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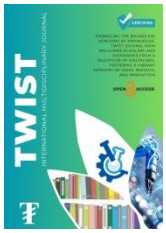

Game – Based Learning Strategy and Performance of Grade 2 Pupils in Mathematics

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Abstract
This study was conducted to determine whether game-based learning strategy intervention would improve the early-grade mathematics assessment (henceforth EGMA) among twenty-five (25) Grade 2 learners in a public elementary school. A pre-experimental pre-test and post-test design was adopted, and statistical tools such as t-tests were utilized to test the significant differences. Hypotheses were tested, and the findings revealed the following: the null hypothesis that there was no significant difference between pupils' pre-test and post-test scores after the game-based learning strategy in EGMA was rejected. These findings provide a solid foundation for future research, emphasizing the importance of further studies in this field. This study recommends that the teacher may implement targeted interventions, the teacher may expand and enhance Game-Based Learning Programs, the teacher may conduct ongoing assessment and evaluation, and future studies should employ mixed-methods approaches to gather comprehensive data on student learning outcomes, attitudes toward mathematics, and classroom dynamics.

Keywords
Game-based learning strategy, Pre-test, Post-test, EGMA

INTRODUCTION

Establishing a solid mathematical foundation in the early grades is a pivotal steppingstone for future success in mathematics, playing a critical role in the development of essential workplace skills and knowledge (Malloy, 2008; Nunes & Bryant, 1996; Steen, 2001; U.S. Department of Education, 2008). Moreover, everyday activities like shopping and personal banking heavily rely on fundamental mathematical reasoning. Recent meta-analyses suggest that early mathematics skills hold a predictive power akin to early reading abilities for later success (Duncan et al., 2007; Romano et al., 2010).

This research endeavors to shed light on the strategies employed by educators in the Early Grade Mathematics Assessment (EGMA) with the ultimate goal of enhancing math proficiency. The EGMA is a vital tool in evaluating the foundational mathematical knowledge of young students through a series of eight subtests. Typically administered to students in Grades 1-3, it aids in identifying fundamental numerical competencies. The data derived from EGMA assessments catalyzes policy reform, inform intervention strategies, and influence educational practice enhancements (Platas, Ketterlin-Geller, & Sitabkhan, 2016).

The Core EGMA, focusing on numbers and operations, consists of six distinct subtests or tasks that collectively offer insights into young learners' mastery of early-grade mathematical skills. These subtests include number identification, reasoning about magnitude, recognition of number patterns, addition and subtraction (Levels 1 and 2), and word problems. Notably, the Core EGMA is designed to be administered orally, aligning with the early grades' developmental stage, where students begin grasping the art of reading.

The EGMA's baseline assessment shapes educational standards, benchmarking, and teacher training programs. Pre- and post-measurement interventions encompass curricula, classroom strategies, instructional materials, teacher

training, coaching models, textbooks, and various combinations thereof. It is worth highlighting that the EGMA's developers advocate for the presentation of subtest findings as separate sub-scores rather than amalgamating them into a composite or total score, a practice widely adopted in showcasing EGMA outcomes (RTI International, 2014) (Brombacher et al., 2015; Piper & Mugenda, 2014; Torrente et al., 2011).

The Department of Education (DepEd) had issued guidelines stipulating the use of EGMA Tools for System Assessment as a fundamental tool for monitoring and evaluating the implementation of Mother Tongue-Based Multilingual Education (MTB-MLE) and Kindergarten to Grade 3 literacy and numeracy programs (D.O. 57; S. 2015 – Utilization of The Early Grade Reading Assessment (EGRA) and Early Grade Math Assessment (EGMA) Tools for System Assessment). This move aims to ensure the proper implementation of MTB-MLE (DepEd, 2015).

The recurring application of EGMA assessments each year has piqued the researcher's curiosity, mainly due to the observed lower scores in our school.

Games have emerged as an effective tool for fostering students' motivation and engagement in learning (da Rocha Seixas, Gomes, & de Melo Filho, 2016). A thoughtfully designed gamified instructional approach can create an immersive learning environment, encouraging active student participation and interaction. Previous studies have also proposed that instructors can employ process-oriented approaches through games or activities to mitigate negative academic emotions (Brunyé et al., 2013; Harper & Daane, 1998; Kim & Hodges, 2012). This issue has captivated the researcher's interest, prompting an exploration of game-based learning to bolster learners' math skills, ultimately leading to improved performance in the EGMA.

MATERIALS AND METHODS

The research method employed in the study is a pre-experimental research design, focusing solely on an experimental group without utilizing a control group. The sampling technique used involved selecting Grade 2 learners from a public elementary school in San Pablo City. The research instrument consisted of meticulously developed and validated game-based learning modules tailored to Early Grade Mathematics Assessment (EGMA). These modules adhered to the Grade 2 Mathematics curriculum guide endorsed by the Department of Education.

Research Design

This design aims to investigate the causal relationship between the game-based learning strategy and the enhancement of Early Grade Mathematics Assessment (EGMA) scores among Grade 2 pupils at San Pablo City Central School.

Respondents of the Study

The participants were chosen from one homogeneous section, totalling 25 learners. This section was taught using game-based learning, and comparisons were made before and after the application of the strategy.

Research Instrument

The instrument included both EGMA pre-test and post-test assessment tools, covering various dimensions of mathematics proficiency. To ensure the validity and reliability of the instrument, rigorous validation procedures were conducted. This involved consultations with mathematics teachers, school head teachers, and mathematics experts. Additionally, content validity was ensured through meticulous evaluations of the game-based learning modules.

Research Procedure

The data collection procedure began with the formulation of mathematics lesson plans centred on the game-based learning approach. These plans underwent validation and consultations before implementation. During each lesson, game-based learning activities were introduced, such as bingo, colour games, and fraction war, designed to reinforce key concepts. Pre-test assessments were conducted to establish a baseline, followed by post-tests to evaluate learning outcomes.

Statistical Treatment of Data

The statistical tools used for data analysis included descriptive statistics, mean, standard deviation, t-test, and frequency distribution. These tools were employed to assess the efficacy of the game-based learning intervention in enhancing EGMA scores. Statistical tests such as the t-test were used to determine the significance of differences between pre-test and post-test mean scores. Ethical considerations were likely addressed by informing participants (students) and obtaining necessary permissions from relevant authorities before conducting the study. This ensures transparency regarding the purpose of the study and maintains ethical standards in research involving human participants.

RESULTS AND DISCUSSION

This chapter presents the data showing the game-based learning strategy and its effect on early grade mathematics assessment scores among Grade 2 pupils. The gathered data were analyzed and interpreted to answer the research questions enumerated in Chapter 1 of this study.

In summary, no students achieved the highest score range of 9-10 across any domain, suggesting a general absence of advanced numeracy skills among the participants. Similarly, there were minimal instances of students scoring within the high numerate range (7-8) in most domains, indicating a lack of mastery in specific mathematical concepts. Most students fell within the low numerate (3-4) or non-numerate (0-2) ranges, implying significant room for

improvement in foundational numeracy skills. These findings underscore the necessity for targeted interventions and enhanced pedagogical strategies to foster mathematical proficiency among early-grade students. By addressing these deficiencies, educators can better support the development of essential mathematical competencies crucial for academic success and lifelong learning.

Table 1 Distribution of Pupil's Pre-test Scores in EGMA

Scores	Number Identification		Number Discrimination		Number Recognition		Addition		Subtraction		REMARKS
	f	%	f	%	f	%	f	%	f	%	
9-10	-	-	-	-	-	-	-	-	-	-	Advance Numerate
7-8	-	-	-	-	-	-	1	4	-	-	High Numerate
5-6	2	8	4	16	5	20	10	40	1	4	Numerate
3-4	10	40	12	48	14	56	8	32	11	44	Low Numerate
0-2	13	52	8	32	6	24	6	24	13	52	Non-Numerate
Total	**25**	**100**	**25**	**100**	**25**	**100**	**25**	**100**	**25**	**100**	

Table 2 Distribution of Pupil's Post-test Scores in EGMA

Scores	Number Identification		Number Discrimination		Number Recognition		Addition		Subtraction		REMARKS
	f	%	f	%	f	%	f	%	f	%	
9-10	12	48	23	92	10	40	16	64	15	60	Advance Numerate
7-8	12	48	2	8	15	60	8	32	9	36	High Numerate
5-6	1	4	-	-	-	-	1	4	1	4	Numerate
3-4	-	-	-	-	-	-	-	-	-	-	Low Numerate
0-2	-	-	-	-	-	-	-	-	-	-	Non-Numerate
Total	25	100	25	100	25	100	25	100	25	100	

The integration of game-based strategies in educational interventions offers a promising approach to enhancing learning outcomes in mathematics, as evidenced by the potential benefits outlined above. By leveraging the motivational and instructional advantages of gameplay, educators can effectively support students in attaining higher results in mathematical skills, as reflected in post-test scores and overall academic achievement.

Table 3 Test of Significant Difference between Pretest and Posttest Scores in EGMA

EGMA	Pre-Test		Post-Test		t	df	Sig. (2-Tailed)
	Mean	SD	Mean	SD			
Number identification	2.56	1.16	8.52	1.05	-40.6	24	.000
Number discrimination	3.28	1.37	9.52	.653	-19.6	24	.000
Number recognition	3.40	1.35	8.28	.891	-15.9	24	.000
Addition	3.80	1.63	8.68	1.03	-13.7	24	.000
Subtraction	2.36	1.19	8.76	1.05	-28.6	24	.000

Table 3 presents the results of a paired-sample t-test comparing the mean scores of students on the pre-test and post-test measures across various numeracy variables, including Number Identification, Number Discrimination, Number Recognition, Addition, and Subtraction. This statistical analysis aims to assess whether there are significant differences in mean scores before and after an intervention or educational program.

In the context of Number Identification, the mean score significantly increased from 2.56 (SD = 1.158) in the pre-test to 8.52 (SD = 1.05) in the post-test, $t(24) = -40.6$, $p < .001$. A similar pattern is observed across all other numeracy variables, indicating substantial improvements in students' performance post-intervention. Researchers have explored various educational interventions to enhance number identification skills among young learners. Obersteiner, Reiss, and Ufer (2018) examined the efficacy of a computer-based training approach, while Nugent and Pitchford (2019) investigated a kindergarten-based number identification intervention. These studies highlight the potential for structured programs to improve number identification in early education contexts.

For Number Discrimination, the mean increased of 6.24, $t(24) = -19.6$, $p < .001$. Research by Mundy, Gilmore, and Hill (2018) highlights the role of subitizing, the rapid enumeration of small sets of objects, as a precursor to more advanced number discrimination abilities. Their study underscores the importance of subitizing in developing accurate number representations in young children.

Likewise, in Number Recognition, the mean increase of 2.05, $t(24) = -15.9$, $p < .001$. These findings suggest that the intervention or educational program effectively enhanced students' abilities to discriminate and recognize numbers. Number discrimination is a critical skill in early mathematics education. Number recognition, a foundational skill in early mathematics education, has garnered significant attention in recent research. Geary, Hoard, and Hamson (2018) assert that individual differences in number recognition proficiency predict overall mathematical achievement. It underscores the critical role of early skill development in shaping math outcomes.

Regarding computational skills, students in both Addition and Subtraction showed significant improvements. The mean score for Addition increased 4.88, $t(24) = -13.7$, $p < .001$. A pivotal aspect of early mathematics education is cultivating cognitive strategies for additional problem-solving (Smith & Johnson, 2019). Research suggests that teaching young learners' methods such as counting on, decomposing numbers, and employing mental math techniques can significantly enhance their ability to tackle addition problems accurately and efficiently.

Similarly, the mean increase in score for Subtraction 6.40, $t(24) = -28.6$, $p < .001$. These results indicate notable enhancements in students' arithmetic skills post-intervention. Recent studies emphasize the need for educators to introduce and reinforce effective subtraction problem-solving strategies (Walker & Anderson, 2019). Strategies like counting back, decomposing numbers, and employing mental math techniques have been found to enhance students' subtraction proficiency. These strategies offer pupils structured approaches to tackle subtraction problems and are crucial for building a solid mathematical foundation.

The findings suggest a consistent and substantial positive effect of the game-based learning strategy as an intervention or educational program on students' numeracy skills across various domains. The significant improvements observed in mean scores reflect the efficacy of the intervention in enhancing students' mathematical proficiency. However, it is essential to interpret these results cautiously and consider potential limitations such as sample size, intervention duration, and external factors influencing students' performance. Further research utilizing rigorous experimental designs and longitudinal assessments is warranted to confirm the long-term effectiveness of the intervention and inform evidence-based educational practices aimed at improving numeracy outcomes among students.

CONCLUSION

In conclusion, this study has shed light on the significant impact of game-based learning strategies on enhancing Early Grade Mathematics Assessment (EGMA) scores among Grade 2 pupils. Through a meticulous pre-experimental research design and comprehensive data analysis, several key findings have emerged: Firstly, the study revealed the prevalence of low numeracy levels among students before the intervention, highlighting the need for targeted interventions to address specific mathematical difficulties. Secondly, the implementation of game-based learning strategies resulted in a promising improvement in students' numeracy skills, as evidenced by higher post-test scores and a shift towards advanced or high numeracy levels across all domains. Furthermore, the statistical analysis confirmed a significant difference between pre-test and post-test scores, rejecting the null hypothesis and underscoring the effectiveness of the game-based learning intervention. The implications of these findings extend beyond the immediate context of this study. Recommendations for practice include the implementation of targeted interventions, expansion of game-based learning programs, and ongoing assessment and evaluation to ensure continuous improvement. Additionally, fostering collaboration between parents and teachers can further support students' learning experiences both at home and in the classroom. Looking ahead, future research endeavours may explore mixed methods approaches and advanced analytics techniques to gather comprehensive data and gain deeper insights into the learning process. By adopting systematic and evidence-based practices, educators and researchers can continue to enhance pedagogical interventions and contribute to improved numeracy outcomes among early-grade students. In essence, this study contributes valuable insights to the discourse on effective pedagogical strategies in mathematics education, emphasizing the transformative potential of game-based learning in fostering numerical proficiency among young learners.

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DECLARATION OF CONFLICT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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