International Journal of Academic and Applied Research (IJAAR)
ISSN: 2643-9603
Vol.5 Issue 5, May – 2021, Pages: 71-75

Exploring the Errors Committed by Third Year High School Students in Solving Word Problems in Geometry Using Newman's Error Analysis

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Abstract: *Teachers were always confronted with students experiencing difficulties with word problems. This paper attempts to reveal the error committed by third year high school students in solving word problems in Geometry using the Newman's Error Analysis, which are classified as Reading Error, Comprehension Error, Transformation Error, Processing Error and Encoding Error. Rather than giving students 'more of the same' involving increased drill and practice and hoping that students would overcome whatever difficulty they are having, Newman's Error Analysis provides a framework for considering the reasons that underlie the difficulties and a process that assist teachers to determine where misunderstandings occur and where to target effective teaching strategies to overcome them.*

Introduction

A critical skill or essential learning for working mathematically is to be able to solve problems. Solving problems is not just a means of finding the correct answers. Rather, it is a vehicle for developing logical thinking; it provides a context for mathematics and an opportunity for the transfer of newly acquired concepts and ideas. We all need to be better problem solvers to manage information and make wise choices in our professional and personal lives. To the degree that problems simulate real life, solving them endows mathematics with meaning. Unfortunately, solving word problems is one of the least popular and least addressed aspects of mathematics curriculum among students and teachers (Hur, 2006).

To help students become successful problems solvers, teachers must accept that student's problem-solving abilities often develop slowly, thereby requiring long-term sustained attention to making problem solving an integral part of the mathematics program. The initial teaching and learning of the problem solving process begins as the child enters school, and it is must continue throughout his entire school experience.

Filipinos in general have not been noted for mathematical ability but are known worldwide for our creativity especially in the arts (Nebres& Lee-Chua, 2000). International surveys (including Trends in International Mathematics and Science Standards) have placed the country near the bottom. Local studies similarly reflect such performance. The high school readiness test administered by the Department of Education in 2004 showed poor results with less than 10% of elementary graduates scored 75% and above.

Failure to solve problems mathematically may or may not be the result of poor understanding of the underlying mathematical concepts. Students may fail to solve problems because they misunderstand the underlying mathematical concepts, or they may fail despite their good conceptual understanding of the necessary mathematical concepts.

Although teachers must understand strategic competency and know effective instructional strategies that facilitate their development, teachers must also learn how to analyze students' error in the processes of problem solving. One strategy to use in finding out the errors committed by the students in answering mathematical tasks is through Newman's Error Analysis. Newman's error analysis process involves interviewing learners, using a series of questions that probe for the exact error that the learner is making. Newman's process also emphasizes the importance of language in mathematics and provides an excellent opportunity for the teacher and learner to get together on a one-to-one basis. However, it is really important that teachers resist the temptation to show their learner how to do the problem. Direct intervention with the learner may get them through a particular assessment but it will not help them to develop their numeracy skills or to do a similar assessment at a later time.

The efficacy of NEA in determining the difficulties confronted by the students inspire the researcher to

conduct a study that explores the different errors committed by the students in solving word problems in Geometry.

The research study aims to explore the errors committed by third year high school students of FVR National High School in solving word problems in Geometry using the Newman's Error Analysis.

Specifically, the study sought answers to the following questions:

1. What is the level of understanding in Geometry of the third year students in FVR National High School?
2. What errors are committed by the students when they are grouped according to their levels of understanding using the Newman's Error Analysis?

Method of the Study

The study utilized descriptive-qualitative research design. A researcher-made test instrument, van Hiele Levels of Understanding Test, was used to identify the levels of understanding of the students. It was designed to determine the levels of understanding of the students in Geometry. The test was pilot tested and item analyzed to determine the discrimination index and choose the best item for the Final Van Hiele Levels of Understanding Test. Also, the professional help of the experts were sought for validation of the instrument and identifying the appropriate levels of each of the items of the test. The reliability of the final instrument was established using the Kuder-Richardson formula 20 on which a reliability of .7 was computed.

Ten percent of the students for each of the levels were randomly taken to undergo the Newman's Error Analysis interview. The researcher recorded the interview for data analysis and interpretation. As described by Newman, errors were classified as: Reading, Comprehension, Transformation, Processing, Encoding and Careless.

Participants of the Study

This study consisted of 278 third year students of FVR National High School. Eighty-two of the participants were considered for the pilot testing and the rest took the final test where the samples were taken. The 196 students were classified according to the van Hiele levels (level 0, level 1, level 2 and level 3). Ten percent of the students for each of the levels were randomly chosen. These are nine students for level 0, seven students for level 1, four students for level 2 and two students for level 3. Students from each van Hiele levels were interviewed to determine the errors committed.

Research Instruments

To answer the stated problem in the study, the instrument *van Hiele Levels of Understanding Test* and Newman's Interview prompts were used.

The *van Hiele Levels of Understanding Test* is a researcher-made test. It was designed to determine the van Hiele levels of the students. Originally, it was composed of 40 items test, 36 multiple choice questions, 2 completion type and 2 items for proving. The result of the test was item analyzed to determine the discrimination indexes, basis for choosing the best items. Based on the results of the item analysis, it was reduced to 15 multiple choice questions and 2 items for proving. The Kuder-Richardson formula 20 was used to test the reliability of the test instrument. The Final Van Hiele Levels of Understanding Test has a reliability of 0.70. The instrument was evaluated by experts based on several criteria with three categories namely, content, appearance and technical.

To achieve the objectives of the study, the researcher attempted to determine how the students are thinking and note the errors they committed while answering a typical word problem in Geometry. Guided by the Newman's Error Analysis hierarchy, these were the questions asked to the student-respondents:

Question for Stage 1: Read the question to me. If you don't know a word, leave it out.

Question for Stage 2: Tell me what the question is asking you to do.

Question for Stage 3: Tell me the method you can use to find the answer to the question.

Question for Stage 4: Show me how you worked out the answer to the question. Explain to me what you are doing as you do it. Do you know you are right? Why?

Question for Stage 5: Now write down your answer to the question. How confident do you feel about the answer?

The interview was transcribed. After careful analysis of the interview, the errors committed by the student-respondents were classified according to the following criteria:

Reading Errors. An error would be classified as READING if the child could not read a key word or symbol in the written problem to the extent that this prevented him/her from proceeding further along an appropriate problem-solving path.

Comprehension Errors. The student had been able to read all the words in the question, but had not grasped the overall meaning of the words and, therefore, was unable to proceed further along an appropriate problem solving path.

Transformation Errors. The student has understood what the questions wanted him/her to find out but was unable to identify the operation, or sequence of operations, needed to solve the problem.

Processing Errors. The student identified an appropriate operation, or sequence of operations, but did not know the procedures necessary to carried out these operations accurately.

Encoding Errors. The student correctly worked out the solution to a problem, but could not express this solution in an acceptable written form.

If the student attempts to answer the question for the second time, then he gets the correct answer and, after the teacher has listened to the answers to the Newman interview prompts, the interviewer was convinced that the student originally made a careless slip, then the error would be classified as Careless error. Or, if the student gave an incorrect answer in the *van Hiele Levels of Understanding Test* but then gave a correct answer immediately during the Newman interview for that question, then it would be suspected that Careless error occurred.

Presentation and Analysis of Data

Using the van Hiele Levels of Understanding Test, the levels of understanding in Geometry of 196 students were determined. The van Hiele levels attained by the students were shown at Table 1.

Table 1. The van Hiele levels attained by the students

van Heile levels	No. of Students	Percentage (%)
Level 0 Pre Recognition	87	44
Level 1 Visualization	72	37
Level 2 Analysis	35	18
Level 3 Abstraction	2	1

Level 4 Deduction	0	0
TOTAL	**196**	**100**

The data gathered revealed that 44% of the student-respondents were working at level 0 and 37% at level 1, 18% was at level 2 and only 1% was working at level 3. On the other hand, nobody reached level 4 of the van Hiele levels. This implies that majority of the students did not attain the necessary skills expected of them to achieve upon completing the Geometry course. It was supported by similar studies conducted by Usiskin (1980), Erfe (1996), and Liwag (2008).

Table 2 summarizes the different errors committed by the students at each van Hile levels of understanding in Geometry.

Table 2. Summary of the type of errors committed by the students at each van Hiele levels

Type of Errors	**Number of Students**				**TOTAL**
	Level 0	**Level 1**	**Level 2**	**Level 3**	
Reading Error	0	0	0	0	**0**
Comprehension Error	5	4	0	0	**9**
Transformation Error	0	1	3	2	**6**
Processing Error	2	1	1	0	**4**
Encoding Error	0	1	0	0	**1**
Careless Error	2	0	0	0	**2**
TOTAL	*9*	*7*	*4*	*2*	**22**

From the conducted interview of 22 students, it was found out that third year high school students possessed reading skills in English but majority of them could not express their thoughts and ideas using the language. When the interviewer asked the student-respondents in English, some of the students would reply in Filipino while others choose to keep silent and few of them were requested to translate the interviewer's question in Filipino. As shown in Table 9, nobody committed error in reading. On the other hand the Comprehension Error was committed the most frequent followed by the Transformation Error, Processing and Careless Error. However, the Encoding Error was committed by the students the least frequent.

The result revealed that Comprehension Error was committed most frequent at the lower levels, level 0 and level 1, while the Transformation Error was committed most at the higher levels, that is, level 2 and level 3. These showed that, students working at the lower levels committed most error in Comprehension while the students from the higher level, committed most error in Transformation. It was observed that respondents from level 3 were persistent problem-solvers. It was also noted that Careless Error and Encoding Error occurred only once at lower levels, that is, level 0 and level 1 respectively. On the other hand, Processing Error occurred at all levels except in level 3.

Furthermore, the result of the study showed that the student-respondents committed most error in Comprehension followed by Transformation. That is, more than half or 68% of the initial error made by the respondents occurred before the application of the process skills. On the other hand, 18% of the error occurred at the Processing level while 9% of the student-respondents committed Careless Error. However, the Encoding Error was committed the least frequent.

Conclusion

Based on the data gathered from the test instrument and the conducted interview, the study revealed the following findings:

1. The result of the study showed that the majority of the students did not attain the necessary skills expected of them to achieve upon completing the Geometry course.

2. Third year high school students possessed reading skills in English that is why, no error occurred at the Reading level. Students working at the lower levels committed most errors in Comprehension while the students from the higher level, committed most error in Transformation. Specifically, it was found out that:

a. Students with level 0 (Pre-recognition) understanding in Geometry committed most error in comprehension. They were not able to identify exactly what the question required them to do. Processing Errors were also committed due to lack of knowledge on mathematical facts necessary to arrive at the correct answer. There were instances that even the student got the correct answer, he/she was not able to give explanation that would support his/her answer. The students at this level, easily gives up whenever they do not know what to do.

b. Students from level 1 (Visualization) committed error in Comprehension. Transformation, Processing and Encoding Errors occurred with the same frequency.

c. Students from level 2 (Analysis) committed majority of the errors in Transformation level and only 1 committed error in Processing level.

d. Students from level 3 committed errors in Transformation. They were able to make meaningful illustration of the data described in the problem. It was observed that these students do not easily give up and they have consumed the longest time in answering the problem among the student-respondents. They maximized whatever time they have to solve the problem and employ whatever knowledge they would retrieve in order to arrive at the best solution.

3. The result of the study revealed that the student-respondents committed most error in Comprehension followed by the Transformation Error. That is, more than half of the initial error made by the respondents occurred before the application of the process skills. On the other hand, 18% of the error occurred at the Processing level while 9% of the student-respondents committed Careless Error. However, the Encoding Error was committed the least frequent.

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