rigor. Moreover, targeted professional development and collaborative resource-sharing among educators can support sustainable implementation. When thoughtfully integrated, didactic games hold substantial promises for enriching arithmetic instruction and advancing learner-centered mathematics education.

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APPENDIX 1

Activity

Complete the following Magic squares by working out the missing values

Section A – Numerical

$\frac{31}{31}$

1.

2	7	6
9	5	1
4	3	8

2.

4	9	2
3	5	7
8	1	6

3.

11	3	10
7	8	9
6	13	5

4.

13	8	15
14	12	10
9	16	11

5.

4	3	8
9	5	1
2	7	6

6.

20	13	18
15	17	19
16	21	14

Section B – Non-numerical

7.

$7x-3y$	$2x+4y$	$3x-y$
$2y$	$4x$	$8x-2y$
$5x+y$	$6x-4y$	$x+3y$

8.

$x-2$	$x+5$	x
$x+3$	$x+1$	$x-1$
$x+2$	$x-3$	$x+4$

9.

$x-2$	$x+5$	x
$x+3$	$x+1$	$x-1$
$x+2$	$x-3$	$x+4$

10.

$a+4b$	$7a+6b$	$8a+3b$
$6a+9b$	$3a+8b$	$2a+b$
$5a+7b$	$4a+5b$	$7b$