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Effectiveness of Four Corners and a Diamond Graphic Organizer in Solving Mathematics Word Problems

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***Abstract*—** The purpose of this study was to determine the effectiveness of Four Corners and a Diamond graphic organizer in solving mathematics word problems. A quasi-experimental two-group pretest posttest design was used. Universal sampling was employed in selecting the research subjects. A researcher-made questionnaire was used as a tool in gathering substantial data. Further, mean, standard deviation, paired t-test, and independent t-test were used as a statistical tool to address the questions regarding the proficiency level of the subjects and whether there is a significant difference in the scores within and between groups. The results showed a significant difference to the scores of students exposed in the graphic organizer in their ability to solve mathematics word problems. With this, the study recommends that students should try this alternative way in solving mathematics word problems. Also, teachers should try different ways of teaching mathematics word problems. Further, the study also suggests the Department of Education conduct training and webinars on alternative ways to solve word problems in mathematics.

***Keywords*—** Four Corners and a Diamond graphic organizer, mathematics education, mathematics word problems, quasi-experimental research, Philippines

I. INTRODUCTION

Mathematics word problem is one of the many things that students struggle with. These are among the most challenging problems that mathematics learners encounter (Verschaffel et al., 2020). Even though problem-solving skills are critical for preparing the learners for the workforce since they are expected to pinpoint and solve various problems that arise in numerous settings (Quinto & Mabansag, 2023), regrettably this issue is prevalent in the Philippine education sector today.

In Indonesia, students face difficulty solving word problems (Haerani et al., 2021). The result of the PISA in 2022 showed that 15-year-old Indonesian students scored lower (366) than the average (472). Only 18% of students got at least Level 2 proficiency in mathematics; the average is 69% (Organisation for Economic Co-operation and Development, 2023).

Also, countries such as Vietnam and the Kingdom of Saudi Arabia have students who struggle with mathematics problem-solving. Most students in Vietnam are still weak in problem-solving in mathematics. This situation is manifested in their PISA result. Vietnam has had a declining average in mathematical literacy from 2012 to 2015 (Mawarti et al., 2018). Moreover, in the Kingdom of Saudi Arabia, the academic performance of K-12 students has been seen as unsatisfactory based on international comparison. Alrashdi & Almutawa (2022) stated that the recent Trends in International Mathematics and Science Study (TIMSS), the Kingdom of Saudi Arabia was included in the five countries with the lowest mean achievement in mathematics around the globe.

In the Philippines, students performed poorly in mathematics over the past 15 years (Roman, 2019). It is evident in the recent result of PISA in 2022, which showed that the mean score in Mathematics for learners situated in the Philippines was only 355 compared to the average of 472. In addition, only 16% of Filipino students scored at least Level 2 proficiency in mathematics compared to the average of 69% (Organisation for Economic Co-operation and Development, 2023). Moreover, Filipino learners' poor mathematics performance during the PISA 2018 also varies. Students from private schools performed slightly better than public school students, where the mean was 395 and 343, respectively (Lapinid et al., 2022).

Locally, students also struggle to answer mathematics word problems in one of the schools in the Compostela East District, Division of Davao de Oro. The researcher, who handled General Mathematics and Statistics and Probability, observed an alarmingly low score in written works involving word problems. The mean scores in the 40-item second-quarter examination of the two sections handled by the researcher were 20.96 and 21.47. Its corresponding proficiency levels were 52.40%, and

53.86% translated to low mastery. Following the essential learning competencies, some topics were interests, annuities, stocks and bonds, and consumer loans. Hence, most of the questions given were word problems.

According to a study by Abdullah & Nor (2022), graphic organizers can be a useful tool to help students improve their problem-solving abilities when used in conjunction with high-quality instruction. A graphic organizer is a tool for showing the students' knowledge. Additionally, it helps pupils articulate their ideas and allows them to do it in a way that is unique to their own linguistic style. Moreover, a study by Razzaq et al. (2022) revealed that graphic organizers are the best tool for learning since they make teaching more effective compared to other teaching methods.

Four-Corners and a Diamond graphic organizer is one kind of graphic organizer. There are five primary sections to this graphic organizer: (1) What problem are we attempting to resolve? (2) What details are provided? (3) What are some possible approaches to the problem's resolution? (4) Try a method and illustrate your work. (5) What knowledge did you gain from resolving this problem? Anywhere along the graphic organizer, students can begin working nonlinearly and still arrive to the same result (Swenson, 2018). This graphic organizer enhances the effective learning of mathematics. This is done by linking new information to existing knowledge in long-term memory. This graphic organizer also helps learners to understand and preserve information. Moreover, high and low achievers could improve using this graphic organizer (Blessing & Taiwo, 2024).

A study conducted by Obiukwu (2021) revealed that this graphic organizer enhanced students' achievement. Wong & Tengah (2022) revealed that the learners' performance after being introduced to the Four-Corners and a Diamond graphic organizer was significantly better. In particular, students with low ability benefitted more from the graphic organizer. It is an alternative way of answering mathematics word problems and is effective. This was also supported by Sai et al. (2018), who stated that using this graphic organizer improved the students' results. Introducing it as a strategic tool to learners and giving them chances to learn and hone their comprehension is favorable.

Regardless of this existing issue, the researcher observed that although there are studies that talk about the effectiveness of the Four Corners and a Diamond graphic organizer, there is no research, or there is little, if there is any, that has investigated this graphic organizer in the national context. Hence, this study will also contribute to the body of knowledge by adding more insights. Mathematics word problems are complex and challenging to understand. With the present issue, it is urgent to conduct this study to help teachers and learners traverse it in the education sector.

Thus, this study aims to determine the proficiency level of the subjects during the pretest and posttest. Also, whether there is an improvement in the student's ability to solve mathematics word problems after using the intervention. With this, the experimental group will use the Four Corners and a Diamond graphic organizer in this study. The control group will use Polya's Four-Step Approach in Problem Solving. This approach to problem-solving is one of the various ways adopted by the Department of Education (Obiano & Parangat, 2023). The process of problem-solving using the steps formulated by Polya comprises (1) Understanding the problem, (2) Making a plan, (3) Executing the plan, and (4) Looking back or reflecting (Nguyen et al., 2023).

It is to be noted that all the hypotheses in this study were at the 0.05 significance level, stating that, firstly, there is no significant difference in the pretest and posttest of the control group. Second, there is no significant difference in the pretest and posttest of the experimental group. Lastly, there is no significant difference between the control group and the experimental group.

II. METHODS

This study utilized a quasi-experimental research design. This research design uses non-researcher-induced variation in the main independent variables of interest. It mimics experimental conditions in which subjects are exposed to treatments and others are not on a random basis (Gopalan et al., 2020). The design was applied in this research to determine if there was a significant difference between using the Four Corners and a Diamond graphic organizer in the ability of students to solve mathematics word problems.

The research subjects were the 56 Grade 11 regular students taking Statistics and Probability at Bango National High School in Compostela, Davao de Oro. A universal sampling technique was used to select the subjects. The subjects were allowed to discontinue their participation if they are uncomfortable or threatened.

The two groups took the pretest and posttest in the study utilizing a thirty-item researcher-made test. The questionnaire was patterned on the Most Essential Learning Competencies (MELCS) of the Department of Education, and its content was based on the third-quarter learning competencies. The instrument was meticulously crafted and presented with a Table of Specifications (TOS) to ensure the proper distribution of test questions. The questionnaire was designed to know if there was a significant difference in the pretest and posttest of the groups as well as if there is a significant difference between the control and experimental group. Internal and external validators subjected this questionnaire to validation and reliability. The pilot testing was done in Bango National High School in selected 20 Grade 12 students. Further, the group who utilized the Four Corners and a Diamond graphic organizer were exposed to it in a span of six-weeks.

Descriptive and inferential statistics were used to demonstrate the robustness of the data analysis. Mean was used to determine the proficiency level of the students in solving mathematics word problems. Standard deviation was used to determine the dispersion of the data to the mean. Paired t-test was used to determine the significant difference in the students' scores during the pretest and posttest in solving mathematics word problems of the same group. Independent t-test was used to determine the significant difference in the scores during the posttest in solving mathematics word problems between the control and experimental groups.

III. RESULTS

This section presents the results of the data. The manner of presentation is both in tabular and textual formats. All the information presented is subjected to a 0.05 significance level and will answer the following: proficiency level of the pretest scores of the control and experimental group; proficiency level of the posttest scores of the control and experimental group; pretest and posttest scores of the control and experimental group; pretest and posttest scores of the control group; pretest and posttest scores of the experimental group; and posttest scores of the control and experimental group.

Proficiency Level of the Pretest Score of the Control and Experimental Group

Presented in Table 1 were the mean, standard deviation, proficiency level, mastery level, p-value and corresponding remarks for the control and experimental groups.

Table 1: *Pretest Proficiency level of the Control and Experimental Group in Solving Mathematics Word Problems*

Pretest	Mean	Standard Deviation	Proficiency Level	Mastery Level	p-value	Remarks
Group A (Control)	8.25	1.89	27.5%	Low Mastery	0.717	Not Significant
Group B (Experimental)	8.40	2.00	28%	Low Mastery		

As shown in the data, using the thirty-item researcher-made questionnaire, the mean scores of the control and experimental groups in the pretest were 8.25 and 8.40, respectively. In addition, the corresponding standard deviations were 1.89 and 2.00, respectively. Hence, the scores were slightly dispersed. The class proficiency was 27.5% for the control group and 28% for the experimental group. Although there was a slight variation in their proficiency level, the mastery level of the two groups was categorized as Low Mastery. This entails that the students need more help in solving mathematics word problems

Proficiency Level of the Posttest Scores of the Control and Experimental Group

Presented in Table 2 were the mean, standard deviation, proficiency level, and mastery level for the posttest scores of the control and experimental group.

Table 2: *Posttest Proficiency level of the Control and Experimental Group in Solving Mathematics Word Problems*

Posttest	Mean	Standard Deviation	Proficiency Level	Mastery Level
Group A (Control)	16.29	3.07	54.3%	Near Mastery
Group B (Experimental)	20.53	2.22	68.43%	Near Mastery

The data reveals that the six-week intervention significantly improved the mean scores of the control and experimental groups during the thirty-item posttest, with scores of 16.29 and 20.53, respectively.

The corresponding standard deviations were 3.07 and 2.22, and the two groups achieved a class proficiency of 54.3% and 68.43%. This marked improvement in proficiency, from the initial class level to Near Mastery, underscores the effectiveness of the intervention in enhancing students' ability to solve mathematics word problems.

Pretest Scores of the Control and Experimental Group

Presented in Table 3 were the mean, p-value and remarks of the pretest scores of the control and experimental groups. This section will determine if the difference between their scores in the pretest was negligible and if the two groups were comparable. The significance level used to interpret the table was 0.05.

Table 3: *Significant Relationship between the Pretest Scores of the Control and the Experimental Group*

Pretest	Mean	p-value	Remarks
Group A (Control)	8.25	0.717	Not Significant
Group B (Experimental)	8.40		

As presented in the table, the mean during the pretest of the control and experimental group were 8.25 and 8.40, respectively. There is only a slight difference in the average scores. In addition, the p-value was 0.717, greater than the significant level used in the study, which was 0.05. This means that the variation of the score was not significant. The two groups were comparable. Thus, no group was more intellectually advantageous than the other. This meticulous approach ensured the utmost fairness for the quasi-experiment, providing a solid foundation for the study's integrity.

Pretest and Posttest Scores of the Control Group

Table 4 presents the results of the pretest and posttest of the control group. Paired t-test was used with a 0.05 level of significance. This section will determine if the null hypothesis, stating there is no significant difference in the pretest and posttest of the control group, is accepted or rejected.

Table 4: *Pretest and Posttest Scores of the Control Group*

Group A (Control)	Mean	t-value	p-value	Remarks
Pretest	8.25	-12.827	0.000	Significant
Posttest	16.29			

As shown, the mean of the pretest in the 30-item test questionnaire was 8.25. Then, the control group's mean score in the posttest was 16.29. As observed, the mean scores almost doubled their value in the posttest. The t-value was -12.827. A negative t-value indicated that the posttest was higher than the pretest.

Furthermore, the probability value between the two mean scores of the pretest and posttest was 0.000, significantly lower than the 0.05 significant level. This result, based on the p-value, clearly indicates a substantial difference between the scores on the pretest and posttest of the control group. Consequently, the null hypothesis was firmly rejected. This means that Polya's four-step approach in problem-solving made a significant difference in the scores of the learners who utilized this method during the six-week intervention. These findings have significant implications for educational interventions and assessment, suggesting the potential for improved learning outcomes.

Pretest and Posttest Scores of the Experimental Group

The data in Table 5 presented the mean score of the pretest and posttest of the experimental group. Paired t-test was used with a 0.05 level of significance. This will determine if the null hypothesis, with no significant difference in the pretest and posttest of the experimental group, is accepted or rejected.

Table 5: *Pretest and Posttest Scores of the Experimental Group*

Group B (Experimental)	Mean	t-value	p-value	Remarks
Pretest	8.40	-26.77	0.000	Significant
Posttest	20.53			

As shown, the mean of the pretest in a 30-item test questionnaire was 8.40. Afterwards, the mean score of the posttest was 20.53. The mean score increased more than 100% in the posttest. The t-value rendered was -26.77. A negative t-value indicated that the pretest was less than the posttest.

Moreover, the probability value between the mean scores of the control and experimental group was 0.000. This was less than the level of significance set, which was 0.05. Hence, based on the p-value result, the remarks were significant. It means that there is a significant difference in the pretest and posttest of the experimental group, which means that there is a significant difference in the scores of the students who used Four Corners and a Diamond graphic organizer in the six-week intervention.

Posttest Scores of the Control and Experimental Group

Presented in Table 6 were the posttest scores of the two groups. Independent t-test was used with a 0.05 level of significance. This will show if the null hypothesis, no significant difference between the control and experimental groups, is accepted or rejected.

Table 6. *Posttest Scores of the Control and Experimental Group*

Posttest	Mean	t-value	p-value	Remarks
Group A (Control)	16.29	5.990	0.000	Significant
Group B (Experimental)	20.53			

In the table, the mean scores of the control and experimental groups were 16.29 and 20.53, respectively, as shown in the previous table. The t-value rendered was 5.990, meaning the experimental group's mean score was greater than the control group. Moreover, the probability between the mean scores of the posttest of the control and experimental group was 0.000, which was less than the significance level of 0.05. Thus, based on the computed p-value, the remarks was significant. It means that the null hypothesis was rejected. This signifies that comparing the two methods, Polya's Four-Step Approach in Problem-Solving for the control group and Four Corners and a Diamond graphic organizer for the experimental group, the graphic organizer was more effective.

IV. DISCUSSION AND CONCLUSION

This chapter includes a discussion of the findings, a conclusion based on the results, and recommendations that could be made regarding the study.

Proficiency Level in Problem Solving

The result during the pretest of both control and experimental groups in the preceding chapter stipulated the perennial issue of problem-solving skills in mathematics. Translating the proficiency level of the two groups during the pretest resulted in a mastery level in the category of Low Mastery. This result indicated that the students only acquired a little information that they needed to learn and to have set by the Department of Education. This finding was highly supported by Roman (2019), who indicated that over the past 15 years, in the Philippine context, the study revealed the poor performance of students in mathematics.

Furthermore, the results of the 2018 and 2022 PISA supported this. The mean score in Mathematics of Filipino students in PISA 2018 was only 353 compared to the average, which was 489. Further, less than 1% of Filipino students score at Level 5 or higher in mathematics (Organisation for Economic Co-operation and Development, 2019). It is consistent as well to the result of the recent PISA. The mean score in Mathematics of Filipino students was 355 compared to the average of 472 (Organisation for Economic Co-operation and Development, 2023). These results in the PISA showed the consistent challenges faced by Filipino students in mathematics problem-solving among Filipino learners. However, on a positive note, changes were perceived during the posttest, indicating potential for improvement.

The control group, those students who utilized Polya's four-step approach in problem-solving, improved their performance. Based on the proficiency level, they upgraded from Low Mastery to Near Mastery. The upgrade was reinforced by the study of Gopinath & Lerlit (2017), which revealed that mathematics problem-solving significantly improved using Polya's model. However, it is also important to note that this was inconsistent with the study of Yayuk & Husamah (2020), which concluded that the ability of students to answer problem-solving questions using Polya's steps was still relatively weak.

There was also improvement in the mastery level of the experimental group – those students who used Four Corners and a Diamond graphic organizer. They also upgraded from Low Mastery to Near Mastery based on calculated proficiency level. Hence, there was a significant change in the scores of the experimental group. This means that using the graphic organizer positively affected their ability to solve mathematics word problems. This finding implied a significant difference when using the graphic organizer during the six-week intervention. This was strongly supported by the study of Sei et al. (2018), which stated that there were slight improvements in the overall comparison of the students' test results.

Polya's Four-Step Approach in Problem Solving and Ability to Solve Mathematics Word Problems

Over the six-week intervention, the control group consistently applied Polya's Four-Step Approach in problem-solving. This widely used approach, also found in the Senior High School topics in General Mathematics of the Department of Education, led to a significant improvement in the control group's scores. Students who were initially at a Low Mastery level progressed to Near Mastery, demonstrating a marked difference in their performance. The positive effect of Polya's Four-Step Approach on problem-solving abilities was clearly evident.

The result, as mentioned above, conformed to the study of Gopinath & Lerlit (2017), which stated that using Polya's four-step model drastically improved the students' performance in answering questions in mathematics. Also, similar results were stated by Daulay & Ruhaimah (2019). Based on the data, it was shown that learners can improve their abilities in solving mathematics problems using Polya's learning theory.

However, it's also equally important to mention that the study's findings were not supportive of the work of Nurkaeti (2018), who stated that when students were using Polya's steps, they still faced difficulty in solving mathematics problems. It was caused by several factors, such as students not being accustomed to answering problems and learning not developing problem-solving. Also, it differed from the findings of Kaliky et al. (2019), which revealed that the students were still in a weak category regarding problem-solving ability. It used Polya's model in the analysis of the findings. Further, the results were also inconsistent with the study of Yayuk & Husamah (2020) which implied that students still faced difficulties in all Polya's stages. Still, the learners' ability to answer mathematics problem-solving based on Polya's steps was still weak.

Four Corners and a Diamond Graphic Organizer and Ability to Solve Mathematics Word Problems

During the six-week intervention, the experimental group was introduced to the Four Corners and a Diamond graphic organizer. This innovative approach to mathematics problem-solving resulted in a significant improvement in the experimental group's scores, demonstrating a clear and positive impact on students' performance.

The finding was supported by Sai et al. (2018), who stated that when students utilize graphic organizers, improvement in students' results is manifested. The study was also parallel to the study of Obiukwu (2021), which stated that students' achievement improved using Four Corners and a Diamond graphic organizer. This was also congruent with the findings of Wong & Tengah (2021), who stated that the Four Corners and a Diamond graphic organizer can help lower-ability students. This can enhance students' performance of the learners in mathematics problem-solving. They also revealed that the learners' performance after they were introduced to the Four Corners and a Diamond graphic organizer was significantly better.

Upon comparing the Four Corners and a Diamond graphic organizer with Polya's Four Steps Approach, it became evident that the graphic organizer was significantly more effective. While Polya's approach did show improvement in students' results, the data revealed that the graphic organizer was superior, providing more promising results.

CONCLUSION

The intervention and findings in this study provided promising outcomes in the ability to solve word problems. Returning to the aims of this study, these results addressed the research questions as follows: (1) The proficiency level of the pretest of the control group and the experimental group fell under Low Mastery. (2) The proficiency level of the posttest of the control group and the experimental group fell under Low Mastery. (3) There is a significant difference between the pretest and posttest mean scores of the control group. (4) There is a significant difference between the pretest and posttest mean scores of the experimental group. (5) There is a significant difference between the mean posttest scores of the control and experimental groups.

Given the results of the study, the researcher confidently affirms that the Four Corners and a Diamond graphic organizer is a reliable tool for enhancing students' proficiency in solving mathematics word problems.

RECOMMENDATION

Upon conducting a thorough analysis of the findings, discussions, and conclusions of the study, the researcher formulated the following recommendations as to how to utilize Four Corners and a Diamond graphic organizer to improve students' ability to solve mathematics word problems in the Philippine education sector:

Department of Education officials should conduct training or seminars on alternative ways of solving mathematics word problems. One focus of the training is the utilization of Four Corners and a Diamond graphic organizer. This is done so teachers can have a repertoire of current research-based approaches to be at par with other countries and to help learners address this pressing issue in mathematics education.

The mathematics teachers are highly recommended to use this graphic organizer in their teaching. They could use this to test whether this graphic organizer suits their learners.

Students should try this graphic organizer to aid their learning of mathematical word problems. It is a great alternative to try if it works better than the traditional and conventional way of solving mathematical word problems.

Future researchers may explore this matter further to add to the body of knowledge. Similar studies may be conducted using other grade levels in their respective localities.

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