The Influence of Error Analysis as a Formative Assessment Activity in the Performance of Junior High School Students in Geometry

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Abstract

The use of error analysis is an effective instructional strategy that holds promise to help students in retaining their learning. This study determined the influence of using error analysis as a formative assessment activity in the performance of junior high school students in geometry. It specifically aimed to determine the level of performance of students, significant difference in the performance of students in control and experimental groups before and after the intervention, significant difference in the performance of the students in the two groups after controlling the pretest scores, and the strengths and weaknesses of using error analysis as formative assessment. Quasi-experimental design was used in this quantitative and descriptive-comparative research. The result of the mean scores of the students taught with or without error analysis before and after the intervention was "did not meet expectation" and "fairly satisfactory", respectively. There is no significant difference found in the performance of the students in the control and experimental groups after controlling the pretest scores. Thus, the use of error analysis as a formative assessment can be an innovative teaching technique in improving the performance of the students.

Keywords: *alternative teaching strategy, assessment for learning, effectiveness, erroneous solutions, innovative teaching technique, metacognition*

1. INTRODUCTION

Mathematics has been used by different peoples in various ways. Arithmetic and geometry are utilized to meet the needs of people everyday. The used of geometry by Egyptians was to construct pyramids for burial purposes (Snipes and Moses, 2001). Mathematics is one of the important lessons in education. The study of mathematics is considered to be significant in basic education because mathematical skills are used in daily life (Mahanta, 2012). Mathematics can enhance students' thinking; systematically, logically, critically, creatively, and consistently. The purpose of mathematics education is to produce students who have skill in solving problems, and are fostering a high interest and motivation in mathematics (National Council of Teachers of Mathematics-NCTM, 2000).

Mathematics is studied at all levels of education. At junior high school level, it includes patterns and algebra, geometry, trigonometry, probabilities and statistics. The mathematical aspect in geometry relates to the study of different forms (Adolphus, 2011). Geometry is not only developing students' cognitive domain, but also forms concrete to abstract thinking. Geometry helps students to analyze and interpret the world, and also equip them with tools that can be applied in other mathematical fields (Ozerem, 2012).

Teaching Geometry provides students with the ability to think critically and creatively, solve problems, and understand better that geometry is quite large in our education system (Yilmaz & Turgut, 2007). In teaching mathematics specifically in geometry, assessment is an integral part of education because it is a way to identify specific errors of students inside the classroom. Assessment for learning or formative assessment is increasingly being emphasized for its positive effect (Taras, 2008). Formative assessment is an assessment for learning; it is conducted during the teaching-learning process with the purpose of evaluating the student's level of understanding so that the teacher can adapt and modify the instruction for better engage with the students. The use of formative assessment is to enhance learning through generating feedback information that benefits students during the learning process and leads to positive learning outcomes (Evans, Zeun & Stainer, 2014). The strength of formative assessment is to identify difficulties of students immediately because it is done during discussions. During formative assessment, errors of students in the classroom can be identified and immediately find solutions to accommodate that errors. Identification of students' specific errors is strongly significant for students with learning disabilities and low performing students (Salvia & Ysseldyke, 2004 in Lai, 2012). By identifying students' errors, the teacher can provide instruction targeted to the students' area of need. By these, identifying errors or error analysis is important in teaching-learning process to improve learning. Error analysis is an instructional technique that holds promise of helping students enhance their learning (McLaren, Adams, Durkin, Goguadze, Mayer, Rittle-Johnson & Van Velsen, 2012). This study aimed at using error analysis as a formative assessment to determine its influence in the performance of junior high school students in Geometry. This study sought to determine the following objectives; 1) The level of performance of the students before and after the intervention in the control and experimental groups, 2) Significant difference in the performance of the students taught with and without error analysis as a formative assessment activity before and after the intervention, 3) Significant difference in the performance of the students in control and experimental groups after controlling the pre-test scores, 4) The strengths and weaknesses of using error analysis as a formative assessment activity.

2. RESEARCH METHODOLOGY

Research Design

This study is an action research because an intervention – the use of error analysis as formative assessment – was implemented and evaluated. A quantitative approach was used because the performance of the students was measured through pre-test and post-test. Also, this study used a descriptive-comparative design to determine, describe and compare the level of performance of the students in the two groups.

This study used the quasi-experimental research design, specifically the pre-test posttest control group design. The scores of pre-test and posttest of the control and experimental groups were compared to determine the influence of error analysis as formative assessment in students' performance.

Respondents

The subjects of the study were the students from two Grade 9 science sections, Dalton and Avogadro in Bintawan National High School. 9-Avogadro was the control group and 9-Dalton was the experimental group. Students, as respondents, were chosen regardless of their age and gender. There were 38 students in 9-Avogadro and 36 students in 9-Dalton.Thirty students each section were chosen randomly as the respondents because some of the students were out or athletes during the conduct of the study.

Research Instruments

Pre-test and Posttest. This tool was adapted from Asuncion, Ordonez, Raneses & Tuguinay (2018) study. The tests are 40 items and multiple choice type. The items are inclined on the competencies of the K to 12 Basic Education Program Mathematics Curriculum.

Curriculum Guide. It is a structured document prescribed by Department of Education to have an orderly teaching-learning process. It includes what students should know and be able to do, from content standards, performance standards, and to the learning competencies. This serves as a guide for teachers in knowing what to teach and be achieved.

Lesson Plan. It is a blueprint for teaching-learning process that is made by the teacher that includes several parts. The content standard(s) describes the highest achievement of the students' in defining the knowledge, concepts and skills that they should acquire at each grade level. The performance standard(s), describes what students should be able to know and to do. The learning competencies are statements which the students achieve to meet the expected standards. All these three were lifted from the curriculum guide. Each group had different lesson plans, the lesson plans used in the experimental group had the integration of the use of error analysis as formative assessment activities. The lesson plans used in the control group do not have the intervention.

Data Gathering Procedure and Data Analysis

The researcher wrote a communication letter to ask the Division Office of DepEd Nueva Vizcaya to conduct an action research in Bintawan National High School. Since the approval was delayed the researcher wrote a letter to the Principal to start the gathering of data in the said school. The Researcher adapted a tool of Asuncion, et al. (2018) for pre-test and posttest. The administration of pretest as on the two science sections of grade 9. After the administration of the pre-test the researcher started the integration of error analysis as a formative assessment activity for 10 sessions. In the experimental group, the use of error analysis as a formative assessment activity was integrated while in the control group followed the traditional teaching was used where there was no integration of error analysis. After all the interventions, the researcher administered posttests in the two groups to compare their mean scores to determine the influence of error analysis as formative assessment in students' performance will be done.

Several statistical measures were used to analyze the data gathered. The frequency counts, percentage and scores of the subjects and mean scores of the experimental and the control groups was described according to the level of performance prescribed by DepEd Order No. 8, s.2015.

Table 1. *Basis for the Performance Levels of Students in their Academic Achievement in Geometry*

Performance Level	Percent Score (%)	Raw Score
Outstanding	84-100	34-40
Very Satisfactory	76-83.99	31-33
Satisfactory	68-75.99	28-30
Fairly Satisfactory	60-67.99	24-27
Did Not Meet Expectation	0-59.99	0-23

The control and experimental groups mean scores were compared using paired sample t-test. Results from this test determined the significant difference of the control and experimental groups before and after the intervention. And also the use of ANCOVA to determine the significant difference of the two groups after controlling the pre-test scores.

3. RESULTS AND DISCUSSION

Section 1. Level of performance of the students taught with and without error analysis as a formative assessment activity before and after the intervention

Table 2

Mean Level, Frequency count and Percentage of the Students in the Different Levels of Performance

	CONTROL GROUP				**EXPERIMENTAL GROUP**			
	PRETEST		POSTTEST		PRETEST		POSTTEST	
	f	%	F	%	f	%	f	%
Outstanding	0	0.0%	0	0.0%	0	0.0%	2	6.7%
Very Satisfactory	0	0.0%	0	0.0%	0	0.0%	3	10.0%
Satisfactory	0	0.0%	2	6.7%	0	0.0%	2	6.7%
Fairly Satisfactory	0	0.0%	18	60.0%	2	6.7%	8	26.7%
Did Not Meet Expectations	30	100.0%	10	33.3%	28	93.3%	15	50.0%
TOTAL	**30**	**100.0%**	**30**	**100.0%**	**30**	**100.0%**	**30**	**100.0%**
Mean	17.47		23.67		17.83		24.60	
SD	2.488		3.790		3.983		5.581	
Level	**Did Not Meet Expectations**		**Fairly Satisfactory**		**Did Not Meet Expectations**		**Fairly Satisfactory**	

Legend: 0-23 (Did not meet expectations) 24-27 (Fairly Satisfactory) 28-30 (Satisfactory) 31-33 (Very Satisfactory) 34-40 (Outstanding)

In Table 2, the mean score of the control group in the pre – test (before intervention) was 17.47 where all of the students got a score of 23 and below which is described as "did not meet expectations". After intervention, the mean score in the posttest increased to 23.67 described as "fairly satisfactory", where exactly two-thirds of the respondents got a score higher than 23.

The pre-test and posttest of the experimental group are also shown in table 2. The pre-test mean score of the students was 17.83, 93.3% of the students got 23 and below. The posttest scores of the students increased to 24.60 which is described as "Fairly Satisfactory", where 50% of the students got more than 23. Since the mean scores of the two groups increased, these imply that the two groups have improved performance with or without the intervention error analysis as a formative assessment activity.

The table also shows that the number of students in the control group who increased from did not meet expectation to fairly satisfactory (66.67%) is greater than the number of students who increased in the experimental group (50%). However, it can be implied that the students in the experimental group has greater improvement because 16.67% got a score higher than 30.

The results show poor performance which is related to the study of Adolphus (2011) in which he stated that it is in the core topics in geometry where the problems of teaching and learning occurs most in mathematics. Topics such as plane and solid shapes, measurement of plans and solid shapes, polygons, Geometrical ratio, geometrical transformation, latitude and longitude are topics that are generally identified to be difficult by the students.

The poor performance of the students in the pre-test scores of the students in the experimental group may be attributed to their lacking of prior knowledge about the topics included in their test. During intervention, the results of their activities were good; which indicated that they were learning something. After the intervention, the result of their posttest scores had an increased but it still indicated poor performance. The researcher observed that the students answered the posttest very fast but not accurate because they were excited to practice their presentation for the program the day after. This may explain the cause of their poor performance in their posttest.

According to Lai (2012), the other possible causes of students' poor performance are poor attention and carelessness. To address this issue teacher should first consider the alignment between the instruction, student ability, and the task.

Section 2. Difference in the performance of the students taught with or without error analysis as a formative assessment activity before and after intervention

Table 3

Paired samples t-test of the performance of the students before and after the intervention for the two groups

		Mean Difference	Mean	SD	t	df	Sig. (2-tailed)
CONTROL	Pretest	6.20	17.47	2.488	-8.172	29	.000**
	Posttest		23.67	3.790			
EXPERIMENTAL	Pretest	6.77	17.83	3.983	-5.944	29	.000**
	Posttest		24.60	5.581			

**significant at .01

Table 3 shows that the difference of the mean scores in the pre-test and posttest of the students in the control group is 6.20, where the mean scores in the pre-test and posttest are 17.47 (SD=2.488) and 23.67 (SD=3.790), respectively. Using paired samples t-test, the pre-test and posttest of the control group has a significant difference with a p value less than 0.05. This implies that there was an increased in the students' performance using the traditional way of teaching.

This negates the statistics found in the study conducted by Asuncion, Ordoñes, Rañeses & Tuguinay (2018). It stated that there is no improvement in the mathematics achievement of the students taught in traditional strategy of teaching.

Table 3 also shows that the mean scores in the pre-test (M=17.83) and posttest (M=24.60) of the experimental group differ by 6.77. Using paired sample t-test it can be inferred that there is also a significant difference in the pre-test and posttest scores of the experimental group with a p value of less than 0.05. Since the mean scores in the pre-test and posttest of both the control and experimental groups have a significant difference, this means that with or without the use of error analysis as a formative assessment activity there is an improvement in the performance of the students.

This agrees with the study of Krasne (2006) which stated that formative assessment should be one that ultimately helps improve learning. It has been suggested that there should be focus on the three specific drivers of any formative assessment i) using a method to inform students of gaps in teaching-learning process, ii) familiarizing students with the expectations of summative assessments and iii) providing feedback that guides the direction of student learning.

Section 3. Difference in the performance of the students between the control and experimental groups after controlling the pretest scores

Table 4. *Covariate of Performance between Groups*

GROUP	Mean	SD	Estimated Marginal Means	Std. Error	df	F	Sig.
Control	23.67	3.790	23.714[a]	.865	1,57	.469[b]	.496
Experimental	24.60	5.581	24.553[a]	.865			

a. Covariates appearing in the model are evaluated at the following values: PRETEST = 17.65.
R Squared = .042 (Adjusted R Squared = .008)

Table 4 shows the mean scores of the students in the control and experimental groups which were 23.67 and 24.60, respectively. The p value was greater than 0.05 which means that there is no significant difference in the performance of the students between the control and experimental groups after controlling the pre-test scores. Even though there is no significant difference found in the performance between the two groups, still the mean difference of the pre-test and posttest of control and experimental groups were found to be significant as shown in Table 3. Thus, it implies that the use of error analysis as a formative assessment activity can be an alternative strategy in the teaching-learning process to improve the performance of the students in geometry.

The findings are similar with the statistics found in the study of Rushton (2018). The results of the study stated that, the students can learn mathematical concepts through a variety of methods. Nevertheless, the retention of mathematical knowledge is significantly increased when error analysis is added to the students' lessons, assignments, and quizzes. The difference between the means from the pretest to the posttest was higher in the treatment group versus the control group, implying that even though there was not a significant difference in the means, the treatment group did show a greater improvement.

Section 4. The strengths and weaknesses of the use of error analysis as a formative assessment activity

The use of error analysis as a formative assessment activity in the classroom had a positive impact in the performance of students as shown in table 2. The strengths of the use of this strategy were to enhance the metacognition of the students – the students' quick reaction to an erroneous solution – make them think harder and to promote innovation in teaching.

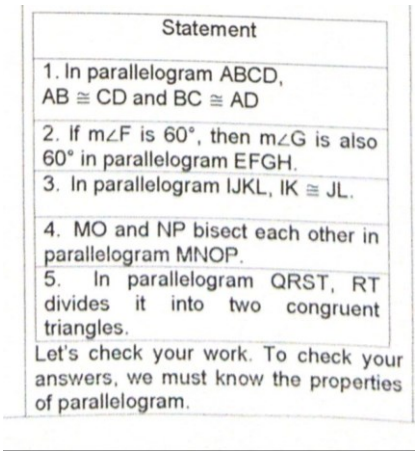
After the conduct of the interventions, the following are the identified strengths and weaknesses of the error analysis as a formative assessment.

The strengths of the error analysis were:

1. It serves as formative assessment in teaching quadrilaterals.
2. As formative assessment, it allows the students and teacher to measure the understanding in the lesson.

3. It boosts the interest of the students in learning the concepts.
4. It allows the students to realize their own mistake. (metacognition)

As mentioned, the error analysis serves as a formative assessment in teaching quadrilaterals. Figure 3 shows an excerpt how it was used in determining the different properties of a parallelogram.



Statement
1. In parallelogram ABCD, AB ≅ CD and BC ≅ AD
2. If m∠F is 60°, then m∠G is also 60° in parallelogram EFGH.
3. In parallelogram IJKL, IK ≅ JL.
4. MO and NP bisect each other in parallelogram MNOP.
5. In parallelogram QRST, RT divides it into two congruent triangles.

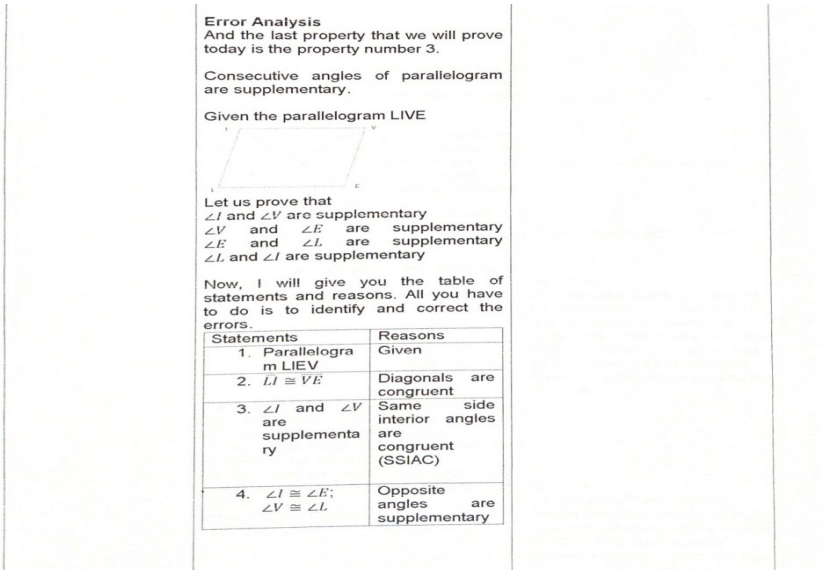
Let's check your work. To check your answers, we must know the properties of parallelogram.

Figure 3. Excerpt of a lesson plan

During the intervention, students noted that some of the statements were wrong. Several students reacted that statement 2 was incorrect. Some constructed parallelogram EFGH and pointed out that if m∠F is 60^0, then m∠G is not equal to 60^0 because a property states that adjacent angles of a parallelogram are supplementary. Two students even gave the m∠G which was 120^0.

Many students shouted that statement 3 was not always true because not all parallelograms had equal diagonals. Some students even said that, only square or rectangle had equal diagonals.

Moreover, it also allowed the students to measure their understanding in proving a property of a parallelogram. Figure 4 shows the excerpts of the sample activity given to the students.



Error Analysis

And the last property that we will prove today is the property number 3.

Consecutive angles of parallelogram are supplementary.

Given the parallelogram LIVE

Let us prove that
$\angle I$ and $\angle V$ are supplementary
$\angle V$ and $\angle E$ are supplementary
$\angle E$ and $\angle L$ are supplementary
$\angle L$ and $\angle I$ are supplementary

Now, I will give you the table of statements and reasons. All you have to do is to identify and correct the errors.

Statements	Reasons
1. Parallelogram LIEV	Given
2. $\overline{LI} \cong \overline{VE}$	Diagonals are congruent
3. $\angle I$ and $\angle V$ are supplementary	Same side interior angles are congruent (SSIAC)
4. $\angle I \cong \angle E$; $\angle V \cong \angle L$	Opposite angles are supplementary

Figure 4. Excerpt of a lesson plan

During the intervention, in statement 1, the students understood that naming parallelograms should follow the vertices. So, parallelogram can have many names. One student gave the correct name of the parallelogram, which was parallelogram LIVE. Some students even gave the other names of the parallelogram, which were IVEL, VELI and ELIV.

It also mentioned that, the use of error analysis as formative assessment boosts the interest of the students in learning the concept. In the control group, using the traditional way of teaching, the students were very passive. If they did not know the answer they just kept quiet. However, in the experimental group, if they noticed erroneous solution presented on the board they usually yelled the correct ones.

The use of error analysis as formative assessment also allows students to realize their own mistake – thinking their own thinking – or the so called metacognition. The figure shows the excerpt of the sample problem given to the students.

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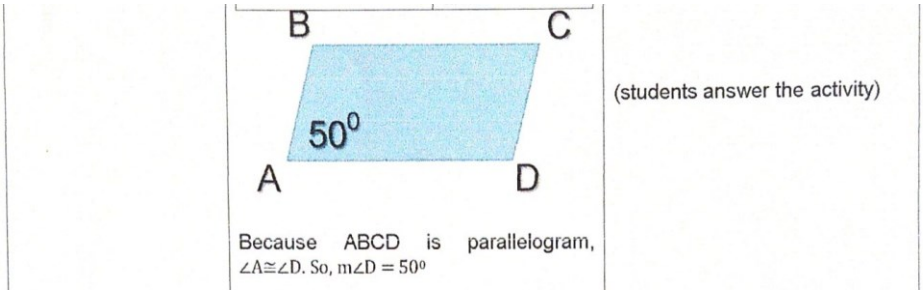

Figure 5. Excerpt of a lesson plan

During the intervention, a student was tasked to answer the presented problem. At first, the presented solution was incorrect. After a minute, the student realized that a property of a parallelogram states that, two consecutive angles or adjacent angles are supplementary. The student said that the measure of angles A and D were not equal, and angle D measured 130^0.

However, despite of the mentioned strengths of the intervention there were also few weaknesses observed such confusion on the part of the students because of the failure to orient the students regarding the main objective of the formative assessment. Some of the reasons considered by the teachers were to let them realize their own mistake and correct themselves on the process.

As observed, after some interventions, the results of their recorded activities were positive. However, sometimes students did not easily realize that the teacher's solutions are erroneous because it was not introduce in the beginning that the formative assessment activities were error analysis and that causes confusion about the lesson.

The poor performance of the students in the pre-test scores of the students in the experimental group could be attributed to their lacking of prior knowledge about the topics included in their test. During intervention, the results of their activities were good; which indicated that they were learning something. After the intervention, the result of their posttest scores had an increased but it still indicated poor performance. The researcher observed that the students answered the posttest very fast but not accurate because they were excited to practice their presentation for the program the day after. This would explain the cause of their poor performance in their posttest. Lai (2012) stated that the important thing to remember when engaging in error

analysis relates to student attention. Even though poor attention is one of the plausible reasons why students persistently make errors, there are concerns that teachers may exclusively look for this trait and fail to consider other reasons.

4. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The following conclusions are made based on the findings.

1. The performances of the students in the two groups in Geometry had an increase from did not meet expectation to fairly satisfactory. Even though there was an increase, their performances are still in low level.
2. The use of error analysis as a formative assessment activity has a significant positive influence in the performance of the students.
3. The use or non-use of error analysis as a formative assessment activity has a positive influence in the performance of the students, thus, the use of error analysis as a formative activity can be an alternative teaching technique.
4. Formative assessment such error analysis can be effective in improving the performance of the students in Geometry. However, the teacher must be aware that despite of its strengths, it may still result to some of weaknesses. Error analysis can be an alternative and innovative way in the teaching-learning process but other factors need to be considered such as the students' attention to avoid its weaknesses or to fully meet the objectives of the teachers.

Recommendations

1. The school administrators could to encourage teachers to use innovative strategies in teaching like the use of error analysis as a formative assessment activity.
2. Mathematics teachers could integrate the use of error analysis as a formative assessment activity in class for its significant effect in the performance of the students.
3. Students could strive for positive performance with the use of error analysis in formative assessment is recommended for its enhance their metacognition.
4. Future researchers could conduct more studies on metacognition is highly recommended for its positive impact in students' performance. The use of error analysis as a formative assessment activity may be also recommended to other areas.

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