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An Analysis of Students' Errors in Solving Geometry Problems Based on Cognitive Style

Miftahul Huda*[1], Rachmat Satrio Wahyudi[1], Supratman[1]
Master of Mathematics Education, Siliwangi University, Indonesia
Corresponding email: miftahulhudaa223@gmail.com

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Abstract

This research aims to analyze the types of errors made by students in working on geometry questions of the Minimum Competency Assessment (MCA) type according to Newman's stages in terms of cognitive style. The method used in this research is qualitative. Data collection techniques were carried out through cognitive style tests, geometry test questions, and unstructured interviews. The instruments in this research were the GEFT test and the MCA type geometry test. The research took place a junior high school in Tasikmalaya, the subjects in this research were class IX students who had consistent cognitive styles and made different mistakes. The data analysis techniques used are according to Miles and Huberman, namely data reduction, data presentation and verification. The findings from this research were that Field Dependent subjects made mistakes at the understanding, process skills and encoding. The contributing factors are that they did not master the material, were not being careful in calculations, and were not used to checking answer results. Meanwhile, Independent Field subjects made mistakes at the process skills and encoding. The causal factor is that they were not used to doing large number calculation operations. The implications of this study suggest that teachers should design differentiated learning strategies that consider students' cognitive styles to minimize specific types of errors and enhance overall problem-solving abilities.

Keywords: Newman Error, Geometry, Minimum Competency Assessment, Cognitive Style, Mathematics lesson

Abstrak

Penelitian ini bertujuan untuk menganalisis jenis kesalahan yang dilakukan siswa dalam mengerjakan soal geometri tipe Asesmen Kompetensi Minimum (MCA) sesuai tahapan Newman ditinjau dari gaya kognitif. Metode yang digunakan dalam penelitian ini adalah kualitatif. Teknik pengumpulan data dilakukan melalui tes gaya kognitif, tes soal geometri, dan wawancara tidak terstruktur. Instrumen dalam penelitian ini adalah tes GEFT dan tes geometri tipe MCA. Penelitian bertempat di salah satu SMP di Tasikmalaya, subjek dalam penelitian ini adalah peserta didik kelas IX yang memiliki gaya kognitif konsisten dan melakukan kesalahan berbeda. Teknik analisis data yang digunakan adalah menurut Miles dan Huberman yaitu reduksi data, penyajian data, dan verifikasi. Temuan dari penelitian ini adalah subjek *Field Dependen* melakukan kesalahan pada tahap memahami, keterampilan proses, dan penulisan jawaban. Faktor penyebabnya adalah tidak menguasai materi, tidak teliti dalam perhitungan, dan tidak terbiasa melakukan pengecekan hasil jawaban. Sedangkan subjek *Field Independen* melakukan kesalahan pada tahap keterampilan proses dan penulisan jawaban. Faktor penyebabnya adalah tidak terbiasa melakukan operasi hitung bilangan yang besar. Implikasi dari penelitian ini menunjukkan bahwa guru sebaiknya merancang strategi pembelajaran yang berdiferensiasi dengan mempertimbangkan gaya kognitif siswa untuk meminimalkan jenis-jenis kesalahan tertentu dan meningkatkan kemampuan pemecahan masalah secara keseluruh

Kata Kunci: Kesalahan Newman, Geometri, Asesmen Kompetensi Minimum, Gaya Kognitif, pembelajaran Matematika

INTRODUCTION

Geometry material is one of the materials in mathematics subjects that has been taught since elementary school (Taufik, 2024), this is stated in Minister of National Education Regulation (Permendiknas) no. 3 of 2003 (Minister of National Education, 2006). Geometry is also one of the contents tested in the Minimum Competency Assessment (MCA). MCA is an assessment of the fundamental competencies needed by all students to be able to develop their own capacity and participate positively in society (Ministry of Education and Culture, 2020). MCA it is part of the National Assessment which is carried out as an effort to improve the

quality of national education and ensure that students have achieved the minimum standards of competency that have been set. National assessments are carried out at the mid-school level, namely class 5 for elementary level, class 8 for middle level, and class 11 for high school/vocational school level so that this policy is expected to provide opportunities for educational actors to improve learning in the following year. There are two fundamental competencies measured in IMR, namely reading literacy and mathematical (numeracy) literacy. To ensure that measures the competencies needed in life, also in accordance with the meaning of Reading Literacy and Numeracy that has been conveyed, MCA questions are expected to not only measure certain topics or content but various content, various contexts and at several levels of cognitive processes (Ministry of Education and Culture, 2020).

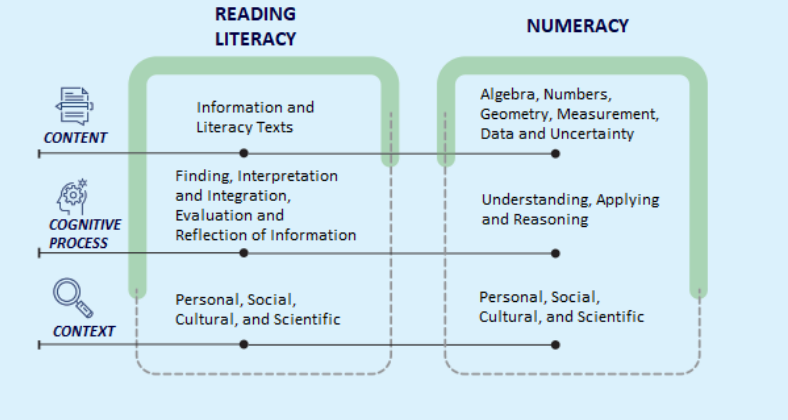


Figure 1. Differences between Literacy and Numeracy Assessments
Source: National Assessment question and answer sheet (Ministry of Education and Culture, 2021)

Based on MCA report card results at a middle School, Tasikmalaya City academic year 2021/2022 ability class students IX in geometric content gets the lowest value compared to number, algebra, data and probability content, namely 58.45. This data is supported by the results of the TIMMS survey in 2015 which showed that Indonesian students' geometric abilities received the smallest proportion, namely *20%* (Sari, 2015). Based on this data, it shows that there are still many students who have difficulty working on mathematics problems, especially geometry materials. One way that can be used to find out the causes of students' low geometric abilities is by analyzing errors. There are several common method used to analyze errors, among them watson's category, Nolting theory, Polya's step, and Newman's procedure. However, in this research, researcher Will using error analysis Newman (1977) these are: reading errors, misunderstandings, transformation errors, process skill errors, and answer writing errors. The difference between Newman's error analysis and Polya's steps lies in the absence of reading stages in Polya's steps. In fact, difficulties in reading will affect students' ability to solve questions with the MCA type which trains students' literacy and numeracy skills. Therefore, researchers chose Newman's error analysis in this study in order to more comprehensively reveal the types of errors made by students. To identify mistakes made by students based on Newman's stages, researchers used the Newman error indicator put forward by (White, 2005) as follows:

Table 1. Newman Error Indicator

No	Error Type	Error Indicator
1	Misreading questions (*Reading*)	1) Students are unable to read or recognize symbols Mathematics in questions 2) Students are unable to interpret the meaning of every word, term, or symbols Mathematics in questions
2	Misunderstanding the question (*Comprehension*)	1) Students are unable to understand what is known from the questions completely and correctly 2) Students are unable to understand what is asked from the questions completely and correctly
3	Problem transformation error (*Transformation*)	1) Students are unable to create mathematical models of the information presented, 2) Students cannot determine the right formula to solve the problem
4	Process skills errors (*Skill process*)	1) Students do not know the procedures or steps that will be used to solve the problem 2) Students are unable to perform procedures or counting operations correctly
5	Error writing the answer (*Encoding*)	1) Students are unable to show the final answer to the problem solution 2) Students do not write precise conclusions from their work

Prakitipong and Nakamura (2016) divide the five stages of Newman's error analysis into two categories based on the difficulties students face. The first category is linguistic or linguistic problems consisting of reading ability and conceptual understanding. The second category is mathematical processing problems consisting of transformation, process skills, and answer writing (Vitaloka et al., 2020).

According to Kartikasari et al. (2021), students' ability to solve problems varies so there is a possibility that the errors that arise will also be different. Apart from that, students also have their own ways of arranging what yang seen, remembered and thought about (Ridwan, 2021). Individual differences that persist in how to organize and manage information and experiences are known as cognitive styles.

Cognitive style is a typical way of learning for students, including how they receive information, process it, and use it to solve problems or make decisions. Witkin (1977) divide cognitive style becomes two viz: *field independent* (FI) and *field dependent* (FD). FI cognitive style is a cognitive style where students are more likely to process information separately, working separately *independent*, and don't like the way you learn to curl up. Meanwhile, the FD cognitive style is a cognitive style where students are more likely to process information as a whole, are more sensitive to context, and prefer learning through group discussions. To be able to determine whether a student belongs to the FD or FI cognitive style, a perceptual test was used which was developed by Witkin in 1977 (Rochmawati & Hariastuti, 2017). This perceptual test is called *Group Embedded Figures Test* (GEFT) is a test that uses images. In this test, a set of simple images are given that are hidden in more complicated images. Students are asked to find simple images given in these complex images by thickening them. The

classification of cognitive styles is based on whether students are correct in finding simple images within a predetermined time limit.

Research relating to error analysis student judging from cognitive style, it has been done, including: (Kartikasari et al., 2021) with the title Analysis of Mistakes Students Solve Mathematical Story Problems Based on Newman Procedures Judging from Cognitive Style. The research concluded that students with the cognitive style of FI made mistakes transformation, process skills, and answer writing. Errors that occur during the process skill stages, affect errors in later stages. Meanwhile, students who have an FD cognitive style are more likely to make mistakes during the transformation stage, process skills and answer writing. In this research Nah explained about causal factors occurrence mistakes, so in this research students' mistakes and their causal factors will be discussed.

Previous studies have analyzed student errors in mathematical problem solving using Newman's procedures, with some focusing on the influence of cognitive styles. However, most of these studies have concentrated on conventional mathematical problems or story problems without considering the specific characteristics of the Minimum Competency Assessment (MCA) type questions, which emphasize literacy and numeracy aspects. Research examining student errors specifically in solving MCA-type geometry problems in relation to cognitive styles remains very limited. Moreover, there is a lack of studies that not only identify the types of errors but also explore the causal factors behind these errors in the context of MCA geometry content. This study seeks to fill this gap by analyzing both the types and causes of students' mistakes, providing deeper insights that could contribute to more effective learning strategies tailored to students' cognitive styles.

Apart from that, the problem given in this research is the type of MCA which is new in the world of education and has not been discussed much in research. By description as explained, researchers are interested in analyzing the types of errors made by students in solving IMR type questions and their causes. Thus, the research questions is: what is the students' mistakes in solving geometry questions assessment type minimum competency judging from cognitive style.

METHOD

This research employs a qualitative approach with a descriptive research type to investigate students' errors in solving MCA-type geometry problems based on Newman's error analysis, viewed from the perspective of cognitive styles. A qualitative approach was chosen because it allows for an in-depth exploration of students' thought processes, providing a detailed description of the types of errors made and the factors influencing them (Mufaridah, Yono, Ikhtiar, & Raharjo, 2022). Descriptive research is suitable for revealing the phenomena of student errors as they naturally occur, without manipulating the variables involved.

The research subjects were class IX students, selected based on the consideration that these students had already been introduced to the Minimum Competency Assessment (MCA) and had experience solving MCA-type questions. The selection of subjects in this study was carried out through purposive sampling, where students were chosen deliberately to meet certain criteria. First, students needed to have a consistent cognitive style, either Field Dependent (FD) or Field Independent (FI), as identified through the Group Embedded Figures Test (GEFT). Second, students were selected if they exhibited different types of errors during the geometry test, ensuring a variety of mistakes could be analyzed comprehensively during the interview stage. This selection process aimed to capture a broad picture of student error patterns according to cognitive style.

The data collection techniques used in this study consisted of tests and unstructured interviews. The test phase involved two types of instruments. The first was the GEFT test, developed by Witkin, which aims to categorize students into Field Dependent or Field Independent cognitive styles based on their ability to identify simple shapes hidden within complex figures within a set time limit. A consistent cognitive style was an essential criterion to ensure the reliability of the subsequent analysis. The second test was a set of MCA-type geometry questions designed to identify the types of errors students made. These errors were categorized according to Newman's Error Analysis, which includes misreading (reading), misunderstanding (comprehension), problem transformation errors (transformation), process skill errors (process skills), and encoding errors (answer writing).

After the testing phase, unstructured interviews were conducted with selected students. These interviews aimed to explore deeper the thought processes behind the students' answers, the difficulties they faced, and the reasons for their mistakes. Using unstructured interviews allowed researchers to adapt questions flexibly based on the students' responses, thereby capturing more nuanced and authentic data regarding students' problem-solving experiences.

The data analysis in this study followed the stages proposed by Miles and Huberman (in Sugiyono, 2017), namely data reduction, data presentation, and verification or conclusion drawing. Data reduction involved selecting, focusing, simplifying, and transforming raw data obtained from the tests and interviews into a manageable form. During this phase, the researchers categorized students' errors according to Newman's framework and grouped them by cognitive style. The next stage was data presentation, where the data were organized systematically, typically using matrices, tables, or narrative texts, to make patterns and relationships more apparent. Finally, verification involved interpreting the patterns found, formulating findings, and drawing conclusions regarding the relationship between cognitive style and types of errors made by students in solving MCA-type geometry problems.

GEFT Test (*Group Embedded Figures Test*) is a psychological test used to measure a person's ability to find simple images hidden in more complex images. The GEFT test was originally developed by Herman A. Witkin (1977) and has been used extensively in psychological research. This test is used to group students into cognitive style groups *Field Dependence* (FD) and cognitive style *Field Independence* (FI). There were 25 questions in the three stages of the GEFT instrument. 7 questions were in the first session, and 9 in each of the second and third sessions. The first session was not scored because it was intended as an exercise for students and as an example. Each-each question given a score of 1 if the answer is correct and a score of 0 if didn't answer or answered incorrectly, resulting in a score minimum 0 and maximum of 18. The time allotted for the first session was 7 minutes, for the second and third sessions respectively given time 9 minutes. Furthermore, the total score obtained by students is then grouped based on the criteria set by Gordon & Wyant (1994) in (Nengsih et al., 2019) namely

- $0 \leq Field\ Dependent \leq 11$
- $\leq 12\ Independent\ Fields \geq 18$

RESULTS AND DISCUSSION

This research was carried out at a junior high school in Tasikmalaya City, precisely in class IX, totaling 20 people and researchers named it Q1-Q20. At the beginning of the research implementation, student asked to taking the GEFT test (*Group Embedded Figures Test*) with the aim of grouping students based on cognitive styles which consist of cognitive styles *Field Dependence* (FD) and cognitive style *Field Independence* (FI). This GEFT test is carried out

repeatedly twice to determine students who consistently have cognitive styles. Then, based on the GEFT test results of the 20 students, there were 16 students who achieved consistent results and 4 students were inconsistent. The following are the results of students' consistent GEFT tests after grouping them based on their cognitive style:

Table 2. Grouping of Students Based on Cognitive Style

No	Cognitive Style	Subject
1	*Field Dependence* (FD)	S3, S7, S8, S9, S12, S14, S15, S18, S20
2	*Field Independence* (FI)	S1, S2, S4, S11, S13, S17, S19

Based on the table above, of the 16 students who had a consistent cognitive style, 9 students had an FD cognitive style and 7 students had an FI cognitive style and were then coded in the order, namely $FD1-FD9$ and $FI1 - FI7$. After knowing their cognitive style, the 16 students were given an MCA type geometry question test to select students who could do it question until completion and data were obtained on 9 students who worked on the questions until completion and 7 students did not work on the questions until completion. Students who worked on the questions until completion consisted of 3 students with FD cognitive style and 6 students with FI cognitive style. Researchers analyzed the location of the errors of the 9 subjects based on the location of the errors according to Newman, namely: reading errors, understanding errors, transformation errors, process skill errors, and answer writing errors and obtained the following data:

Table 3. Student Error Data Based on Newman Stages

No	Subject	Subject Code	Newman's fault				
			RE	CE	TE	PE	EE
1	S7	FD 2	-	-	-	V	V
2	S12	FD 5	-	V	-	V	V
3	S20	FD 9	-	-	-	V	V
4	S1	FI 1	-	-	-	V	V
5	S4	FI 3	-	-	-	V	V
6	S11	FI 4	-	-	-	V	V
7	S13	FI 5	-	-	-	V	V
8	S17	FI 6	-	-	-	V	V
9	S19	FI 7	-	-	-	V	V

Description:

RE = *Reading Error* (Reading Error)
CE = *Comprehension Error* (Misunderstanding)
TE = *Transformation Error* (Transformation Error)
PE = *Process Skill Error* (Process Skills Error)
EE = *Encoding Error* (Mistake Answer Writing)

After seeing the results geometric tests are based on the location of Newman's errors in the table above, it can be seen that of the 9 subjects, several subjects made the same error location, both those with FI and FD cognitive styles so that researchers choose research subjects

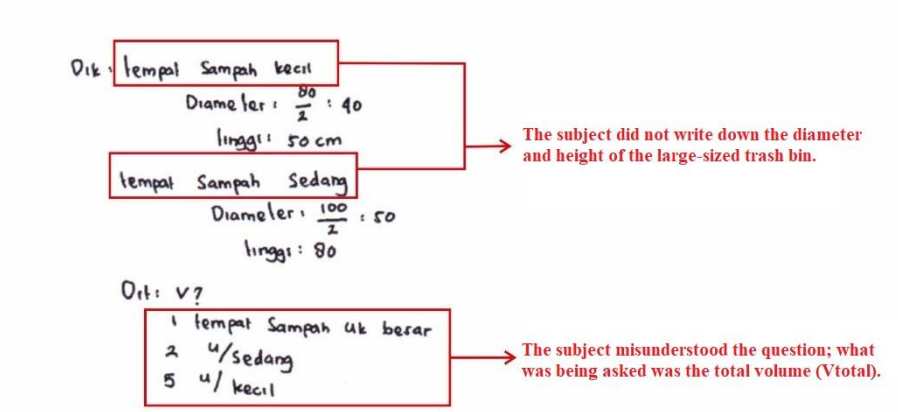
based on predetermined criteria, namely subjects who have different cognitive styles and have different error locations and researchers choose subjects *FD5*, *FD9*, and *FI1* to be the subject of research and conduct in-depth interviews.

Table 4. Research Subject

No	Subject	Subject Code	Newman's fault				
			RE	CE	TE	PE	EE
1	S12	FD 5	-	V	-	V	V
2	S20	FD 9	-	-	-	V	V
3	S1	FI 1	-	-	-	V	V

Based on in the table above, the location of the subject's errors in solving geometric problems of different MCA types. The research findings in each cognitive style group are explained as follows:

FD subjects make mistakes in the stages of understanding, process skills, and writing answers. Stage understand subject FD less complete in writing down what is known from a problem that is, namely not writing the diameter and height of a large trash can and misunderstanding the questions in the problem.



This error is in line with Zulyanty's statement (2019: 386) in (Putri et al., 2021) namely, misunderstandings can be identified if students are unable to identify what is known and asked correctly so that students make mistakes in determining solutions and cannot find the right solution. The causal factor is that the subject is less thorough and rushes in solving the problem.

At the process skills stage, the FD subject makes a mistake, namely not knowing the procedures or steps that will be used completely to solve the problem, this happens because the subject thinks what is sought is the volume of each trash can n.e.i volume total everything. Apart from that, the subject also experienced a calculation error in looking for a small volume of waste. This error is in line with Rahmawati and Permata's statement (2018: 180) deep (Putri et al., 2021) which states process skills errors occur when students make computational errors and are able to complete counting operations but cannot know the exact completion steps. Meanwhile, according to Yusnia and Fitriyani (2017: 81) in (Putri et al., 2021) process skills errors occur when students are unable to perform calculation steps correctly.

As for the stage of writing the answer, the FD subject made a mistake because he wrote the wrong answer. This is due to an error in the previous stage and not checking the counting

operations carried out again. This matter in line with the statement Putri et al., (2021) that mistakes in drawing conclusions made by students include not making conclusions, not being correct in finding the final result, conclusions written incorrectly, and not checking the answer results again.

Subject *Independent Field* (FI) already able to read and interpret the meaning of every word and term in the question. It can be seen from the results of the interviews that the subjects were able to interpret what is meant by diameter, radius and height. Likewise deep stage understand the subject problem FI can explain and able to sort out what is known and what is asked about a problem completely and correctly. On transformation stage, Fi subject have been able to determine the correct formula and can determine steps which will be used to solve a problem. The subject FI can name the exact formula and the values to look for first are circle radius, then count volume of each trash can. From the FI subject's answer, it can be seen that in planning problem solving, the FI subject can determine the solution of the problem independently. This is in accordance with what Witkin stated in (Lusiana, 2017) that the learning character of FI type students is usually better able to solve problems without explicit instruction and guidance. Meanwhile, FD subjects are less able to choose the strategy that will be used to solve the problem.

At the process skills stage, FI subjects are able to determine the right steps to solve the questions and use them, but experience errors in carrying out multiplication and division calculation operations small size trash can volume. This error is in line with the statement made by Rindyana and Chandra (2013) in (Putri et al., 2021) errors made by students in process skills include errors in operating multiplication, addition and subtraction. In the writing stage of the subject's answer with type FI making mistakes due to mistakes at the process skills stage.

Based on the discussion above, there are more errors made by FD subjects than errors made by FI subjects, this shows that there are differences in the ability to solve problems between FD and FI subjects. There is this difference is because subjects with the FD cognitive style think more generally while subjects with the FI cognitive style think more analytically. This condition is in line with the research results of Wulan & Anggraini (2019) and Ahna (2022) who found that subjects with FI cognitive style were better than subjects with FD cognitive style in terms of problem solving abilities. So that subjects who have better problem solving will be better at solving mathematical problems.

Despite providing valuable insights, this study has several limitations that should be acknowledged. First, the sample size was relatively small, with only nine students analyzed in-depth, which may limit the generalizability of the findings to broader student populations. The use of purposive sampling, while suitable for qualitative research, introduces potential selection bias because it focuses only on students with consistent cognitive styles and specific error patterns, possibly overlooking other types of thinking processes and errors that could occur in a more diverse group. Additionally, the reliance on unstructured interviews, although providing rich and flexible data, could lead to inconsistencies in the depth and breadth of information collected across different subjects. The study also only categorized cognitive styles into two broad types, Field Dependent (FD) and Field Independent (FI), without considering potential variations within these groups or the influence of other cognitive or emotional factors that could affect problem-solving performance. Furthermore, the focus was limited to MCA-type geometry questions, meaning the findings might not fully represent students' error patterns in other mathematical domains. Finally, because the data analysis heavily relied on researchers' interpretation, there is a risk of subjective bias influencing the coding and conclusions, even

though established frameworks like Newman's error analysis and Miles and Huberman's qualitative data analysis stages were employed.

CONCLUSIONS AND SUGGESTIONS

Based on an analysis of the mistakes made by students in terms of cognitive style, the following conclusions can be drawn: Errors made by the subject *Dependent Fields* (FD) tends to be at the stage of understanding problems, process skills, and writing answers. The factors that cause FD subjects to make mistakes are because the subjects do not master the material well, lack learning, are not careful in writing down the calculation results, and are not used to re-examining the answers. Meanwhile, the mistakes made by the subject *Independent Field* (FI) tends to be at the stage of process skills and writing answers. The causal factor is that the subject is not used to carrying out counting operations with large numbers, and is not optimal in checking the calculation results again. Errors at the answer writing stage occur due to errors in the previous process.

Based on the results of the discussion that have been presented, it is recommended for teachers can more often give practice questions in the form of math problems application form which varies. This aims to ensure that students have a cognitive style *field dependent* (FD) and *field independent* (FI) better trained and more systematic in solving math problems. Teacher also it is best to know the cognitive style of students, so that they can have the right strategy to improve students' ability to solve mathematical problems. Furthermore, students with the FD cognitive style can provide continuous practice questions accompanied by clear instructions and guidance from the teacher, while students with the FI cognitive style can one of them is given more challenging questions with larger numbers to deepen and develop his understanding.

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