KWATRO: Its Effect on Improving Students' Performance in Addition of Integers

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***Abstract*—** Game-based learning instruction allows students to engage with educational games and strategic instructional materials in a playful and dynamic way. Kwatro is a mathematical card game designed to develop mastery of the computational skill of the students on the topics relative to addition of integers. A quasi-experimental pretest-posttest design was used to determine the effectiveness of the game Kwatro in improving the level of performance of the least performing students in Addition of Integers with twenty-five 7th-grade students from San Roque National High School, School Year 2021-2022. The instruments of the study consisted of a 20-item multiple choice teacher-made pre-posttest about addition of integers and card games. The results of the pre-test and post-test show an increase in the performance of students from DNME (Did Not Meet Expectation) to FS (Fairly Satisfactory) after the utilization of the game. The result of the t-test revealed that there is a significant difference between the pretest and posttest scores of the 25 students after the utilization of the game. This means that the utilization of Kwatro is effective in improving the level of performance of the least performing students in addition of integers. Kwatro can be used even in blended learning with teachers and parents' supervision in times of pandemic.

***Keywords*—** Game-based, Effectiveness, Intervention, Level of Performance.

INTRODUCTION

Number and Number Sense is one of the branches of mathematics which made a unique and meaningful contribution to the students in the variance of mathematics achievement (Jordan, Glutting, and Ramineni, 2010). In addition, it was noted by Cheng and Wang (2012) that an earlier curriculum with a great concentration on number sense development helps children perform better in mathematics later on. Mastering these skills will enable every individual to handle numerical problems in their daily life.

One of the specific learning competencies included in Number and Number Sense is the addition of integers under operation on integers (K to 10 Mathematics Curriculum Guide, 2013). Adding is an essential basis in daily lives. Its applications are important particularly in counting things or different variables. Basically, if one does not know how to add, then he or she will never know math. The addition of integers is identified by most elementary and secondary teachers as one of the prerequisite learning competencies in other content such as in algebra and in geometry. Woods, Geller, and Basaraba 2018 provided the general idea that a strong foundation with the early number of concepts including the addition of integers is very essential for students' future success in mathematics.

Unfortunately, the performance of students in Mathematics is exceptionally low (Morita- Mullaney, Renn, & Chiu, 2020; Wong & Chan, 2019; Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015). In line with this issue, mathematics teachers of San Roque National High School (SRNHS) revealed that based on the result of the interview during the home visitation and the result of the summative test, most of the grade 7 students have insufficient knowledge in some learning content and competencies which are included in Number and Number Sense most especially in adding integers. This is the reason why the students are having a hard time learning or understanding other related learning competencies in other branches of mathematics in all grade levels. Therefore, it is a great challenge for the teachers and students to teach and learn higher mathematics respectively.

Teachers mentioned that only 10 percent of their students who are considered the truly motivated ones get a quality education. Low achievers in mathematics who are considered at risk in mathematics performance need more guidance, assistance and care, unfortunately, most of the time they do not receive enough attention from the teachers (Cramer, Post, & delMas, 2002; Empson, 2003) and it is almost impossible for the individual attention (Mydans, 2009).

Education remains a top priority in the Philippine context. However, many factors must be considered in implementing academic curricular changes particularly in mathematics (Andres & Francisco, 2008). The

development of an effective intervention program therefore is important in helping students to overcome these issues (Optiz, Freesemann, Prediger, Grob, Matull, & Hubmann, 2017). It was illustrated by Arnold, Fisher, Doctoroff, & Dobbs, 2002 that students receiving intervention improved their mathematics skills and showed increased interest in mathematics. Therefore, it is a great challenge for every mathematics teacher to craft and implements an intervention that will improve the performance of students in addition of integers.

Various teachers' practices are an important part of the development of students' understanding and skills in solving problems related to integers (Akyuz, Stephan, & Dixon, 2012). Teachers play a vital role in planning activities that require the application of students' acquired knowledge and skills and provoke critical thinking and problem-solving skills (Dio, 2015). Teaching is all about guiding and engaging students in learning (Biddle, 2001). Active learning environments improve the learning outcome and engagement of students in their learning process (Bodnar & Clark, 2014). It is then agreed upon by the majority of educators and learners that one of the most loved teaching strategies by the students is Game-Based Learning.

The motivational psychology involved in game-based learning allows students to engage with educational materials in a playful and dynamic way. It is not just creating games for students to play, it is designing the learning activities that can incrementally introduce concepts, and guide users towards an end goal (Trybus, 2015). Game-based learning involves instruction with a realistic game experience (White & Mccoy, 2019). This approach yielded better outcomes than the paper-based setting in both students' confidence and students' performance (Ku, Chen, Wu, Lao & Chan, 2014).

With all the data gathered and presented, the researchers therefore conducted a study entitled KWATRO: Its Effect on Improving Students' Performance in Addition of Integers. Kwatro was a mathematical card game intended to develop mastery of the computational skill of the students on the topics relative to the addition of integers. The study specifically answered the following questions; (1) What is the level of performance of grade 7 students before the conduct of the game Kwatro in mathematics?, (2) What is the level of performance of grade 7 students after the conduct of the game Kwatro in mathematics?, and (3) Is there a significant difference between the level of performance in the pretest and posttest of grade 7 students before and after the utilization of the game Kwatro in mathematics?

METHODOLOGY

The study employed the Quasi-experimental and One-Group Pre-test-Post-test research design focusing on determining the effectiveness of kwatro as a mathematical game in improving the performance of students in addition of integers. This includes the phenomenon and its identities or characteristics (Nassaji, 2015) and the assessment of the changes in the phenomenon over the duration of the study (Jaikumar, 2018). Purposive sampling was used in identifying the respondents. The respondents were the 25 grade 7 students for the school year 2021-2022 identified as the low performing students based on their poor performance and low quarterly grades in mathematics subject as well as based on the findings of the conducted home visitation and monitoring.

The researcher used one set of multiple-choice type of test which was comprised of 20 questions in getting the performance level of students before and after the conduct of the intervention. The multiple-choice type of test provides an efficient and effective measure of student learning (McKeachie, 1999), it is also reliable across scorers, and students who studied less can be easily identified in this type of test (Roediger & Marsh, 2005). For this reason, many educators and researchers consider multiple-choice format as an optimal method of testing (Frederiksen, 1984).

KWATRO

The game Kwatro is intended to develop mastery of the computational skill of the students on the topics relative to addition of integers. For the players to win, they must collect large amount of points at the end of the game.

Four players and one host are needed to play the game. The game comes with 38 cards, including 32 playing cards and six category cards. The category cards are the cards that the host will present each round. The following are the list of category cards: (1) Even Numbers, (2) Odd Numbers, (3) Positive Numbers, (4) Negative Numbers, (5) Numbers Divisible by 2, and (6) Numbers Divisible by 3. The numbers on the 32 playing cards range from -8 to 8, excluding zero. These cards will be given to the four players at the start of the game. A score sheet is also included to record the players' scores for each round in order to determine the game's winner.

Figure 1. *Sample Cards in Kwatro*

Figure 1 shows the sample cards for the game Kwatro. The first card is the back part of all cards of the game, the second is one of the examples of a category card, and the third is an example of playing cards.

Mechanics

- To start, the host will give each player with eight (8) random cards.
- Then, the host will choose a category and will present it to the players.
- Each player will then pick a card from their 8 cards and will show it to the other players.
- All cards laid down by the players will be added (Mathematical rules for adding Integers will apply)
- The player with the highest value of card put down will have the total score for the round. The score will depend on the cards laid down by the players. So, it could be a loss (negative) or gain (positive) depending on the sum of the cards laid down.
- This will continue until all the category cards are drawn by the host.
- The Player with the highest score will be the winner of Kwatro.

Kwatro was played by the participants every after regular class hours and every Friday as part of the Independent Cooperative Learning (ICL) for two (2) weeks. They are assisted by the researchers to avoid the contamination of the game Kwatro with non-respondents.

After the two weeks conduct of intervention, the same test was administered to the group. The result of the post-test was recorded and compared to the pre-test. The data were gathered and interpreted using the frequency count, mean, and performance level (PL).

The gathered data were treated statistically. These are presented in a logical order based on the study's specific problems. To determine the level of performance of respondents in the tests, the mean score in each competency were utilized. They were converted into percentage score using the formula:

$$PS = \frac{\text{Total raw scores}}{\text{highest possible score}} \text{ x } 100\%$$

The scores were transformed into transmuted grades using the DepEd Order no.8, series of 2015, also known as Policy Guidelines on Classroom Assessment for the K to 12 Basic Education Program. The percentage scores in the pre-test and post-test of the group was reported using the descriptors as identified in the same DepEd Order.

Scale		**Descriptor**
Below 75& Expectations	-	Did not Meet
75% - 79%	-	Fairly Satisfactory
80% - 84%	-	Satisfactory
85% - 89%	-	Very Satisfactory
90% - 100%	-	Outstanding

Mean Normalized Gain (MNG) was used to identify the mean gain between pretest and posttest, this study used Hake's g. This statistical tool helps analyze students with widely varying initial knowledge states using pretest and posttest results (Hakes, 1998). This has the following scale:

g>0.7	-	High Gain
0.7>g>0.3	-	Medium Gain
g<0.3	-	Low Gain

The study used Cohen's d to determine the effect size of the t-test's result by comparing the pretest and post-test scores. To compute this, the t-computed value (t) was divided by the square root of the number of respondents (N) (Cohen, 1998). The interpretations of Cohen's d result are as follows:

Cohen's d	**Descriptive Interpretation**	**References**
≤0.01	Very Small	Sawilowsky, 2009

0.02 – 0.20	Small	Cohen, 1988
0.21 – 0.50	Moderate / Medium	Cohen, 1988
0.51 – 0.80	Large	Cohen, 1988
0.81 – 1.20	Very Large	Sawilowsky, 2009
1.21 – 2.00	Huge	Sawilowsky, 2009

Moreover, statistical tools such as weighted mean for the mean score and t-test (two-tailed) for correlated samples for the pretest and post-test results were also used in the study. This determined the significant difference between the pretest and posttest results before and after the conduct of the game Kwatro.

RESULTS AND DISCUSSIONS

This chapter discusses the effectiveness of the game Kwatro in improving the performance of the least performing grade 7 students in addition of integers. It includes the results, analyses, and interpretation of the data gathered. The gathered data was presented in tables for a clearer presentation. The data is presented in the following order: 1) students' level of performance on the pretest and posttest results, and 2) significant differences between the pretest and posttest results.

1. Students' level of performance in Pre-Post Test

The goal of the game is to improve students' knowledge and skills in adding integers. It is intended for least performing students who failed to meet the required skills in the modular distance learning approach This is a 20-item teacher-made multiple choice type of examination in addition of integers for grade 7 SY: 2021-2022. Table 1 shows the result of the pretest and posttest through mean gain and performance level (PL) using the assessment and evaluation scale adopted from DepEd Order No. 8, s. 2015.

Table 1: *Level of Performance of Grade 7 Students in the Pretest and Posttest*

Topic	**Total Items**	**Pretest**			**Posttest**			**MNG**
		Mean Score	PL%	Description	Mean Score	PL%	Description	
1. Addition of Integers	20	5.28	26.4	DNME	15.92	79.6	FS	0.72

Legend: DME – Did Not Meet Expectation FS – Fairly Satisfactory MNG – Mean Normalized Gain PL – Performance Level

Table 1 shows that the mean for pretest is 5.28 with a corresponding PL of 26.4% with a descriptive rating of Did Not Meet Expectation (DNME). The mean for the post-test is 15.92 with a corresponding PL of 79.6% which falls on the descriptive rating Fairly Satisfactory (FS). The result shows that students failed to meet the passing rate of 75% set by the Department of Education in the pretest, but the numerical rating in the posttest shows an increase in the level of performance of students after the utilization of the game. The mean rating increased from 26.4% (Did Not Meet Expectation) to 79.6% (Fairly Satisfactory).

This means that the least performing grade 7 students passed the passing rate set in DepEd Order 8 s. 2015 in posttest and the mastery level of students in addition of integers have increased after the utilization of the game Kwatro. This also proves that the implementation of Kwatro helped enhance the competencies of the students in addition of integers. It also enhances the motivation and increases students' interest in the subject matter. This is also supported by the study of Carale (2019) that remediation as a means of improving students' performance and learning skills is effective.

2. Difference between the Pre-Test and Post-Test Scores

This study used paired sample t-Test (two-tailed) to identify the existence of significant difference between scores in pretest and post-test. Table 2 shows the result of the paired sample t-Test (two-tailed).

Table 2: *Difference Between the Pretest and Posttest*

Statistical Bases	**Statistical Analysis**
N	25
Df	24
α	0.05
t-tabular value (two-tailed)	1.71
t- computed value (two-tailed)	-22.28
Decision on Ho	Reject Ho
Interpretation	Significant
Cohen's d	4.46
Effect size	Huge

As shown in table 2, the t-computed value (two-tailed) of -22.28 is less than the t-critical value (two-tailed) of

1.71 at 0.05 level of significance with 24 degrees of freedom. Thus, the null hypothesis is therefore rejected implying that there is a significant difference between pretest and posttest scores of Grade 7 students in Addition of Integers before and after the utilization of the game Kwatro. This result also signifies that the scores of the 25 least performing grade 7 students in the posttest are significantly higher than the scores in pretest. This indicates that the remediation tool in a form of a game was effective in improving the performance of the students in addition of integers. The result also showed that the game Kwatro assisted in addressing the least performing students in Mathematics. This result supports the study made by Liu & Chen (2013) that the use of the card games enhances learning motivation and learning effectiveness.

CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of the study, it can be concluded that the use of the game Kwatro significantly increased the performance level of Grade 7 students and is effective in improving the performance of the least performing students in Mathematics. To further test the effectiveness of the game Kwatro, a more robust experimental research design may be conducted. Also, the game may be used as a reference in creating more learning materials to enhance students' performance. Finally, future studies related to remediation may be undertaken by covering other learning competencies in Mathematics.

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