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Effectiveness of Puzzle Room Game in Enhancing Learners' Engagement in Mathematics Among Kindergarten

Alia I. Pacasirang[1], Amnah M. Baraiman[2], Norhanifah D. Guro[3], Yahya G. Domaub[4], Najma A. Ali[5], Kristine Jade C. Ibonia[6], Joseph S. Funo-an[7], Norhamidah I. Norhazim[8], Rohaimah M. Yusoph[9], Hanifah W. Samsodin[10], Hanadi P. Asnawi[11], Jane Elizabeth A. Batuhan[12], Akisah H.L. Ampuan[13], Sittie Nor P. Ampuan[14], Janine Fathma N. Dimatingcal[15]

[1,2,3,4,5,6,7,8,9,10,11,12,13,14,15]College of Education, Mindanao State University-Marawi City

ABSTRACT: Traditional teaching methods often fail to capture the attention of young learners, leading to disengagement, lack of motivation, and disruptive behaviors. This study focuses on the use of game-based learning (GBL), specifically the Puzzle Room Game, as a strategy to enhance learners' engagement and academic performance in mathematics among kindergarten learners. It explores how integrating puzzle games into mathematics lessons creates a more interactive, engaging, and collaborative environment, addressing challenges such as maintaining focus and encouraging active participation. A quasi-experimental approach was employed, involving 25 learners in control and experimental groups. Teachers provided feedback through interviews, while the study utilized pre-test and post-test interventions to assess the impact of GBL. A lesson plan incorporating the Puzzle Room Game was delivered to the experimental group. The results revealed a significant positive effect of GBL, specifically the Puzzle Room Game, in enhancing learners' engagement and learning outcomes in mathematics. Puzzle-based games were also found to improve creativity and problem-solving skills, aligning with previous studies. Additionally, GBL fosters essential cognitive and emotional skills, reduces learning anxiety, and promotes collaborative learning. These findings highlight the value of GBL in addressing challenges faced by young learners and improving their academic performance. Educators are encouraged to integrate game-based strategies, such as the Puzzle Room Game, to create an engaging and effective learning environment that nurtures critical thinking, problem-solving, and active participation.

KEYWORDS: mathematics, game-based learning, engagement, puzzle room game

I. INTRODUCTION

Traditional teaching methods often fail to engage young learners, resulting in disengagement, lack of motivation, and disruptive behaviors. This study explores the use of game-based learning (GBL), specifically the puzzle room game, as a strategy to enhance learners' engagement and academic performance in mathematics among kindergarten learners at MSU - ILS Employees' Multi-Purpose Cooperative-Child Learning Center (EMPC-CLC). Inspired by the escape room format popularized in the early 2000s, puzzle room games offer an interactive and immersive problem-solving experience where participants solve challenges collaboratively within a set time. The study addresses the need for dynamic and engaging teaching methods that meet the developmental needs of young learners, who thrive in hands-on, interactive environments.

Classroom challenges such as low engagement, disruptive behaviors, and difficulty maintaining focus during traditional lessons necessitate innovative solutions. Research highlights that traditional teaching methods often fail to meet the varied learning needs of young children, leading to frustration and disengagement (Ryan & Deci, 2000). Factors such as attention deficiencies (Barkley, 1997) and mismatched learning styles (Tomlinson, 2001) exacerbate behavioral issues. By incorporating puzzle games into mathematics lessons, this study aims to create a more interactive and collaborative environment, addressing these challenges while fostering learners' intrinsic motivation and active participation.

The study employs a quasi-experimental approach, dividing 25 learners into control and experimental groups. Teachers provided feedback through interviews, while pre-test and post-test interventions assessed the impact of GBL. Results revealed a significant positive effect of the puzzle room game in enhancing learners' engagement, creativity, and problem-solving skills. Aligning with related studies, game-based learning supports cognitive development, reduces learning anxiety, and improves retention of academic content (Hirsh, Pasek et al., 2015). These findings emphasize the transformative potential of GBL to address common challenges in early childhood education.

This study's significance lies in its focus on game-based strategies to tackle learners' disengagement, a widespread issue in early education. Games such as puzzle room games integrate interactive and problem-solving elements into lessons, creating a meaningful and enjoyable learning experience. Prior research supports the use of games to boost intrinsic motivation and academic achievement (Plass, Homer, & Kinzer, 2015). By fostering a love for learning early, this approach has the potential to improve learners' long-term academic success and well-being, providing teachers and administrators with effective tools for classroom management and curriculum design.

Despite existing studies on GBL, limited research examines its application in enhancing engagement in mathematics among kindergarten learners, particularly within localized educational contexts. This study bridges that gap, offering tailored insights into the developmental needs of young learners. Its findings aim to influence teaching practices, curriculum design, and policymaking in early childhood education. Ultimately, this research advocates for integrating game-based strategies to create more supportive and engaging learning environments, benefiting learners, teachers, and the broader educational community.

Hence this study aimed to assess the effectiveness of the game-based approach to the learners of MSU ILS -EMPC to actively involve themselves in the lesson. Through the use of puzzle games that can be integrated into math subjects, the following research questions below guided the researchers in conducting this action research:

1. What are the perceptions of teachers regarding learners' engagement in mathematics in the classroom setting?
2. What is the distribution of learners' engagement levels based on score ranges in the pre-test and post-test results among kindergarten learners in the experimental group (puzzle room game) and the control group (traditional method)?
3. Is there a significant difference in the pre-test and post-test levels of learner's engagement between the experimental and control groups?
4. What are the challenges and opportunities of implementing a puzzle game in a mathematics lesson in the kindergarten classroom of MSU-ILS EMPC-CLC that may differ from the other kindergarten setting?

II. LITERATURE REVIEW

Game-based learning (GBL) has gained recognition for its potential to enhance learners' engagement, motivation, and academic outcomes. Games are defined as purposeful and enjoyable activities with specific rules and measurable results, fostering both cognitive and emotional development (Arkün, Kocadere & Samur, 2016; Salen & Zimmerman, 2003). Studies highlight that games encourage children to express themselves, develop communication skills, and acquire problem-solving abilities, making them valuable tools for both discipline and learning (Gözalan & Koçak, 2014; Turan Ozpolat, 2019). Digital GBL further enhances these benefits by using interactive elements like visuals and sounds to maintain learners' focus and foster collaboration through online mediums, promoting teamwork and negotiation skills (Adipat et al., 2021; Dichev & Dicheva, 2017). Research also demonstrates that GBL significantly improves learning outcomes, particularly in mathematics, where learners show increased motivation and achievement compared to traditional methods (Kebritchi, 2009; Tuzun et al., 2009). Additionally, GBL has been effective in supporting learners with developmental challenges, improving their cognitive, linguistic, and social-emotional abilities (Cassell & Ryokai, 2001; Hsiao & Chen, 2016).

Despite its benefits, GBL has faced criticism regarding its appropriateness for young learners, with concerns over its impact on social, emotional, and psychomotor development (alliance for childhood, 2000). However, studies have found limited evidence to substantiate these claims (Plowman & Stephen, 2003). Recent research highlights the effectiveness of integrating gamification models into education to boost learners' engagement and academic performance, particularly in online learning environments (Suartama et al., 2024). Gamification strategies, such as case- and project-based models, provide innovative solutions to challenges in maintaining learner motivation in both traditional and online settings. Overall, GBL emerges as a promising approach to creating dynamic, interactive, and effective learning experiences, particularly for younger learners and those in mathematics-related subjects.

The studies reviewed demonstrate the effectiveness of game-based learning (GBL) in enhancing learners' engagement, motivation, and academic achievement, particularly in mathematics. Mageed (2024) highlighted the integration of puzzles in mathematics education, showing that puzzles stimulate interest, develop problem-solving skills, and make abstract concepts more tangible. Similarly, Cayang and Ursabia (2024) found that GBL significantly improved mathematical performance by fostering an interactive, enjoyable environment that reduced anxiety and promoted critical thinking. Other studies, like Weng (2022), support the idea that puzzle-based games can foster creativity and enhance problem-solving abilities in learners. Zeng et al. (2024) conducted a meta-analysis revealing that gamification generally improves academic performance, with the effectiveness of game elements varying based on the educational context and type of game used.

In addition to cognitive benefits, GBL also positively impacts learners' attitudes and engagement. Debrenti (2024) discovered that non-digital games, such as board games, had a more profound effect on learning outcomes than digital games, due to their interactive nature. Karakoc et al. (2022) confirmed that GBL fosters active learning and critical thinking, leading to better knowledge retention. Karamert and Kuyumcu Vardar (2021) demonstrated that gamification in mathematics led to significant academic improvements, though its impact on learners' attitudes towards the subject was less clear. These studies underscore the

potential of game-based strategies to create a more engaging, interactive, and effective learning environment, particularly when tailored to specific educational needs and contexts.

III. METHODOLOGY

This action research study employed a quasi-experimental design to explore the impact of puzzle room game activities on learners' engagement and academic performance in the EMPC -kinder classroom at MSU – ILS Employees' Multi-purpose Cooperative Child Learning Center. The research focused on a control and experimental group of 25 kindergarten learners each, where the experimental group engaged in puzzle room games designed to increase interest and participation in mathematics lessons. The study aimed to observe classroom behaviors, conduct surveys, and interview both learners and teachers before and after the intervention to measure changes in engagement and academic performance.

The study's locale was the MSU-ILS EMPC child learning center, located in Marawi city, which provides a diverse learner population. The participants were from the junior kindergarten section, with 25 learners in both control and experimental groups. Instruments for data collection included observations, pre- and post-tests to measure academic performance, surveys, and interviews to assess engagement levels and teacher perceptions of game-based learning. Ethical considerations were given priority, ensuring informed consent from parents and guardians, confidentiality of participants, and the use of safe, age-appropriate game activities to support learners' emotional well-being.

Data collection procedures included baseline observations, pre-intervention surveys, and the implementation of puzzle room game activities, followed by post-intervention observations and assessments. Quantitative data was analyzed using mean, standard deviation, and frequency analysis, while qualitative data from interviews and surveys was analyzed through thematic analysis. The findings were presented to stakeholders through reports and workshops, aiming to assess the effectiveness of puzzle-based learning in enhancing engagement and performance in kindergarten mathematics.

IV. RESULTS AND DISCUSSION

This action research aimed to determine the effectiveness of the puzzle room game in enhancing learners' engagement in mathematics among kindergarten learners. By integrating playful and interactive learning strategies, the study aims to address challenges in sustaining young learners' focus and active participation during math lessons.

Table 1. Perceptions of teachers regarding learners' engagement in mathematics in the classroom setting.

Themes	Theme Description	Categorizations	Responses
Importance of Real-world Application	Teachers perceive that learners engage more effectively when mathematical concepts are tied to real-life situations.	Application in daily life	P1: learners really need to learn mathematics as they can apply it in a real-life situation such as buying something in the canteen during recess.
Use of Visual Aids	The integration of real objects and visual aids is crucial for enhancing learners' engagement and understanding in mathematics.	Visual and manipulatives	P1: Children learn more when real objects or pictures are integrated into the lessons. P2: Learners are more interested in learning math with the use of pictures.
Multifaceted Teacher Perception	Teachers' views on learners' engagement are shaped by their experiences, training, and classroom interactions.	Teacher background and Experience	P3; The perceptions of teachers regarding learners' engagement in mathematics often encompass a variety of perspectives shaped by their experiences, professional training, and classroom interactions.

Theme 1: Importance of real-world application

Learners can engage in the discussion with the integration of real-life sitting. Providing rules can let the learners have a sense of discipline to follow the given rules. In general, games with specific rules can also be considered to be a means of discipline. Rules such as order, rights, and equality (having equal rights both at the beginning and during the game) can also be useful to discipline life, as they are also among the rules of real life. In this way, she prepares for real life and adult roles (Turan Ozpolat 2019). It implies that the engagement of the learners in mathematics with the application of real-life situations allows the learners to understand the concept of mathematics.

Theme 2. Use of visual aids

To implement game-based, use of visual aids is an effective way to promote learning and engagement. The games use images, sounds, and colors to foster responsiveness in players; further, the games are structured to obtain maximum user attention (Adipat s., et al., 2021). In addition, a study suggests that such an approach not only makes learning more enjoyable but also helps reinforce

mathematical concepts by making abstract ideas more tangible and accessible. Hence, active performance of the learners when visual aids are well created with images, colors, and shapes that could also foster attention on the lesson.

Theme 3. Multifaceted teacher perception

Teacher's view that learners' engagements are shaped by their experiences, training, and classroom interactions. Learners' engagement helps the teacher to have easier discussion of the lesson. While playing, the child takes the opportunity to express his/her feelings and thoughts and gain many experiences. S/he tries to convince others and seeks to communicate to do so, and thus improves his/her language. She/he takes the opportunity to improve himself/herself in all areas of development (Gözalan and Koçak 2014). Furthermore, engagements of the learners in discussion help each of the learners to develop a knowledge based on their experiences and training.

Table 2. Teachers' Views on How Participatory Activities Influence the Level Of Engagement Among Learners During Mathematics Lessons.

Themes	Theme Description	Categorizations	Responses
Engagement through Participation	Teachers believe that learners are more engaged when they observe their peers actively participating in lessons and activities.	Peer interaction	P1: They will engage themselves if they see their classmates participating in the lesson and/ or activities. P2: learners are participating together with their peers.
Benefits of Interactive Learning	Interactive methods, such as puzzle games, are viewed positively as they help learners develop analytical skills.	Hands-on activities	P1: Puzzle games for children help them learn analysis…

Theme 1. Engagement through participation

To have an easier understanding of the concepts of mathematics, engagement of the learners is highly recommended. Game-based learning is an effective approach to enhance the mathematical skills of the learners. Most of the learners who engaged in game-based learning showed improved mathematical performance, particularly in problem-solving, conceptual understanding, and engagement with the subject. The research highlighted that games foster a more interactive and enjoyable learning environment, which motivates learners to participate actively and reduces anxiety associated with traditional mathematics instruction. (Cayang and Ursabia, 2024). This proves that engagement of the learners through participation can enhance their mathematical skills during discussion.

Theme 2. Benefits of interactive learning

Interactive methods, such as using puzzle games, help the learners to improve their critical and analytical thinking skills. The role of puzzles in developing critical thinking, promoting creativity, and improving learners' ability to visualize complex problems (Mageed, 2024). In addition, the benefits of GBL on learning outcomes, learners' motivation, and general academic performance have been shown in numerous research studies. When compared to standard teaching approaches, research repeatedly demonstrates that GBL can greatly enhance learners' motivation, especially in areas like mathematics, resulting in higher levels of academic performance motivation (Kebritchi, 2009; Kebritchi et al., 2010). Hence, using interactive learning like puzzle games not only enhances the critical thinking of the learners but also enhances the motivation and academic performance of the learners.

The thematic analysis provides compelling evidence that the game is both accurate and informative based on the answers of the participants. It draws from real-world observations and aligns with educational research on the benefits of applied learning. For instance, the game itself provides a real-world application of mathematical concepts, such as spatial reasoning and problem-solving, which are essential skills for young learners. This approach is supported by research on the power of contextualized learning. The National council of teachers of mathematics (2014) the research also demonstrates that the game is designed with clear and concise language, making complex mathematical concepts accessible to young children.

Table 3. Level of Competency in Addition and Subtraction Score Distribution of the Experimental Group Learners

ADDITION CONCEPT			
		Count	Percent
Experimental Addition Pre-Test	Not Competent	3	12.0%
	Average	15	60.0%
	Competent	6	24.0%

	Highly Competent	1	4.0%
	Total	25	100%
Experimental Addition Post-Test	Not Competent	0	0.0%
	Average	2	8.0%
	Competent	2	8.0%
	Highly Competent	21	84.0%
	Total	25	100%
SUBTRACTION CONCEPT			
		Count	Percent
Experimental Subtraction Pre-Test	Not Competent	9	36.0%
	Average	7	28.0%
	Competent	9	36.0%
	Highly Competent	0	0.0%
Experimental Subtraction Post-Test	Not Competent	0	0.0%
	Average	3	12.0%
	Competent	6	24.0%
	Highly Competent	16	64.0%
Legend: 10-8 High Competent; 6-7 Competent; 4-5 Average; 0-3 Not Competent			

Table 3 shows a significant improvement in learners' additional competency after using the Puzzle Room Game. Before the intervention, only 4% of learners were "Highly Competent," while most (60%) were at the "Average" level, and 12% were "Not Competent." After the intervention, the "Not Competent" category was completely eliminated, with 84% of learners achieving the "Highly Competent" level and the remaining 16% distributed between "Competent" (8%) and "Average" (8%). These results demonstrate that the Puzzle Room Game effectively enhanced the learners' additional skills, with the majority reaching mastery, highlighting its potential to make learning more engaging and effective.

Table 3 highlights a significant improvement in subtraction competency for the experimental group after using the Puzzle Room Game. In the pre-test, 36% of learners were "Not Competent," another 36% were "Competent," 28% were "Average," and none were "Highly Competent." After the intervention, the "Not Competent" category was completely eliminated, and 64% of learners achieved "Highly Competent" status. Meanwhile, 24% became "Competent," and only 12% remained "Average." These results show that the Puzzle Room Game effectively enhanced learners' subtraction skills, transforming most into "Highly Competent" learners and addressing the gaps in their performance.

Table 4. Level of Competency in Addition and Subtraction Score Distribution of the Control Group Learners

ADDITION CONCEPT			
		Count	Percent
Control Addition Pre-Test	Not Competent	6	24.0%
	Average	15	60.0%
	Competent	4	16.0%
	Highly Competent	0	0.0%
	Total	25	100%
Control Addition Post-Test	Not Competent	0	0.0%
	Average	14	56.0%
	Competent	8	32.0%
	Highly Competent	3	12.0%
	Total	25	100%
SUBTRACTION CONCEPT			
		Count	Percent
Control Subtraction Pre-Test	Not Competent	11	44.0%
	Average	11	44.0%
	Competent	3	12.0%
	Highly Competent	0	0.0%
	Total	25	100%

Control Subtraction Post-Test	Not Competent	5	20.0%
	Average	7	28.0%
	Competent	8	32.0%
	Highly Competent	5	20.0%
	Total	25	100%

Table 4 shows in addition competency levels of the control group (learners taught using traditional methods) before and after the intervention. In the pre-test, 24% of learners were "Not Competent," 60% were "Average," 16% were "Competent," and none were "Highly Competent." After the intervention, there was some improvement: the "Not Competent" category was eliminated, 12% of learners became "Highly Competent," and the proportion of "Competent" learners increased to 32%. However, the majority (56%) remained at the "Average" level. While traditional methods helped some learners improve, the progress was less pronounced compared to the experimental group using the Puzzle Room Game. This highlights the limited effectiveness of traditional teaching methods in significantly boosting learners' competency.

Table 4 shows the subtraction competency levels for the control group (learners taught using traditional methods). In the pre-test, 44% of learners were "Not Competent," 44% were "Average," 12% were "Competent," and none were "Highly Competent." After the intervention, there was some improvement: the "Not Competent" category was reduced to 20%, while 20% of learners achieved "Highly Competent," 32% became "Competent," and 28% remained "Average." Although there was some progress, a significant portion of learners still remained at the "Average" level, and the improvements were not as drastic as in the experimental group. This suggests that traditional methods had a more limited impact on improving learners' subtraction skills compared to the Puzzle Room Game.

The findings of the study show that the experimental group, which utilized the Puzzle Room Game, achieved significant improvements in addition and subtraction skills compared to the control group that used traditional teaching methods. Specifically, in the experimental group, the percentage of learners categorized as Highly Competent increased dramatically, from 4% to 84% in addition and from 0% to 64% in subtraction. In contrast, the control group demonstrated more modest improvements, with many learners remaining at the Average level. These results align with prior studies highlighting the effectiveness of game-based learning strategies. For instance, research by Wang et al. (2019) emphasized that gamified learning environments improve engagement and motivation, leading to better academic outcomes. Similarly, Plass, Homer, and Kinzer (2015) noted that interactive games enhance cognitive processing and retention of foundational skills, particularly in mathematics. Moreover, Hamari et al. (2016) found that game-based methods foster deeper engagement by making learning enjoyable and dynamic, which traditional methods often fail to achieve. These supporting studies reinforce the conclusion that integrating interactive games into instruction not only addresses learning gaps but also motivates learners to excel academically.

The results emphasize the effectiveness of game-based learning in improving learners' engagement and performance, particularly in math. Traditional methods may not be as effective in boosting learner's competency, suggesting that interactive, gamified strategies can better address learning gaps and motivate learners. Educators should integrate game-based learning, like the Puzzle Room Game, into their curricula to enhance engagement, improve outcomes, and make learning more enjoyable.

Table 5. Significant difference in the pre-test and post-test levels of learners' engagement between the experimental and control groups using Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Experimental Addition	Pre-Test	4.92	25	1.412	.282
	Post-Test	8.88	25	1.536	.307
Control Addition	Pre-Test	4.24	25	1.234	.247
	Post-Test	5.84	25	1.650	.330
Experimental Subtraction	Pre-Test	4.40	25	1.708	.342
	Post-Test	8.20	25	1.780	.356
Control Subtraction	Pre-Test	3.88	25	1.301	.260
	Post-Test	5.56	25	2.181	.436

The mean score for the experimental group in the additional pre-test was 4.92 with a standard deviation of 1.412 and a standard error mean of 0.282. In the post-test, the mean score increased to 8.88, with a standard deviation of 1.536 and a standard error mean of 0.307. For the control group, the mean score in the additional pre-test was 4.24, with a standard deviation of 1.234 and a standard error mean of 0.247. In the post-test, the mean score increased to 5.84, with a standard deviation of 1.650 and a standard error mean of 0.330.

Table 5 shows the average scores for the experimental and control groups in addition, both before and after the intervention. For the experimental group, the mean score increased from 4.92 in the pre-test to 8.88 in the post-test, indicating a significant improvement after using the Puzzle Room Game. For the control group, the mean score increased from 4.24 to 5.84, showing a smaller improvement with traditional teaching methods. These results suggest that the Puzzle Room Game was much more effective in improving learners' additional skills compared to traditional methods.

The Paired Samples Statistics for the experimental group in subtraction showed a pre-test mean of 4.40 with a standard deviation of 1.708 and a standard error mean of 0.342. The post-test mean was 8.20 with a standard deviation of 1.780 and a standard error mean of 0.356. For the control group, the pre-test mean was 3.88 with a standard deviation of 1.301 and a standard error mean of 0.260. The post-test mean was 5.56 with a standard deviation of 2.181 and a standard error mean of 0.436.

The Paired Samples Statistics table shows that the experimental group, which used the Puzzle Room Game, had a much larger improvement in subtraction skills compared to the control group. The experimental group's average score increased from 4.40 in the pre-test to 8.20 in the post-test, reflecting a significant improvement of 3.80 points. In contrast, the control group's average score only increased from 3.88 to 5.56, showing a smaller improvement of 1.68 points. This indicates that the Puzzle Room Game was far more effective in helping learners improve their subtraction skills. Additionally, the control group's increased variability in scores suggests that traditional methods may not have been as consistent in supporting all learners. Overall, the results highlight the advantage of game-based learning over traditional teaching methods.

Table 6. Paired Samples Correlations

		N	Correlation	Sig.	Remarks
Experimental Addition	Pre-Test & Post-Test	25	.456	.022	Significant
Control Addition	Pre-Test & Post-Test	25	.511	.009	Significant
Experimental Subtraction	Pre-Test & Post-Test	25	.535	.006	Significant
Control Subtraction	Pre-Test & Post-Test	25	.333	.104	Insignificant

The correlation between the pre-test and post-test for the experimental group in addition is 0.456, with a significance value of 0.022. For the control group in addition, the correlation is 0.511, with a significant value of 0.009.

The Paired Samples Correlations table shows a moderate positive relationship between the pre-test and post-test scores for both the experimental and control groups in addition. In the experimental group, the correlation is 0.456, indicating that learners who performed better in the pre-test generally performed better in the post-test. The significance value ($p = 0.022$) confirms that this relationship is statistically significant. Similarly, the control group has a slightly higher correlation of 0.511, with a significant value of $p = 0.009$, also showing a statistically significant relationship. While both groups demonstrate that prior performance influenced post-test results, the lower correlation in the experimental group may suggest that the Puzzle Room Game had a greater impact on helping learners improve regardless of their initial performance levels.

The Paired Samples Correlations for the experimental group in subtraction showed a correlation of 0.535 with a significant value of 0.006. For the control group, the correlation was 0.333 with a significance value of 0.104.

The Paired Samples Correlations table reveals that the experimental group, which used the Puzzle Room Game, showed a moderate positive correlation of 0.535 between pre-test and post-test scores in subtraction, with a statistically significant p-value of 0.006. This indicates that learners who performed better on the pre-test were also likely to show improvement in the post-test, suggesting the Puzzle Room Game had a positive impact on their learning. In contrast, the control group showed a weaker correlation of 0.333, and the significance value of $p = 0.104$ indicates that the correlation was not statistically significant. This suggests that traditional teaching methods had less of an effect on improving subtraction skills, as prior performance did not strongly predict post-test outcomes. These findings further emphasize the effectiveness of game-based learning in enhancing learners' performance in subtraction.

Table 7. Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			

Experimental Addition	Pre-Test - Post Test	-3.960	1.541	.308	-4.596	-3.324	-12.852	24	.000
Control Addition	Pre-Test - Post Test	-1.600	1.472	.294	-2.208	-.992	-5.435	24	.000
Experimental Subtraction	Pre-Test - Post Test	-3.800	1.683	.337	-4.495	-3.105	-11.288	24	.000
Control Subtraction	Pre-Test - Post Test	-1.680	2.135	.427	-2.561	-.799	-3.934	24	.001

The Paired Samples Test for the experimental group in addition showed a mean difference of -3.960, a standard deviation of 1.541, and a standard error mean of 0.308. The 95% confidence interval for the difference ranged from -4.596 to -3.324. The t-value was -12.852 with 24 degrees of freedom, and the significance value was 0.000. For the control group, the mean difference was -1.600, the standard deviation was 1.472, and the standard error mean was 0.294. The 95% confidence interval for the difference ranged from -2.208 to -0.992. The t-value was -5.435 with 24 degrees of freedom, and the significance value was 0.000.

The Paired Samples Test shows a statistically significant improvement in addition skills for both the experimental and control groups from pretest to post-test. In the experimental group, the mean difference is -3.960, indicating a large improvement in scores after using the Puzzle Room Game. The t-value of -12.852 and a significant value of p = .000 confirm that this improvement is highly significant. The 95% Confidence Interval of the difference ranges from -4.596 to -3.324, ensuring the reliability of this result. In contrast, the control group showed a smaller mean difference of -1.600, with a t-value of -5.435 and a significant value of p = .000, also indicating a statistically significant improvement. However, the experimental group's larger mean difference demonstrates that the Puzzle Room Game was far more effective at improving learners' additional skills compared to traditional teaching methods.

The Paired Samples Test for the experimental group in subtraction revealed a mean difference of -3.800, with a standard deviation of 1.683 and a standard error mean of 0.337. The 95% confidence interval for the difference ranged from -4.495 to -3.105, and the t-value was -11.288, with a significance value of 0.000. In the control group, the mean difference was -1.680, with a standard deviation of 2.135 and a standard error mean of 0.427. The 95% confidence interval for the difference ranged from -2.561 to -0.799, and the t-value was -3.934, with a significance value of 0.001.

The Paired Samples Test results show that both the experimental and control groups made statistically significant improvements in subtraction, but the experimental group showed much greater progress. The mean difference for the experimental group was -3.800, indicating a substantial improvement in subtraction skills after using the Puzzle Room Game. The t-value of -11.288 and a significant value of p = 0.000 confirm that this improvement is highly significant. In contrast, the control group showed a smaller improvement with a mean difference of -1.680 and a t-value of -3.934, also statistically significant (p = 0.001). These findings highlight that the Puzzle Room Game had a much more significant impact on improving subtraction skills compared to traditional teaching methods.

The study demonstrated the effectiveness of the Puzzle Room Game compared to traditional teaching methods in improving learners' addition and subtraction skills. In addition, the experimental group showed a significant improvement, with mean scores increasing from 4.92 in the pre-test to 8.88 in the post-test. The mean difference of -3.960, supported by a t-value of -12.852 and a p-value of 0.000, indicates a highly significant improvement. Meanwhile, the control group exhibited a smaller increase, from 4.24 to 5.84, with a mean difference of -1.600 (p = 0.000) and a t-value of -5.435. The paired samples correlation showed a moderate positive relationship for both groups, with the experimental group at r = 0.456 (p = 0.022) and the control group at r = 0.511 (p = 0.009). The slightly lower correlation in the experimental group suggests that the Puzzle Room Game improved scores more effectively, regardless of learners' initial performance levels. In subtraction skills, the experimental group again showed substantial improvement, increasing from 4.40 in the pre-test to 8.20 in the post-test. The mean difference of -3.800, with a t-value of -11.288 and a p-value of 0.000, confirms the significant impact of the game-based intervention. By contrast, the control group demonstrated a modest increase, from 3.88 to 5.56, with a mean difference of -1.680 (p = 0.001) and a t-value of -3.934. The paired samples correlation for the experimental group was moderately positive at r = 0.535 (p = 0.006), whereas the control group showed a weaker and non-significant correlation of r = 0.333 (p = 0.104), suggesting traditional methods were less effective in improving subtraction skills. Overall, these findings highlight that the Puzzle Room Game was far more effective than traditional teaching methods in

enhancing learners' addition and subtraction abilities. This game-based approach led to greater mean score improvements, reduced dependence on prior performance, and provided a consistent and impactful learning tool.

Data implies that games, by nature, stimulate excitement and engagement, fostering both cognitive and emotional development. Güneş (2015) and Kocadere & Samur (2016) emphasize that games provide pleasurable and rule-based activities that promote discipline, problem-solving, and communication skills. Turan Özpolat (2019) further highlights that games help children's express emotions, establish relationships, and solve problems, preparing them for real-life challenges. According to Adipat et al. (2021), digital GBL increases motivation and engagement through interactive visuals and sounds, while Kebritchi (2009) and Tuzun et al. (2009) found GBL particularly effective in enhancing math-related learning outcomes. Similarly, Mageed (2024) demonstrated that puzzles improve problem-solving and cognitive engagement by transforming abstract concepts into tangible learning tasks. The study by Cayang and Ursabia (2024) also supports the effectiveness of GBL in enhancing mathematical performance, fostering active participation, and reducing learning anxiety. Weng (2022) found that puzzle-type logical games enhance creativity and problem-solving skills, while Debrenti (2024) highlighted the role of non-digital games in improving both learning outcomes and attitudes toward mathematics. Moreover, meta-analyses by Karakoc et al. (2022) and Zeng et al. (2024) affirm that GBL significantly enhances academic performance, motivation, and retention of knowledge. These findings reinforce the conclusion that integrating games, such as the Puzzle Room Game, into educational curricula offers a fun, interactive, and highly effective means of improving learners' skills, particularly in mathematics.

Overall, these findings suggest that teachers should consider using game-based learning strategies to improve learners' engagement and help them learn better. Game-based learning can make lessons more fun and effective, helping learners master key skills more easily.

Table 8. Themes generated on the challenges encountered by teachers when implementing a puzzle game in Mathematics lessons

Themes	Theme Description	Categorizations	Responses
Challenges of Diverse Learners	Teachers identify difficulties in processing instructions, especially for learners with varying skill levels.	Processing instructions	P1: Children are having a hard time processing the instructions especially to those kids who are weak and not so good at doing mathematics.
Logistical challenges	Managing a classroom with many learners can complicate the implementation of puzzle games.	Classroom managements	P2; If we have small group of learners 10-15, then it is good to perform puzzle games for kids… but they are more than 30 learners and it's hard to accommodate other kids…
Context-Dependent Challenges & Opportunities	The success of puzzle game implementation depends heavily on the setting and context.	Contextual factors	P3: Implementing a puzzle game in a mathematics lesson for kindergarten learners can present unique challenges and opportunities, especially as settings and contexts differ.

Theme 1. Challenges of Diverse Learners

A classroom with varied learners can be a challenge to integrate puzzle games. It is stated in a study that a fun activity with a measurable result and an element of challenge based on a specific rule or rules for a specific purpose or purposes. And the other definition about the game is explained as a system in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome" (Salen and Zimmerman 2003). Furthermore, the application of puzzle games must consist of simple instructions for learners with varied skills.

Theme 2. Logistical challenges

These logistical challenges underscore the importance of addressing infrastructural and technical barriers to fully optimize the benefits of game-based learning in diverse educational settings. Travinio and Gonzales (2022) Despite the significant improvements in learner performance and high engagement levels, the study noted potential limitations in implementing game-based applications, such as the need for stable internet connectivity, access to compatible devices, and the technical proficiency required to navigate and utilize these tools effectively. Hence that Logistical challenges, such as access to devices, stable internet connectivity, and technical proficiency, must be addressed to ensure the effective implementation of game-based learning and maximize its educational benefits.

Theme 3. Context-Dependent Challenges & Opportunities

The success of puzzle game implementation depends heavily on the setting and context. The effects of game-based learning, specifically through a puzzle-type logical thinking game, on the problem-solving abilities of sixth-grade learners. The study revealed

that creativity positively influenced learners' learning attitudes and problem-solving skills. Weng, (2022) Hence, the success of implementation of the puzzle's games gives opportunities to the learners.

Table 9. Themes generated from the opportunities perceived by the teachers in implementing puzzle games among kindergarten learners

Themes	Theme Description	Categorizations	Responses
Opportunities for Skill Development	Implementing puzzle games can foster analytical thinking and cognitive skill development among learners.	Cognitive development	P1: Integrating a puzzle game develop the children to become an analytical learner where they will think out of the box…
Long-Term Learning Benefits	Early engagements in mathematics are viewed as beneficial for learners' future real-life application	Early learning	P1: It is good for children to learn mathematics in their early years or early age as they can apply it in a real-life situation

Theme 4. Opportunities for Skill Development

Implementing puzzle games can foster analytical thinking and cognitive skill development among learners. It indicated that game-based teaching practices support learners' development and skills, and they also offer them different learning opportunities (AlTarawneh, 2016; Bai, 2012; Gelman, 2010; Güner, 2018; Hayıroğlu & Ulus, 2017; Ploger & Hecht, 2009). This proves that integrating game-based learning among kindergarten helps learners to develop skills in mathematical concepts.

Theme 5. Long-Term Learning Benefits

Early engagements in mathematics are viewed as beneficial for learners' future real-life application. Rules such as order, rights, and equality (having equal rights both at the beginning and during the game) can also be useful to discipline life, as they are also among the rules of real life (Turan Özpolat 2019). It showed that early exposure in game-based settings will let the learners apply in the real-life experience of the learners.

This concludes that the research comprehensively addresses various aspects of learners' engagement in mathematics, including the challenges faced by diverse learners in processing instructions (Tomlinson, 2014). The evidence presented suggests that the puzzle room game is a valuable tool for enhancing learners' engagement in mathematics among kindergarteners, demonstrating a commitment to evidence-based practices, clear communication, and comprehensive coverage of the topic.

VI. CONCLUSION

This action research reinforces the idea that game-based learning, particularly through the Puzzle Room Game, significantly contributes to enhancing learners' engagement and improving learning outcomes in mathematics. The study reveals that GBL fosters essential cognitive and emotional skills, promotes problem-solving, and reduces learning anxiety, making it a valuable tool in addressing the challenges faced by young learners. These findings suggest that educators should consider integrating game-based learning strategies to create a more engaging, interactive, and effective learning environment, ultimately leading to improved learners' performance in mathematics.

VII. RECOMMENDATIONS

This study provides suggestions to teachers to incorporate interactive game-based learning tools, such as math related puzzles or mathematical digital games, into the mathematics curriculum to have the learners engage and improve their academic performance. Teachers can create or adapt affordable and easy-to-implement game-based learning tools that align with their current curriculum. Future studies may explore the effectiveness of game-based learning in other subjects and across different grade levels to validate its broader applicability in improving learners' performance.

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