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Effect of MatHCOmp Card Game to the Numeracy Skills of Students

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Abstract

Aim: This study addressed the critical gap in mathematics education in the Philippines, where students have consistently underperformed in international assessments. It evaluated the effectiveness of the MatHCOmp Card Game, an innovative educational tool designed to enhance numeracy skills, specifically in performing operations on integers with zero, positive, negative, and rational exponents.

Methodology: It employed a quasi-experimental two-group posttest research design, whereas the study compared outcomes of the control group, which received the traditional teaching methods, and the experimental group which utilized the MatHCOmp Card Game. Each group was consisted of forty-five students, and further categorized into low-performing, average-performing, and high-performing levels based on their initial numeracy skills. Descriptive method was used to assess the numeracy skills, and 2-factor ANOVA was conducted to determine significant differences in performance among the three categories and between the two groups. The research included teaching demonstrations and a posttest.

Results: The results revealed that the experimental group exhibited higher numeracy skills in three out of four competencies compared to the control group. There were very high significant differences (p=.000) in numeracy skills among the categories, as well as between two groups. However, no significant interaction (p=.083) was found between the categories and the groups. Notably, significant differences were observed among low-average (p=.000), low-high (p=.000), and average-high (p=.000) levels.

Conclusion: The findings highlight the importance of innovative instructional strategies in mathematics education. The MatHCOmp Card Game significantly improved numeracy skills, outperforming traditional methods. This study provides valuable insights for educators in designing engaging and effective mathematics instruction that can bridge the gap between current performance levels and international standards.

Keywords: Numeracy Skills, Card Game, Scaffolding

INTRODUCTION

Math plays a very vital role in human existence. Years ago, up to the present, some literature would tell stories incorporating significant numbers about survival and life. Thus, it is particularly important for one person to be numerate. Numeracy would formally start in the four corners of the classroom, where students are involved, facilitated and given entertaining and interesting activities like card games to encourage them to engage in classroom learning.

However, there are so many factors that contribute to not learning math. One of the major contributors to this problem was the COVID-19 pandemic which led to tremendous challenges to several aspects of human existence particularly in line with education and caused huge learning losses for students all over the world (Carvajal, et al., 2024; Carvajal, Sanchez & Amihan, 2023; Muńoz & Sanchez, 2023; Sanchez, et al., 2024a). And, at the peak of the covid-19 crisis, UNESCO showed data that over 1.6 billion learners in more than 190 countries were out of school (UNESCO, 2021). This event caused a massive learning loss, which is still evident up to the present time (Amihan & Sanchez, 2023; Carvajal & Sanchez, 2023).

In the light of setting international standards, identifying significant findings for improvement and progress, international math assessments are being conducted by different organizations such as the PISA, TIMSS and SEA-PLM and others. Their goal is to measure the math performance of the learners. This is being participated by different countries worldwide, including the Philippines.

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Just this December 2023 the Organization for Economic Cooperation and Development or OECD released the result of the Program for International Student Assessment (PISA) in 2022. As DepEd has anticipated, there was no significant improvement in the average scores of Filipino students in reading, mathematics, and science which remained low. The passing average set by PISA was 472 yet the Philippines only got an average of 355, making it ranked sixth to the last out of 81 participating countries in Mathematics. (Bautista, 2023).

Similarly, the Philippines took part in PISA in 2018, the Trends in International Mathematics and Science Study (TIMSS) in 2019, and the Southeast Asia Primary Learning Metrics (SEA-PLM) in 2019. PISA assesses the achievement and application of key knowledge and skills of 15-year-old students in reading, mathematics, and science. TIMSS gauged proficiency in mathematics and science in the fourth and eighth grades, while SEA-PLM evaluated reading, writing, and mathematical literacy, with an initial focus on Grade 5. Across the three assessments, poor learning results were observed among students in the Philippines, with more than 80 percent of them falling below the minimum levels of proficiency expected for the respective grades. The country was last in reading and second to last in Science and Mathematics among 79 countries in PISA. In TIMSS, it ranked last in both Mathematics and Science among 58 countries in the fourth-grade assessment. In SEA-PLM, it was among the bottom half of the six countries in reading, Mathematics and writing literacy. (De Vera, 2021).

The Philippines, despite numerous attempts to improve its educational outcomes (Carvajal & Sanchez, 2024; Dizon & Sanchez, 2020; Salendab & Sanchez, 2023; Sanchez, 2022; Sanchez, 2020), has instead become an educational laggard, taking the ignominious distinction of getting low rankings in three different global evaluations that scored students' performance in Science, Technology, Engineering and Mathematics (STEM). As the country grapples with an education crisis, Philippine President Ferdinand Marcos Jr.-who admitted in a vlog that the Philippines is falling behind in Sciences and Mathematics compared to other countries-vowed in his first State of the Nation Address in July 2022 to improve Filipino students' performance in STEM under his watch. This pledge came on the heels of the country's inferior performance in global and regional rankings, lagging many of its Asian neighbors. (Sison, 2022).

According to the personal observation of the researcher, learners are by nature smart yet due to the pandemic they have not mastered the competencies supposedly acquired in Elementary level or earlier schooling years. Many students in high school are not mathematically, not even academically ready. Sadly, many high school students are finding it hard to operate arithmetical figures and solve problems in math. That multiplication table, they can hardly remember, which makes day-to-day topics on Algebra, Geometry and Trigonometry tough for them. It supports the findings in the international assessments that students in the Philippines fall below the average performance of the standard set forth.

Another major reason is that students have a weak foundation in computational skills. In fact, Igarashi and Suryadarma (2023) in their study they conveyed that not all higher-grade students master the skills that are taught by grade 3. On a personal note, according to the observation of the researcher, high school students in her class are struggling to recall basic math facts, procedures, or rules, especially in simplifying and evaluating integers that they supposedly have mastered already. However, if they are asked about simple addition or subtraction of integers, or even simple multiplication or division of 1-digit numbers, many high school students cannot answer right away and sometimes utter incorrect answers. This makes the quality of education now a days a challenge.

On the lighter side, students can understand the subject matter if they participate in it and there is an intervention of games that interest them most especially because they are GenZ students who are digital natives. Students are active when gamified instruction is employed, making them interact with fun with their classmates (Amihan, Sanchez & Carvajal, 2023; Salendab, Ocariza-Salendab & Sanchez, 2023; Sanchez, 2023a). That was why the researcher was interested in devising a game that would interest and help improve the numeracy of students.

This concern was in line with the priority area of the Department of Education which is to improve Filipino students' performance. On top of the researcher's mind, she was motivated to devise a modified card game to help improve the numeracy of high school students.

Several studies have tackled the effectiveness of card games to primary school students, locally in the Philippines and even outside the country, but a few focused on high school students. This was the gap that the study wanted to bridge, to find ways to better off the numeracy of students and lessen the learning loss brought by the recent pandemic. Thus, it was the underlying assumption that the study wanted to test, to determine the effect of a card game called MatHCOmp, on the numeracy skills of high school students.

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Objectives

This study determined the effect of MatHCOmp Card Game on the numeracy skills of Grade 9 students. Specifically, it answered the following questions:

1. What is the level of numeracy skills of the students in the controlled group and experimental group after the use of MatHCOmp card game?
   a. Performing Operations on Integers with Zero Exponents
   b. Performing Operations on Integers with Positive Exponents
   c. Performing Operations on Integers with Negative Exponents
   d. Performing Operations on Integers with Rational Exponents
2. Are there significant differences in the level of numeracy skills of students among competencies in the controlled and experimental group among the three performing categories?

Hypothesis

Given the stated research problem, the following hypotheses were tested on 0.05 level of significance:
Hypothesis: There are significant differences among the competencies of numeracy skills of students between the controlled and experimental groups among the three performing categories.

METHODS

Research Design

Quasi Experimental Two Groups Posttest Research Design was applied in this study to determine the effectiveness of MatHCOmp card game in the numeracy skills among the high, average, and low-performing categories between the controlled and experimental groups.

Population and Sampling

This study made use of 4 sections of Grade 9 classes in a public high school. These classes were grouped into two. Two sections were assigned as the controlled group, while the other two sections were assigned to be the experimental group. Each group was composed of forty-five students, with a total of ninety respondents. In each section, the participants were subdivided into 3 subgroups, they were categorized as a) low-performing, b) average-performing and c) high-performing students. The main basis for this grouping is their Quarter 2 grades in Mathematics.

Instrument

The researcher developed a card game called MatHCOmp as a teacher's tool for numeracy skills and Exponential Expressional Achievement Tool or EEAT Posttest to collect the necessary data in this study. Used instruments were validated by experts in the field.

Data Collection

The researcher secured permission from administrators, students, parents and others involved in the conduct of the study. Permits are necessary to keep the concerned respondents, offices and people concerned aware of what is to take place, to be notified of its purpose and to allow the conduct of the study.

Treatment of Data

To identify the level of numeracy skills of the respondents, a mean score was gotten to identify the level of proficiency of the respondents. At the same time, it was used to determine the groupings of the respondents.

On the other hand, 2-Factor ANOVA was utilized. This was used to compare the mean scores of students in their posttest along the different competencies and see significant difference between the numeracy skills of the three subgroups in the controlled and experimental groups.

Ethical Considerations

In adherence to the ethical requirements for research undertakings involving human participants, the researcher sought permission from the students, parents and the school head to conduct the study using the Informed Consent Form, Letter to the Students, Parents and School Head.

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RESULTS and DISCUSSION

Level of Numeracy Skills of Students in the Controlled Group and Experimental Group after the Use of MatHCOmp Card Game

Table 1 shows the level of numeracy skills of the controlled group and experimental group in the posttest after the usual teaching and learning process and after the intervention using MatHCOmp Card Game, respectively. The scores obtained were computed accordingly in which the mean score was drawn.

After the experimentation, the respondents undergone a posttest. Their mean scores were examined according to the level of proficiency as stipulated in DepEd Order # 73 s. 2012. However, the researcher modified a little this level of proficiency depending on the number of items each competency contained.

Table 1
Level of Numeracy Skills of Controlled and Experimental Groups

Competencies	Low		Average		High		Overall	
	Controlled Mean Score	Experimental Mean Score	Controlled Mean Score	Experimental Mean Score	Controlled Mean Score	Experimental Mean Score	Controlled Mean Score	Experimental Mean Score
1 (5 items)	3.80 PL	3.93 AL	4.53 AL	4.87 AL	4.93 AL	5.00 AL	4.42 AL	4.60 AL
2 (14 items)	2.67 BL	3.47 BL	3.93 BL	7.67 DL	6.13 BL	10.87 PL	4.24 BL	7.34 DL
3 (6 items)	0.87 BL	2.60 DL	1.20 BL	3.53 APL	2.87 DL	4.47 APL	1.65 DL	3.53 APL
4 (5 items)	0.27 BL	0.53 BL	0.53 BL	1.80 DL	2.33 BL	3.47 APL	1.04 BL	1.93 DL
Total (30 items)	7.61 BL	10.53 BL	10.19 BL	17.87 DL	16.26 BL	23.81 PL	11.35 BL	17.40 DL

Legend:
1 Integers with Zero Exponent *2 Integers with Positive Exponents*
3 Integers with Negative Exponents *4 Integers with Rational Exponents*
BL= Beginning Level, DL= Developing Level, APL= Approaching Proficiency Level, PL=Proficient Level, AL= Advanced Level

On scale of 5:	*0.00-1.00 BL*	*1.01-2.00 DL*	*2.01-3.00 APL*	*3.01-4.00 PL*	*4.01-5.00 AL*
On scale of 6:	*0.00-1.49 BL*	*1.50-3.49 DL*	*3.50-4.49 APL*	*4.50-5.49 PL*	*5.50-6.00 AL*
On scale of 14:	*Below 7.00 BL*	*7.00-8.49 DL*	*8.50-10.49 APL*	*10.50-12.49 PL*	*12.50-14.00 AL*
On scale of 30:	*Below 15.00 BL*	*15.00-18.49 DL*	*18.50-22.49 APL*	*22.50-26.49 PL*	*26.50-30.00 AL*

Under the level of numeracy skills of controlled group, data revealed that the overall mean score obtained in the first competency "Performs Operations on Integers with Zero Exponent" was 4.42 out of 5, this was interpreted as Advanced Level. This means that the students in the low-performing, average-performing and high-performing

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groups almost perfected the said competency. In other words, they are exceptional in solving expressions raised to zero.

For the second competency "Performs Operations on Integers with Positive Exponents" data revealed that the overall mean score of the three groups in the controlled group was 4.24 out of 14 items. This was interpreted as Beginning Level. This means that even after the teaching-learning process and intervention, the respondents still did not meet the competency. In other words, they find it hard to understand the lesson.

While in the competency "Performs Operation on Integers with Negative Exponents" data showed that the overall mean score of the three subgroups in the controlled group was 1.65 out of 6 items. This was interpreted as Developing Level. Generally, this implies that the students in the three subgroups learned the lesson but not to the point of learning it proficiently.

Lastly, for the fourth competency "Performs Operations on Integers with Rational Exponents", data revealed that the overall mean score of the three subgroups in the controlled group was 1.04 out of 5 items. This was interpreted as Beginning Level. Meaning, just like the second competency, despite the teaching-learning process and intervention the respondents still did not meet the competency. Meaning, the respondents find it hard to understand the lesson. This is because of the exponent ½ which is hard for the students to solve.

Generally, the overall mean score of the controlled group was 11.35 out of 30 items. This was interpreted as Beginning Level. This implies that the respondents in the controlled group, through usual teaching and learning process did not meet the competency and they had difficulty grasping the concepts of the topic.

It can also be gleaned from the table that the students in the controlled group performed better in the competency "Performs Operations on Expressions with Zero Exponents" while in the competencies "Performs Operations on Expressions with Positive Exponents" and "Performs Operations on Expressions with Rational Exponents" students perform the least.

Under the level of numeracy skills of the three subgroups in the experimental group. Data revealed that the total mean score obtained in the first competency "Performs Operations on Integers with Zero Exponent" was 4.60 out of 5. Same with the controlled group, this was interpreted as Advanced Level. This means that the students in the low-performing, average-performing and high-performing groups in the experimental group almost perfected the said competency. Notably, all students achieved an advanced level in performing operations on expressions with zero exponents, indicating a strong grasp of foundational mathematical concepts. This is a significant finding, as mastery of basic concepts is crucial for further mathematical learning and application.

For the second competency "Performs Operations on Integers with Positive Exponents" data revealed that the overall mean score of the three groups in the controlled group was 7.34 out of 14 items. This was interpreted as Developing Level. This implies that the students in the three subgroups learned the lesson but not to the point of learning it proficiently. It can also be noted that the performance of the three groups were categorized at the beginning, developing, and proficient levels, with an overall classification at the developing level. This suggests that while the MatHCOmp Card Game facilitated learning, there remains room for improvement in ensuring that all students reach a higher level of mastery in this area.

While in the competency "Performs Operation on Integers with Negative Exponents" data showed that the overall mean score of the three subgroups in the controlled group was 3.53 out of 6 items. This was interpreted as Approaching Proficiency Level. This implies that the students in the three subgroups were able to correctly solve expressions raised to a negative exponent skillfully. Respondents in the experimental group showed higher numeracy skills Approaching Proficiency Level than the controlled group, Developing Level.

Lastly, for the fourth competency "Performs Operations on Integers with Rational Exponents", data revealed that the overall mean score of the three subgroups in the experimental group was 1.93 out of 5 items. This was interpreted as Developing Level. This means the respondents were able to understand the lesson but not to do point of doing it proficiently. However, this is better than the controlled group whose mean score is only 1.04 and only interpreted as Beginning Level.

The competencies involving operations with negative and rational exponents showed students achieving at developing and approaching proficiency levels. These results underscore the challenges students face with more complex mathematical concepts and highlight the need for targeted interventions to support their learning experience.

Generally, the overall mean score of the students in the experimental group was 17.40 out of 30. This was interpreted as Developing Level. Compared to the students in the controlled group, their mean score was only 11.35, which fell under Beginning Level. This means that the respondents in the experimental group, using the MatHCOmp

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Card Game performed showed better numeracy skills compared to the respondents in the controlled group who underwent a usual teaching and learning process.

The findings may be supported by the research and study path of Igarashi and Suryadarma (2023) when they found that not all higher-grade students master the skills that are taught by Grade 3 because of the low mean scores that were interpreted as Beginning Level. Meaning students were not good at adding, subtracting, or multiplying integers which should have been mastered since Grade 3.

At the same time, it is supported with the recommendations of Hwang (2020), Ramani et al (2019), Cheung et al (2021) and Barham et al (2019) when they revealed that students who engage in more early numeracy activities at home and at school on an earlier age like preschool years tend to have high numeracy and suggest to integrate age-appropriate, engaging and motivating numeracy related games to promote numerical knowledge such as using games, picture books, and technological resources. As well as, early years education provides children with an essential skill for learning and life.

In addition, the result of this study conforms with the findings of the study of Pitogo (2022) that to better one's Mathematics performance, numeracy skills must be mastered as they form part of the basic foundations in Mathematics. Similarly, numeracy is affected by intelligence, learning motivation, family environment, facilities and infrastructure and teacher competence and to better one's numeracy skills, parental support is highly encouraged as recommended by Tanghal and Tanghal (2024), Sukarya and Isnurani (2023) and Layug et al (2021).

The findings from the results of the experimental group underscore the potential of game-based learning, as embodied by the MatHCOmp Card Game, to enhance numeracy skills among students. The success observed in the experimental group suggests that integrating educational games into the mathematics curriculum can provide a stimulating and effective learning environment. This aligns with the scaffolding learning theory, where the game serves as a scaffold that supports students in achieving higher levels of understanding and skill development than they would independently (Sanchez, 2023b; Sanchez, et al., 2024b; Sanchez & Sarmiento, 2020; Sanchez, et al., 2022).

Furthermore, the varied performance across different competencies highlights the importance of designing games that cater to a wide range of mathematical concepts and skills. It suggests that while games can be highly effective in enhancing certain numeracy skills, they must be carefully crafted and integrated with traditional teaching methods to address areas where students may struggle.

Differences in the Level of Numeracy Skills of Students Among Competencies in the Controlled Group and Experimental Group Among the Three Performing Categories

Tables 2 to 6 show the result of the level of numeracy skills among the different competencies among the three performing categories and between the controlled and experimental groups. These tables demonstrate comprehensive data showing the analysis of numeracy skills of High-Performing, Average-Performing and Low-Performing students between Controlled and Experimental Groups in the four competencies involving performing operations on integers with different types of exponents such as zero, positive, negative and rational exponents.

Table 2

Differences and Multiple Comparisons in the Level of Numeracy Skills Among 3 Categories of Students and Between Controlled and Experimental Groups on Performing Operations on Integers with Zero Exponents

Source	Type III Sum of Squares	do	Mean Square	F	p-value	Interpretation
category	19.756	2	9.878	6.024	.004	Highly Significant
Group	.711	1	.711	.434	.512	Not Significant
category * group	.289	2	.144	.088	.916	Not Significant
low * average					.036	Significant
low * high					.004	Highly Significant
average * high					.700	Not Significant

Legend: p≤0.001 Very Highly Significant, p ≤0.01 Highly Significant, p≤0.05 Significant, p>.05 Not Significant

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The analysis of the data revealed high significant difference on the mean scores of low, average and high categories (F(2,84)=6.024,p=.004), no significant mean difference on controlled and experimental groups (F(1,84)=.434,p=.512), and no significant interaction effect between category and group (F(2,84)=.088,p=.916) on competency Performing Operations on Integers with Zero Exponents. It indicates that the impact of the card game intervention on the competency "Performing operations on integers with zero exponent" mean scores is varying among the categories and between the groups.

Specifically, the interaction effect highlights that the effectiveness of the card game intervention in enhancing numeracy skills was almost uniform across all category levels and group. For instance, the mean scores for the low, average and high categories in the controlled group (3.80, proficient level; 4.53, advanced level and 4.93 advanced, level) respectively were very close to the mean score of their corresponding level under the experimental group (3.93, advanced level; 4.87, advanced level and 5.00, advanced level) respectively and fell under almost similar competency levels. Meaning, whether students use the MatHCOmp card game or undergo the usual teaching and learning process, the performance of the students on the particular competency will not have significant difference across low, average and high performing students whether in the controlled or experimental group. That is mainly because, according to the personal observation of the researcher, the respondents easily grasped the concept "any number raised to zero is equal to 1". That is why the respondents in both controlled and experimental groups were able to absorb this competency easily.

Implications of these findings suggest that effectiveness of a card game in enhancing the numeracy skills would not be distinct if concept abiding the competency is obvious. Researchers looking to enhance competency in similar settings should consider the competency being taught with the learning tool to be used for instruction. If the tool to be used would not lead to significant improvement of the numeracy skills of the students, better improve the tool or look for more effective strategy to use.

Moreover, Cox (2019) also supports the finding when he said that card games are not only a fun, natural way to integrate math, but they are also easily customizable for various concepts and skill levels. With that, teachers may customize the tools and strategies appropriate to the needs of the students.

To assess the level of mean difference between the three groups (low, average and high), the post-hoc Tukey HSD was used. It revealed significant mean differences between low and average (p=.036) and high significant mean score difference in the low and high categories (p=.004) underscoring the effectiveness of the instructional methods in differentiating student performance based on their initial ability levels. However, there is no significant difference in the mean scores between average and high students (.700). This means that the level of numeracy skills of the average and high students is close and do not show significant differences compared to the low-average and low-high comparisons.

The result of this study implies that student's level of numeracy skills and the strategy employed by the teacher in the lesson significantly influence learning. Therefore, it is empirical for teachers to have wide knowledge on teaching strategies and apply them in the delivery of the lesson so that students would be engaged in the learning process and their needs would be addressed (Sanchez, et al., 2024c; Sanchez, et al., 2024d; Sanchez, Sanchez & Sanchez, 2023). This is supported by the study of Listrianti et al (2022). Their study provides implications about the importance of learning design that teachers must carry out by utilizing various kinds of media and learning resources around them.

As a summary, card games are tools for enhancing the numeracy skills of students, however, this will be of help depending on the competencies and concepts it upholds. Another factor in its effectiveness would depend on the different learning levels of the students. With this, it is imperative that teachers diagnose the learning levels of the students at the beginning of the session so that they can promptly address the students' needs.

Table 3

Differences and Multiple Comparisons in the Level of Numeracy Skills Among 3 Categories of Students and Between Controlled and Experimental Groups on Performing Operations on Integers with Positive Exponents

Source	Type III Sum of Squares	df	Mean Square	F	p-value	Interpretation
Category	442.822	2	221.411	24.510	.000	Very Highly Significant
Group	214.678	1	214.678	23.765	.000	Very Highly Significant

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category * group	62.689	2	31.344	3.470	.036	Significant
low * average					.002	Highly Significant
low * high					.000	Very Highly Significant

Legend: p≤0.001 Very Highly Significant, p ≤0.01 Highly Significant, p≤0.05 Significant, p>.05 Not Significant

The analysis of the data revealed very high significant effects of category (F(2,84)=24.510,=.000), also very high significant effects of group (F(1,84)=23.765,p=.000), and a significant interaction effect between category and group (F(2,84)=3.470,p=.036) on competency 2. Post hoc tests using the Tukey HSD method indicated significant differences in competency scores between the different categories: low, average, and high. The homogeneous subsets analysis further supported these findings, demonstrating distinct competency levels across the categories.

The significant results for the interaction effect between category and group in the data analysis indicate that the impact of the card game intervention on competency 2 scores varied depending on both the category (low, average, high) and the group (experimental, controlled). This interaction effect suggests that the combination of category and group factors influenced competency outcomes differently than if each factor was considered independently.

Specifically, the interaction effect highlights that the effectiveness of the card game intervention in enhancing competency levels was not uniform across all category levels and groups. For instance, the competency scores for the high category were notably higher in the experimental group ($M_{10.87}$, proficient level) compared to the controlled group ($M_{6.13}$, beginning level), indicating a more pronounced positive effect of the card game intervention in the high category. On the other hand, the impact of the card game intervention in the low and average categories showed varying degrees of improvement in competency scores between the experimental and controlled groups.

It is aligned with Structural Learning (2021) in their viewpoint that the principle of Scaffolding in education which is a teacher's strategy for providing assistance while students master new skills and concepts is deemed very necessary. This is parallel to the standpoint of Blakeley (2023) when it said that scaffolding is a particular strategy for gradually building knowledge designed to give students the support they need initially so that they can complete tasks independently. Moreover, it is also supported by the study of Pitogo (2022). He said that to better one's Mathematics performance, numeracy skills must be mastered as they form part of the basic foundations in Mathematics. And he recommended that teachers and parents shall continue in providing the guidance and assistance to the pupils. Indeed, parents and teacher's assistance are very vital in facilitating the learning of the students.

For the competency indicating performing operations on integers with positive exponents, the post-hoc Tukey HSD was used to test the level of mean difference between the three groups (low, average and high). It revealed high significant mean differences between low and average (p=.002) and average and high (p=.002) and very high significant mean score difference in the low and high categories (p=.000) underscoring the effectiveness of the instructional methods in differentiating student performance based on their initial ability levels. This means that the numeracy skills of these groupings are distinctly different and beyond favor to the effectiveness of the use of MatHCOmp card game.

Implications of these findings suggest that both the category and group factors significantly influence competency levels. Researchers looking to enhance competency in similar settings should consider the impact of these factors when designing interventions or training programs. Understanding how different category levels and group types affect competency can help tailor strategies to optimize performance and outcomes in relevant contexts.

In summary, the significant interaction effect underscores the nuanced relationship between the category levels and group types when assessing the influence of the card game intervention on competency "performing operation on integers with positive exponent" scores. This finding emphasizes the importance of considering the combined effects of distinct factors in interventions to better understand how they interact and contribute to the overall outcomes.

Findings of this study is supported by so many literatures and studies indicating different factors to numeracy. It includes Scispace (2023) that discussed lack of a supportive home numeracy environment, particularly in low- to middle-income communities, socioeconomic status and literacy abilities, inadequate access to educational resources, including calculators and poverty, as well as math anxiety according to Integra Marketing Team (2021); Tanghal and Tanghal (2024) mentioned about sex, family size, and study habits, Sukarya and Isnurani (2023) cited intelligence, learning motivation, fatigue, family environment, facilities and infrastructure and teacher competence, teacher's factor in terms of encouraging cooperation and participation said Latiban and Mendez (2022), economic

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status according to Scalise et al (2019) while Hwang (2020), Ramani et al (2019) and Cheung et al (2021) cited earlier foundation, these are among the so many factors influencing numeracy skills. These factors should be identified by the teachers and its stakeholders including the school administrators, parents and the community. They should work hand-in-hand to help resolve these issues for realization of improved numeracy skills of the school children.

Table 4

Differences and Multiple Comparisons in the Level of Numeracy Skills Among 3 Categories of Students and Between Controlled and Experimental Groups on Performing Operations on Integers with Negative Exponents

Source	Type III Sum of Squares	df	Mean Square	F	p-value	Interpretation
category	58.289	2	29.144	12.689	.000	Very Highly Significant
Group	80.278	1	80.278	34.952	.000	Very Highly Significant
category * group	2.289	2	1.144	.498	.609	Not Significant
low * average					.244	Not Significant
low * High					.000	Very Highly Significant
average * High					.004	Highly Significant

Legend: p≤0.001 Very Highly Significant, p ≤0.01 Highly Significant, p≤0.05 Significant, p>.05 Not Significant

The results showed the very high significant interaction effect in the category (F(2,84)=12.689,p=.000) and very high significant interaction effect in the group (F(1,84)=34.952),p=.000. However there is no significant interaction between the category and group (F(2,84)=.498),p=.609 in the impact of card game intervention to numeracy skills. This means that the mean scores of the three categories (low, average and high) do not have significant interaction with the groupings (controlled and experimental groups) in developing the numeracy skills of students.

Explicitly, the interaction effect highlights that the effectiveness of the card game intervention in enhancing numeracy skills was not uniform across all category levels and groups. For instance, the mean scores for average performing students were notably higher in the experimental group ($M_{3.53}$, approaching proficiency level) compared to the controlled group ($M_{1.20}$, beginning level), indicating a more pronounced positive effect of the card game intervention in the average categories. On the other hand, the impact of the card game intervention in the low and high category showed a varying degree of improvement in mean scores between the experimental and controlled groups.

Implications of these findings suggest that both the category and group factors do not significantly influence numeracy skills. Researchers looking to enhance competency in similar settings should consider digging deeper into the concepts of performing operations on integers with negative exponents. This was because according to the personal observation of the researcher, the students are confused on getting the positive form of an exponential expression given a negative exponent especially if the base is negative.

This finding is supported by Conceptual scaffolding. To address the confusion experienced by the students, the principle of conceptual scaffolding will be helpful. It helps students to navigate complex concepts by connecting new information with existing knowledge. Teachers' role here is to facilitate the students and ensure that their learning experiences are meaningful and that the transition towards independent learning is smooth and effective.

Another, to evaluate the level of numeracy skills among the three groups (low, average and high) under the competency indicating performing operations on integers with negative exponents, the post-hoc Tukey HSD was again utilized. Analysis of data revealed no significant mean differences between low and average (p=.244), yet it is with very high significant mean difference between low and high (p=.000) and high significant difference between average and high (p=.004) signifying significant difference resulted by the obtained ability of the students.

Implications of these findings suggest that indeed, the level of numeracy skills of students significantly influence learning. Hence, researchers looking to enhance numeracy skills in similar settings should consider the impact of this aspect when designing interventions or training programs. Understanding how diverse levels of numeracy skills affect learning can help tailor strategies to uplift the learning outcomes of students.

Results of this study regarding embarking on interventions or training programs is supported by Belleza (2022) in his study that recommended parent's involvement, Latiban and Mendez (2022) cited about a seminar for

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teachers on promoting the use of cooperative learning strategy in the classroom, Layug et al (2021) conveyed conference with parents and students, one–on–one tutorial, redo activities with low scores, home visitation, providing supplementary materials and activities, lessen items of activities and remedial class, while Vogt et al (2018) suggested play-based intervention. Though with different methods, these interventions succeeded in increasing the learning outcomes of students.

Table 5

Differences and Multiple Comparisons in the Level of Numeracy Skills Among 3 Categories of Students and Between Controlled and Experimental Groups on Performing Operations on Integers with Rational Exponents

Source	Type III Sum of Squares	df	Mean Square	F	p-value	Interpretation
Category	98.422	2	49.211	27.956	.000	Very Highly Significant
Group	17.778	1	17.778	10.099	.002	Highly Significant
category * group	4.422	2	2.211	1.256	.290	Not Significant
low * average					.071	Not Significant
low * high					.000	Very Highly Significant
Average * high					.000	Very Highly Significant

Legend: p≤0.001 Very Highly Significant, p ≤0.01 Highly Significant, p≤0.05 Significant, p>.05 Not Significant

In the fourth competency "Performs Operations on Integers with Rational Exponents", results showed the interaction effect between category and group in the impact of card game intervention to numeracy skills. Data revealed that the mean scores of the 3 categories (low, average and high) have a very high significant differences (F(2,84)=27.956),p=.000, also, there is a high significant difference between the mean scores of controlled and experimental groups at (F(2,84)=10.099),p=.002, however there is no significant interaction between the categories and the groups (F(2,84)=1.256),p=.290. It suggests a subtle interaction between the use of MatHCOmp card game in the instruction and the inherent level of numeracy skills of the students.

Particularly, the interaction effect highlights that the effectiveness of the card game intervention in enhancing numeracy skills was not uniform across all category levels and groups. All the categories showed improvement in the mean scores. For instance, the mean scores for the high category were notably higher in the experimental group ($M_{3.47}$, approaching proficiency level) compared to the controlled group ($M_{2.33}$, beginning level), indicating a more pronounced positive effect of the card game intervention in the high category. On the other hand, the impact of the card game intervention in the low and average categories also showed significant degree of improvement in the mean scores between the experimental and controlled groups.

Result of this data is supported by Rasid et al (2022). They discussed that in facing the challenges of Industry 5.0, the younger generation, in particular, needs to master the field of STEM. Hence, efforts in raising students' interest in STEM should include introducing numeracy skills earlier. This is again in line to the concept of developing the numeracy skills of children in their early years. This will be addressed by incorporating play or game and activities in their learning for it succeeded in increasing children's interest, enjoyment, attention span, and confidence.

The post-hoc Tukey HSD test revealed very high significant mean differences in low and high comparison (p=.000) and average and high (p=.000) only indicating distinct performance in accordance with their level of numeracy skills but not in low and average comparison (p=.071). This is because, according to the personal observation of the researcher, the students were confused about getting the square root of an expression. Especially if the number is not a perfect square, students find it hard to get the perfect square closest to it. This confusion was evident mostly to the low-performing students, gladly the average-performing specially the high-performing students got a clear reception of this concept.

This differentiation supports the belief that any tool for learning, including the use of the MatHCOmp card game, have a significant impact based on the existing knowledge of the learners. As well as teacher competence plays a crucial role in the process of learning. Teacher factor such as the ability of teacher to manage classrooms, in

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terms of encouraging cooperation and participation greatly affect behavior of the students as well as their academic performance.

The findings may be supported by the study of Sukarya and Isnurani (2023). They claimed that the factor that is more influential on the numeracy of students in grade VIII of SMP Darus Salam is teacher competence. Therefore, it will be an immense help if teachers will upgrade themselves in terms of their education, enrolling to post graduate studies, if not submitting oneself to other developmental trainings, workshops, seminars or studies would be a nice step for personal and professional development. For in this manner, they will be able to expand their horizons and learn new things, effective methods and approaches in shaping today's types of learners and responding to the needs of times.

Table 6

Differences and Multiple Comparisons in the Level of Numeracy Skills Among 3 Categories of Students and Between Controlled and Experimental Groups

Source	Type III Sum of Squares	df	Mean Square	F	p-value	Interpretation
category	1809.356	2	904.678	42.673	.000	Very Highly Significant
group	822.044	1	822.044	38.776	.000	Very Highly Significant
category * group	108.956	2	54.478	2.570	.083	Not Significant
low * average					.000	Very Highly Significant
low * high					.000	Very Highly Significant
average * high					.000	Very Highly Significant

Legend: p≤0.001 Very Highly Significant, p ≤0.01 Highly Significant, p≤0.05 Significant, p>.05 Not Significant

The 2-factor ANOVA results indicate very high significant differences in the overall performance across categories (high, average, low) with F(2,84)=42.673,p=.000, and gauged a very high significant difference also between groups (experimental, controlled) with $F(1,84)=38.776, p=000$. The interaction effect between category and group was not significant, $F(2,84)=2.570, p=.083$, suggesting a nuanced interaction between the type of instruction (use of MatHCOmp card game) and the inherent ability level of the students.

With this finding, interventions were suggested as supported by Layug et al (2021). They discussed that there should be coherence with parents and students, one-on-one tutorials, Redo Activities, Home Visitation, Provision of Supplementary Materials, lessen activities, and Remedial Classes should be implemented. As well as integration of play experience as agreed by Papic et al (2023), Vogt et al (2018) Susuoroka (2020), Andayani (2022) when effectively used in teaching can improve mathematics learning skills.

That being said the following came up with different game-based studies: Lin and Cheng (2022) studied a technology-enhanced board game, Lee and Choi (2020) studied a tablet-based math game, Aunio and Mononen (2018) studied an educational computer game called Lola's World, Ogbu et al (2023) studied algebrameter and Pan and Ke (2023) studied the three types of game-based learning supports, Tiaturrahmaniah and Fajri (2020) devised a fractional card game, Wulandari et al (2022) devised a dynamic number card, Chong et al (2022) devised a non-digital card game, Rakhmawati et al (2020) devised a dragon snake and Singh et al (2021) devised a Math Zap. The result, all, these are potential tools to be used as medium for teaching and learning math because they succeeded in increasing the students' learning outcomes.

The post-hoc Tukey HSD test revealed very high significant mean differences between all categories, indicating that the performance levels are distinct across the high, average, and low categories. Specifically, the difference between low and average (p=000), low and high (p=.000) and between average and high (p=.000) categories were very highly significant, underscoring the effectiveness of the instructional methods in differentiating student performance based on their initial ability levels. The homogeneous subsets, as determined by the Tukey HSD, further delineate these groups, with low, average, and high categories forming distinct subsets based on their overall performance scores. This differentiation supports the notion that the instructional interventions, including the use of the MatHCOmp card game, have a differential impact based on the initial competency levels of the students.

The significant interaction effect and the clear differentiation among performance categories underscore the importance of tailored instructional strategies, such as scaffolding, in enhancing student learning outcomes in

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mathematics. Scaffolding, which involves providing support to students based on their current level of understanding and gradually removing that support as competence increases, can be particularly effective in contexts where students' initial abilities vary widely. The findings suggest that incorporating tools like the MatHCOmp card game into the scaffolding process could be particularly beneficial. For instance, for lower-performing students, the game can provide a concrete, engaging way to grasp fundamental concepts, while for higher-performing students, it could offer opportunities to explore more complex strategies and mathematical concepts.

This is supported by the study of Vogt et al (2018). They said that differentiated effects were fund as tendencies: children (kindergarten learners) with low competencies tend to gain more from training programs compared to no intervention; children with high competencies gain more from the play-based approach than the training. Further, educators evaluated the play-based intervention with card and board games as better suited to children's diverse needs. Hence, it is important that teachers identify the learning levels of students as to low, average and high to be able to plot interventions and enrichment or advancement appropriate to their level to address their diverse needs.

Conclusions

The level of numeracy skills in the experimental group is higher in the three competencies than the numeracy skills in the controlled group. This means that the use of MatHCOmp card game was effective compared to the usual teaching and learning process in teaching the "Performing Operations on Integers with Positive, Negative and Rational Exponents".

Another, numeracy skills in terms of performing operations on integers with different types of exponents is very highly affected by student's initial ability level. It is also very highly affected by the strategy used for instruction. In this study, use of MatHCOmp card game is very highly effective in enhancing the numeracy skills of students in terms of operations on integers with different types of exponents compared to using the traditional approach.

Recommendations

Proceeding from the foregoing findings and conclusions, the following recommendations are put forward. Engage students in more early numeracy activities at home and at school on an earlier age like primary school years with age-appropriate, interactive and motivating numeracy related games to promote numerical knowledge such as using games, picture books, and technological resources.

Games may be carefully crafted and integrated with traditional teaching methods to address areas where students may struggle. One of the ways is to design card games and use it as a form of intervention for mastery of math concepts.

Traditional teaching is not bad, however teaching incorporated with a game-based learning is better. Math teachers may design their lessons in consonance with this approach because it keeps the learners engaged, active and interested in the lesson.

Make learning fun and engaging academically and interpersonally. Teachers may customize lessons, come up with game-based tools and conduct interactive strategies that may be appropriate and captivate the interests and needs of the students.

At the beginning of the school year, teachers may identify the learning levels of students as to low, average and high by conducting a diagnostic test. At the same time, he may to identify their learning difficulties and think of possible intervention to address the diverse needs of the learners.

Design peer-assisted activity where higher-performing students may assist the lower-performing students. In this manner lower-performing students may be helped on their difficulties while enriching the knowledge, skills and mastery of the higher-performing students.

Teachers are only facilitators of learning. Hence, teachers are advised to provide learning experiences to students that would ensure meaningful, smooth and effective transition towards independent learning.

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