Assessing Scatter Plot Graph as Visual Aid in Understanding Geometric Sequences Among Grade 10 Students at Sapang Palay National High School

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DOI: https://dx.doi.org/10.47772/IJRISS.2025.90600044

Received: 23 May 2025; Accepted: 26 May 2025; Published: 28 June 2025

ABSTRACT

Visual aids can turn abstract mathematical concepts into simple visual representations that can be easily understood by students. In line with this, the main objective of this quantitative study was to assess the utilization of scatter plot graphs as visual aid in understanding the concepts about geometric sequences among Grade 10 students at Sapang Palay National High School. The researchers employed scatter plot graphing sheets, survey questionnaires, and assessment as their research instruments. From the data collection process, the following results have been drawn: (1) majority of the students displayed high accuracy rates in constructing scatter plot graphs for geometric sequences; (2) based on the students' survey responses, there were no hindrances in utilizing scatter plot graphs as visual aid in terms of the clarity of instructions and given time duration; and (3) there is a significant difference between the assessment scores of the students who learned geometric sequences through the traditional method and those who utilized the scatter plot graphs as visual aid for geometric sequences. Therefore, the researchers recommend the utilization of scatter plot graphs for visualizing geometric sequences with proper consideration in the clarity of instructions and time given for constructing the graphs.

Keywords: Scatter plot graph, visual aid, geometric sequence, mathematical understanding, number patterns

INTRODUCTION

Understanding the lessons in Mathematics is as important as solving related problems when it comes to the attainment of mathematical learning for students. Learning with understanding is essential to empower students to solve mathematical problems properly (Mutawah et al., 2019). In line with this, Mathematics teachers are encouraged to first make their students understand the concepts behind a particular lesson before they proceed to solving problems.

Rittle-Johnson (2017) emphasized the importance of developing strong mathematical understanding towards mathematics achievement as well as in academic success, but many students fail to become proficient in the subject. Students who lack the mathematical understanding required for a lesson will perform poorly when attempting to solve problems, leading to low scores in their tests. Fortunately, the concern for the students' lack of mathematical understanding can be remediated through the use of visual aids.

Visual aids can boil down abstract and complex mathematical concepts into simple visual representations that can be understandable to a wider range of students with varying learning styles and mathematical abilities (Fokuo et al., 2023). This implies the primary goal of visual aids to make mathematical concepts easier to understand for every learner, especially those who find it difficult to learn mathematics.

Overall, this research aimed to assess the utilization of scatter plot graphs as visual aid in improving the mathematical understanding of students in geometric sequences. Eventually, the findings, conclusions, and recommendations from this study were used as contribution of the researchers in promoting the role of visual aids in making it easier for the learners to understand mathematics, as well as in proving the potential of visual representations in improving the learning outcomes of students in the subject.

REVIEW OF RELATED LITERATURE AND STUDIES

The importance of mathematics as a core subject is justified by the statements of Abate et al. (2022), Uyen et al. (2021), and Ogena et al. (2018), in the sense that the application of learning this subject for students goes beyond the four corners of the classroom. DepEd even has the objective to instill long-term mathematical skills and competencies among the Filipino learners in order for them to attain life-long learning. This is more evident in mathematical problem-solving, where students are encouraged to apply their acquired knowledge and skills in order to perform analysis and come up with solutions to overcome the given problems in mathematics (Santos-Trigo, 2024; Fadlelmula, 2022). Still, even though its essence is justified, educational problems still arise among students when it comes to learning mathematics.

The leading problem with mathematics lies on its tendency to become too complicated and complex for the students' comprehension. This is shown in lessons such as geometric sequences, where the value of numbers involved can increase or decrease exponentially and becomes too difficult for learners to understand (Broña et al., 2024). This leads to further issues such as the lack of engagement and proficiency among the students, which can be seen in the PISA results in 2018 and 2022 for the Philippines (OECD, 2023; Yeh et al., 2019). Gigante (2020) noted the effects of this problem and called on mathematics teachers to utilize more effective strategies and approaches to address the learning needs of students and their varying skills and proficiency with regards to mathematical proficiency.

In support of this petition, many studies and literature indicated that learning mathematics with visualization is an effective way for students to understand mathematical concepts easily (Amoto, 2023; Bearneza, 2023; Fokuo et al., 2023; Börner et al., 2018). Meanwhile, statements from Learn Statistics Easily (2024), Lumabao and Rosales (2023), Decin (2023), Redbourn et al. (2020), and Bautista et al. (2015) described how visual graphs, such as scatter plot graphs, can help students understand concepts related to difficult topics, such as the geometric sequences. This can help many students improve their understanding of these mathematical topics, especially those who struggle with learning from solely abstract information and purely textual learning materials.

METHODOLOGY

The researchers utilized the quasi-experimental research design because they could collect data through an experiment, while still being able to assign respondents using non-random criteria (Hassan, 2024). In line with this, they utilized the purposive sampling approach by taking two independent samples of respondents from the population, which are the 10 – Brocka and 10 – Bernal students of Sapang Palay National High School.

Moreover, the researchers used the independent samples t-test for their hypothesis because the goal of the research was to test if there is a significant difference between assessment scores of two independent samples which was the controlled and experimental group (Bobbitt, 2019). Furthermore, the methodologies that the researchers have utilized in the data collection helped them to achieve their goals and objectives for this research.

RESULTS AND DISCUSSION

Accuracy of the Scatter Plot Graphs Plotted by the Students

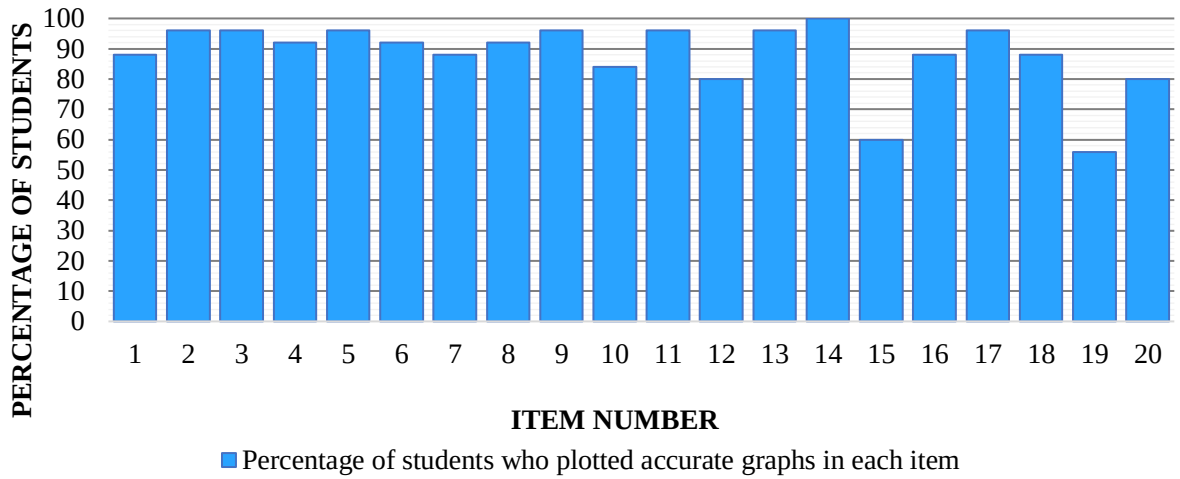

Figure 1.1: Percentage of 10 – Bernal Students Who Plotted Accurate Graphs in Each Item

Figure 1.1 presented a bar graph based on the percentage of Grade 10 – Bernal students who managed to plot accurate graphs for each item in the scatter plot graphing sheet. Based on the gathered data, the majority of the students were able to construct accurate graphs, which is supported by their attainment of high accuracy rates in graphing the geometric sequences all throughout the 20 items. In line with this, 11 items out of 20, which include item numbers 2, 3, 4, 5, 6, 8, 9, 11, 13, 14, and 17, are found to have high accuracy rates between 90% – 100 % of the total number of students. Among these items, only item number 14 got an accuracy percentage of exactly 100%, which meant that all 25 students from 10 – Bernal accurately constructed the scatter plot graph for this item. In addition, seven (7) items out of 20, including item numbers 1, 7, 10, 12, 16, 18, and 20, are also found to have generally high accuracy rates of 80% – 89% of the total number of students from the experimental group.

However, there were two items wherein the students attained low accuracy rates, particularly in item number 19, which had the lowest accuracy rate of 56% or only 14 out of 25 students who managed to construct the accurate scatter plot graph for this item. This was followed closely by item number 15, having the second lowest accuracy rate of 60%, which showed that only 15 out of the 25 students were able to get the accurate graph for this item. This could imply that these items might have been too difficult or too confusing for some of the students, potentially leading them to construct inaccurate graphs. Still, based on the overall results, most of the problem-solving questions that the researchers used in the assessment were suitable for constructing scatter plot graphs in visualizing the given geometric sequences because majority of the students in Grade 10 – Bernal got higher percentage of scores in terms of the accurate scatter plot graphs that they have constructed.

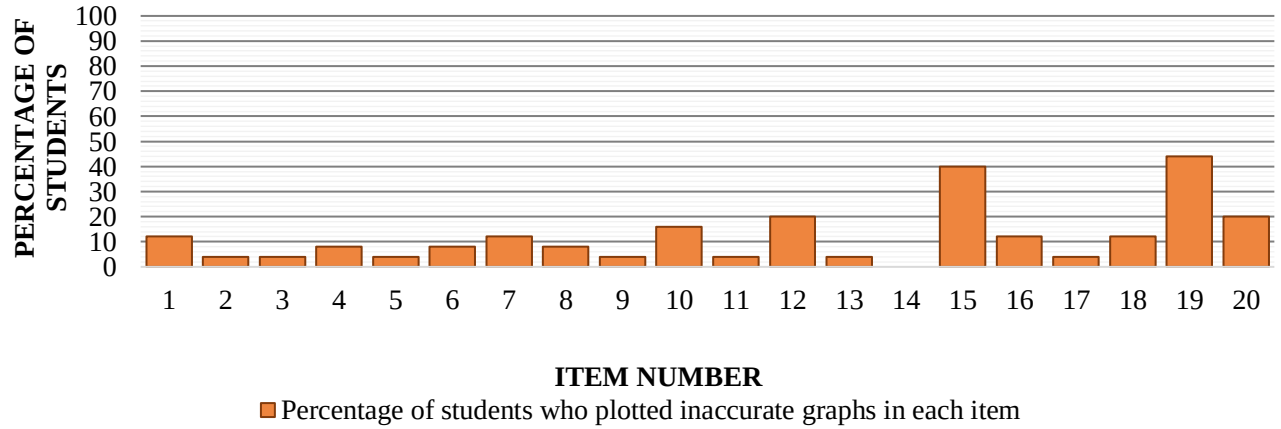

Figure 1.2: Percentage of 10 – Bernal Students Who Plotted Inaccurate Graphs in Each Item

Figure 1.2 presented the percentage of Grade 10 Bernal students who plotted inaccurate graphs for each item in the scatter plot graphing sheet. The data revealed that the majority of the students were able to construct accurate graphs in the scatter plot graphing sheet, which is reflected by their generally low inaccuracy rates across the 20 items. In line with this, item numbers such as 2, 3, 4, 5, 6, 8, 9, 11, 13, 14, and 17 are shown to have minimal errors from the students, with inaccuracy rates ranging from 0% to 8% of the total number of students. Additionally, item numbers 1, 7, 10, 12, 16, 18, and 20 are revealed to also have generally low inaccuracy rates between 10% to 20% of the 25 students from the experimental group.

This implied that most students were able to attain a strong understanding of the geometric sequence concepts as well as in constructing the scatter plot graphs with minimal errors for some of the geometric sequences given in the graphing sheet. However, some of the items still displayed high error rates from the graphs constructed by the students. Item number 19 had the highest percentage of students plotting inaccurate graphs, which had 11 out of 25 or 44% of the students. This is followed closely by item number 15, which had 10 out of 25 or 40% of the students.

This suggested that the students found these items more challenging, which may be due to the difficulty level of the geometric sequences given in these items or a misunderstanding of how to graph the geometric sequences involved. Overall, these results showed that the majority of the students from 10 – Bernal managed to become generally proficient in utilizing scatter plot graphs for understanding geometric sequences since they showed low rates of constructing inaccurate graphs in most items from the scatter plot graphing sheet that they have answered.

Table 1: Grade 10 – Bernal's Total Scores in Constructing the Scatter Plot Graphs

Score	**Frequency**	**Percentage**
20	4	16.00
19	6	24.00
18	5	20.00
17	4	16.00
16	3	12.00
15	1	4.00
14	1	4.00
11	1	4.00
Total	**25**	**100.00**

Table 4 presented the frequency distribution of the total scores that the learners from Grade 10 – Bernal attained in constructing the scatter plot graphs for the 20 problem-solving questions about geometric sequences provided in the assessment. Based on the gathered data for the individual scores of the students: six (6) out of 25 or 24% of the learners attained 19; five (5) out of 25 or 20% of the learners attained 18; four (4) out of 25 or 16% of the learners attained 20; four (4) out of 25 or 16% of the learners attained 17; three (3) out of 25 or 12% of the learners attained 16; one (1) out of 25 or 4% of learners attained 15; one (1) out of 25 or 4% learners attained 14; and one (1) out of 25 or 4% of learners attained 11.

Overall, 24 out of 25 or 96% of the students got the passing scores of 12 or 60% of the total score and above in the scatter plot graphing sheet while the remaining one (1) out of 25 or 4% of the students did not reach the passing score. This was based on the DepEd Order No. 8, s. 2015, which states that the minimum passing score for the students in the K to 12 basic education program is 60% of the total score in a given assessment. Since most students reached the passing score, this meant that the majority of students have enough understanding on how to construct the scatter plot graphs in order to visualize the geometric sequence problems.

Factors that Hinder the Effectiveness of Scatter Plot Graph as Visual Aid

Table 2: Verbal Interpretation of Weighted Means for the 5-Point Likert Scale

Measurement Scale	Range of Weighted Means	Verbal Interpretation
5	4.51 – 5.00	Strongly Agree
4	3.51 – 4.50	Agree
3	2.51 – 3.50	Neutral
2	1.51 – 2.50	Disagree
1	1.00 – 1.50	Strongly Disagree

Table 3.1: Grade 10 – Bernal's Weighted Means in Clarity of Instructions

Challenges in the Clarity of Instructions	Weighted Mean	Verbal Interpretation
a. The given instructions are not clear.	1.08	Strongly Disagree
b. The instructors did not explain how to plot the points	1.24	Strongly Disagree
c. It was not easy to understand how the points show the given geometric sequence.	1.52	Disagree
d. There are no helpful notes and arrows on the graph.	1.24	Strongly Disagree
e. The instructions given are hard to follow.	1.32	Strongly Disagree
Grand Mean	**1.28**	**Strongly Disagree**

Table 3.1 presented the survey results for the factors that could hinder the effectiveness of scatter plot graph as visual aid for geometric sequences in terms of the clarity of instructions provided by the researchers. The item with the highest mean, item c, indicated that "It was not easy to understand how the points show the given geometric sequence." Based on the data collected, item c has a weighted mean score of 1.52 (Disagree). This implied that most students discovered that it was easy to understand how the geometric sequences are shown by the points plotted in the scatter plot graph. Correspondingly, the item with the second highest mean is item e, stating that "The instructions given are hard to follow." Item e has a mean score of 1.32 (Strongly Disagree). This suggested that most students strongly disagreed that they found it hard to follow the instructions provided by the researchers. Moreover, both items b and d have a weighted mean of 1.24, which meant that the students strongly disagreed that the instructors were not able to explain how to plot the points correctly and that they did not provide helpful notes and arrows on the scatter plot graph. Furthermore, the factor with the lowest mean is item a, which has a weighted mean score of 1.08 (Strongly Disagree). This indicated that the instruction for utilizing scatter plot graph was very well explained and the students were able to understand its procedures right away.

Overall, the grand mean for Table 5 about Grade 10 – Bernal's weighted means on the clarity of instructions is 1.28 (Strongly Disagree). This showed that, in general, the majority of the students strongly believed that there were no hindrances in the clarity of instructions from the researchers in terms of utilizing scatter plot graphs as visual aid in geometric sequences.

Table 3.2: Grade 10 – Bernal's Weighted Means on Time Duration for Constructing the Graphs

Challenges in the Time Duration	Weighted Mean	Verbal Interpretation
a. I did not have enough time to make the graphs.	1.96	Disagree
b. The time given to plot the graphs is too short.	1.72	Disagree

c. I feel rushed while making the graph.	1.52	Disagree
d. It was not easy for me to finish the graphs on time.	2.00	Disagree
e. I think extra time would have helped me construct the scatter plot graphs better.	3.08	Neutral
Grand Mean	**2.06**	**Disagree**

Table 3.2 presented the survey results for the factors that could hinder the effectiveness of scatter plot graph as visual aid for geometric sequences in terms of the time duration provided to the students for constructing the graphs. The item with the highest mean, item e, indicated that "I think extra time would have helped me construct the scatter plot graphs better." Based on the gathered data, its weighted mean is 3.08 (Neutral). This suggested that the students were divided on whether or not extra time would have helped them construct the scatter plot graphs better. The item with the second highest mean is item d with a weighted mean of 2.00 (Disagree). This indicated that most students did not seem to struggle in completing the graphs on time. In addition, item a had a weighted mean score of 1.96 (Disagree). This indicated that most of them had sufficient time to create the scatter plot graphs. Furthermore, item b had a weighted mean score of 1.72 (Disagree). This indicated that students did not feel that the time allocated to them to construct the graphs was too short. Furthermore, the item with the lowest weighted mean is item c with an average score of 1.52 (Disagree). This indicated that the majority of the students did not feel rushed when constructing the graphs for the geometric sequences.

Overall, the grand mean for Table 6 about Grade 10 – Bernal's weighted mean scores on time duration for constructing the scatter plot graphs is 2.06 (Disagree). This implied that the majority of the students were generally satisfied about the time duration that was given to them by the researchers in constructing the scatter plot graphs.

In summary, the challenges in the time duration for constructing the scatter plot graphs received a higher grand mean of 2.06 (Disagree) compared to the challenges in the clarity of instructions, which garnered a grand mean of 1.28 (Strongly Disagree). This meant that the majority of the students experienced more difficulties in terms of the given time duration for constructing the graphs while they encountered less problems about the clarity of instructions provided by the researchers.

Significant Difference Between the Controlled and Experimental Group

Table 4: Analysis of the Significant Difference Between the Controlled and Experimental Group

Groups	**Count**	**Sum**	**Mean**	**Var.**	**St. Dev.**	**T-Value**	**P-Value**	**Decision**
Controlled	25	327	13.08	22.41	4.73	–4.8251	0.000*	Reject H_0
Experimental	25	450	18.00	3.58	1.89			

Table 4 showed that the independent samples t-test was used by the researchers to determine if there is a significant difference between the assessment scores of the controlled and experimental group. From the summary, the experimental group attained the higher average (18.00), while the controlled group had the higher values in the variance (22.41) and standard deviation (4.73). In addition, the decision rule for independent samples t-test stated that the P-Value must be lower than the significance level of 0.05 for it to have significant difference between the controlled and experimental group. As such, the statistical results from Table 4 showed that the P-Value = 0.0000145 < the significance level ($\alpha = 0.05$). As a result, the null hypothesis (H_0) has been rejected. Therefore, it may be concluded that there is a significant difference between the assessment scores of the controlled and experimental groups in terms of utilizing the scatter plot graphs as visual aid in understanding geometric sequences.

Table 5: Table of Interpretation for the Effect Sizes in Cohen's *d*

Effect Size *d*	**Interpretation**
0.2	Small Effect
0.5	Medium Effect
0.8	Large Effect

Table 5 showed the different interpretations for the possible values of effect size using the formula for Cohen's *d*. Compared to using p-values for analysis, which show whether a difference is statistically significant for the controlled and experimental groups, Cohen's *d* aids in understanding how large or meaningful the magnitude of difference is (The Researcher Life, 2024). As such, the researchers have utilized this to determine the magnitude of effect size for the utilization of scatter plot graphs as visual aid for geometric sequences.

Table 6: Analysis of the Effect Size using Cohen's *d*

Groups	**Count**	**St. Dev.**	**Pooled Variance**	**Effect Size *d***	**Interpretation**
Controlled	25	4.73	13.00	1.37	Large Effect
Experimental	25	1.89			

Table 6 showed that the formula for Cohen's *d* was used to determine how large the difference is between the mean scores of both the controlled and experimental group in this study. Based on the summary, the calculated value for effect size $d = 1.37 > 0.8$ (large effect). As a result, it may be concluded that there is also a very large magnitude of effect size between the mean scores of the students who utilized scatter plot graphs as visual aid for geometric sequences as compared to those who used the traditional method for understanding the same topic.

CONCLUSIONS/RECOMMENDATIONS

1. Grade 10 – Bernal students performed well in creating accurate scatter plot graphs during the assessment.

2. With sufficient instruction, utilizing scatter plot graphs can help the students to have better understanding of geometric sequences.

3. There were no hindrances in the clarity of instructions and time duration given in constructing the graphs.

4. Students may still face more difficulties in terms of the time duration than the clarity of instructions.

5. There is a significant difference between the assessment scores of the controlled and experimental groups.

6. There is also a very large magnitude of effect size in the difference between the mean scores of the controlled and experimental group.

7. The results of the study showed clear evidences about the potential of visualization in making mathematics easier to understand for students, which can be utilized for the possible adaptations of scatter plot graphs as visual aid in lessons such as arithmetic sequences as well as other topics concerning number patterns.

8. Provide additional activities focusing on the accuracy of students in constructing scatter plot graphs.

9. Deliver clear instructions in teaching scatter plot graphs to avoid confusion.

10. Provide enough time for constructing the scatter plot graphs to avoid conflicts in time duration.

11. Consider implementing the scatter plot graph as visual aid in teaching geometric sequences.

12. Future researchers may also conduct similar studies in different grade levels, schools, and difficulty of word problems to test the consistency of the results of this study.

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