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ANALYSIS OF STUDENT ERROR IN SOLVING NUMBER THEORY PROBLEMS IN VIEW OF COGNITIVE STYLE

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ABSTRACT

This research is a qualitative research using a descriptive approach. The purpose of this study was to describe the errors of mathematics students in working on number theory questions in terms of cognitive style. The subjects of this study were 3rd semester students of the Mathematics Study Program, Faculty of Science and Technology, Nahdlatul Ulama University, Purwokerto, with 3 students representing the Field Dependent (FD) group, 3 students entering the Field Intermediate (FDI) group, and 3 students representing the Field Independent (FI) group. Data related to student errors in working on number theory questions were obtained from diagnostic tests and interviews. While the cognitive style data obtained from the results of the Group Embedded Figure (GEFT) test. Subjects were taken by purposive sampling technique and data validation using triangulation method. The data analysis technique used data reduction, data presentation, and drawing conclusions. The results of this study for students in the FD category made a lot of procedural errors as much as 48.1%, for students in the FDI category many made conceptual errors as much as 33.3%, and students in the FI category made a lot of mistakes. technical errors as much as 25.9%. Furthermore, of the three categories of students according to cognitive style, the FD category made the most mistakes for all forms of conceptual, procedural, and technical errors. The most common form of error from all students studied was conceptual error as much as 44.4%. Many factors cause students to make mistakes in solving number theory questions, the most frequent mistakes are: 1) Students do not master and understand the concepts, theorems and definitions in number theory courses; 2) Students are not careful in calculations which causes the final result to be wrong; and 3) Students do not understand the problem in the problem so that it is difficult to solve.
Keywords: Cognitive Style, Conceptual, Procedural, Number Theory

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PRELIMINARY

In life mathematics has a very important role. This is what makes mathematics one of the basic subjects in almost all study programs. Learning mathematics basically involves understanding concepts and solving problems. According to Zevenbergen et al (2004) states that in solving problems it is necessary to have adequate understanding and knowledge, and have various strategies that can be chosen when facing different problems. Problem solving abilities in students' mathematics can be influenced by several factors.

These factors arise because each individual is different. One dimension of individual differences is cognitive style.

Researchers around the world are very interested in examining the relationship between cognitive style dimensions and mathematical ability (Chrysostomou et al, 2011). According to Suryanti (2014) cognitive style is how individuals receive, store, process and present information where the style will continue to be attached with a high level of consistency in the form of a person's style of thinking that involves cognitive abilities that will influence individual behavior and activities both directly and indirectly. Idris (2006) identify the 3 types of cognitive styles are *Field Intermediate* (FDI), *Field Dependent* (FD), and *Field Independent* (FI). Individuals with FD have a tendency to be able to work with external motivation, namely by seeking guidance and instructions from others. Meanwhile, individual FDI tends to have abilities like FD or FI students because FDI lies between the two. For individuals who view problems analytically, are able to analyze, detect patterns, relevant details, and critically evaluate a problem, they are included in the FI individual group (Yousefi, 2011).

The results stated that the mathematics learning outcomes of students with the FI cognitive style were better than students who studied with the FD cognitive style. This is also reinforced by the results of Wibowo's research (2017) that there is an influence of cognitive style on learning outcomes in mathematics, the learning outcomes of students with the FI cognitive style are higher than students with the FD cognitive style. The results of this study indicate that individuals with the FI cognitive style are better than individuals with the FD cognitive style. Based on this, it can be concluded that students' ability to work on math problems is influenced by cognitive style where they have the ability to solve problems and minimize errors in the process where FI students can solve problems better than FD students. Even so, it cannot be concluded that one style is better than the other because the characteristics of the two cognitive styles each have advantages and disadvantages. According to the characteristics of each cognitive style, it can be stated that there is a relationship between cognitive style and learning outcomes in mathematics. Therefore one of the objectives of this research is to find out and describe the differences in cognitive styles that influence solving math problems.

In the Mathematics Study Program there is an elective course that is taught, namely Number Theory. Number theory is the basis for further courses such as algebraic structures, real analysis, complex analysis etc. This course discusses and examines basic and important concepts in number theories. This course trains students in critically solving a problem in number theory. Students are required to do problem solving ranging from simple to quite complex problems by emphasizing on giving students relatively much time (Karim & Nurrahmah, 2018). Among the theories studied are proving strategies, binomial theorem, mathematical systems, divisibility, Euclide's algorithm, FPB and KPK, modulo congruence, Fermat and Wilson's theorem, and Wilson's theorem.

There are still students in working on math problems, especially number theory questions, who make mistakes in the steps involved. According to the Big Indonesian Dictionary, "The meaning of error means mistake or unintentional. So, mistakes made by someone in completing the task entrusted to him are called errors. Meanwhile, error analysis is an attempt with certain rules to observe, find, and classify errors (Astuty & Wijayanti, 2013). With the error analysis, it will be known what types of errors are made by students and the causes of students making these mistakes. It is hoped that with the results of this analysis the lecturer can provide a solution so that the same mistakes are not made by students in working on math problems.

According to Kastolan (1992) states that the types of student errors are as follows: conceptual errors, procedural errors, and technical errors. Where for each error there are indicators for each form of error which will be explained in table 1 below:

Table 1. Mathematical Error Indicator

No	Error Type	Indicator
1	Conceptual	a. Error answering a problem in determining the definition, formula or theorem b. Not in accordance with the use of formulas, theorems or definitions with the prerequisite conditions for the validity of these definitions, formulas or theorems c. Do not write down definitions, formulas or theorems to answer a problem.
2	Procedural	a. The steps in solving the problem do not match b. Error steps to answer a problem in manipulating answers.
3	Technical	a. Error in calculating the value of a count operation b. Errors in writing, namely missing constants and variables in completion or errors in one step to

No	Error Type	Indicator
		the next step in moving constants and variables.

Many studies have analyzed student errors in solving math problems including research according to Aulia & Kartika (2021), Indah & Dewi (2018) and Rini et al (2017). Based on previous research, the researcher considers it necessary to conduct research related to the analysis of student errors in working on math problems, especially in the Number Theory course which is an elective subject to explore concepts or theorems related to mathematical numbers, where it is not easy to solve the problems in this course.

Student mistakes made in solving math problems can be associated with the student's cognitive style. For each student has a different cognitive style, variation and learning speed. Cognitive style is related to the ability to process, store and use information to respond to various types of environmental situations. Therefore, if students' mistakes in solving mathematical problems and their cognitive style are known by educators, then educators can determine strategies in directing students in providing solutions related to student errors in working on mathematical problems in conceptual, procedural, and technical understanding.

Based on the explanation above, the researcher is interested in conducting research related to the mistakes of students in the mathematics study program, especially at Nahdlatul Ulama University Purwokerto according to the Kastolan stage in terms of cognitive style which consists of Field Dependent (FD), Field Intermediate (FM) and Field Independent (Field Independent) cognitive styles. FI) in Number Theory course. In addition, this study will also analyze the factors that cause students to make these mistakes, so that the lecturers can correct mistakes made by students through learning and whether differences in cognitive styles have an effect on solving math problems.

METHODS

This type of research is qualitative research using a descriptive approach. According to Arikunto (2010) descriptive research is research that is intended to investigate circumstances, conditions, situations, events, activities, etc., and the results are presented in the form of a research report. The purpose of this research is to describe the mistakes made by mathematics students in working on number theory problems from the point of view of cognitive style. The subjects in this study were 3rd semester students of the Mathematics Study Program, Faculty of Science and Technology, Nahdlatul Ulama

University, Purwokerto. The subjects in this study consisted of 10 students who were given the GEFT test in third semester students for the 2021/2022 academic year, consisting of 7 female students and 3 male students. The GEFT test was used to obtain data regarding students' cognitive styles, namely Field Dependent (FD), Field Intermediate (FM) and Field Independent (FI) cognitive styles. while for the interview stage one student will be taken in each cognitive style group. This research was conducted in October 2021 – February 2022.

Data related to student errors in solving questions were obtained from diagnostic tests and interviews, while the results of the Group Embedded Figure Test (GEFT) were used to obtain cognitive style. The selection of research subjects was based on cognitive style by taking subjects from the Field Dependent (FD), Field Intermediate (FDI), and Field Independent (FI) cognitive style groups. The subject or sample selection technique was carried out by means of purposive sampling. The instrument used in determining cognitive style groups is an instrument that is often used to measure a person's degree of field dependence called The Group Embedded Figure Test (GEFT). The GEFT instrument is a non-verbal test and the psychometric properties of the test have been tested across cultures. Bostic (1988) stated that the reliability coefficient of the GEFT test was 0.82 given to male and female students. The following is the GEFT score according to Idris (2006) seen in Table 2.

Table 2. GEFT Score Interpretation

Category	GEFT Score
Field Dependent (FD)	0 – 9
Field Intermediate (FDI)	10 – 13
Field Independent (FI)	14 – 18

For data validation in this study using the triangulation method. Data collection techniques in this study used diagnostic tests and interviews. Where the diagnostic test is in the form of a description test for number theory courses. The expected data is in the form of students' work on a diagnostic test in the form of a description test of 3 questions along with the steps for solving them. The purpose of the diagnostic test is to find out student errors in working on number theory problems. In order to be able to analyze the data, the error scoring rubric will be explained in table 3 below:

Table 3. Error Scoring Rubric

Score	Error		
	Conceptual	Procedural	Technical
0	No	No steps	No calculations

	theorems/concepts		
1	Theorem/concept exists but is wrong	The steps are there but wrong	The calculation is there but the result is wrong
2	Theorem/concept is correct but imprecise	The steps are correct but not quite right	The calculation is correct but the result is not correct
3	The theorem/concept used is correct	The steps are correct	The calculation is correct but not quite right

Furthermore, for the data obtained through the interview method using interview guidelines. The interview guidelines are unstructured because researchers do not use guidelines that have been completely and systematically arranged to collect data, but the guidelines used are only outlines of the problems to be asked (Sugiyono, 2016). The purpose of the interview is to get data on the factors that cause errors.

Data analysis techniques were carried out by data reduction, data presentation, conclusions and verification. In this study also the results of data analysis using a descriptive approach. Data reduction was carried out when taking subjects based on cognitive style and error data when working on number theory questions. Researchers gave GEFT tests and diagnostic tests. GEFT test to group students into three groups of learning styles. Furthermore, the results of the diagnostic test were then analyzed as data on errors made by students in each cognitive style group. Furthermore, the same error data will be taken in each cognitive style group, then interviews with reduced subjects will be carried out. If there is data that can provide information, then the data is used. Presentation of data is done with narrative text. Data from the samples were analyzed using words that describe student errors in terms of cognitive style in solving number theory questions. Conclusions were drawn after the researchers triangulated the method between diagnostic tests and interviews. From the results of the conclusions will be the results of the types of errors that are owned by students with Field Independent (FI) cognitive style, Field Intermediate (FDI) cognitive style and Field Dependent (FD) cognitive style.

RESULT AND DISCUSSION

The results of the research that has been carried out obtained some data including GEFT test data and data on student diagnostic test results related to errors in working on number theory questions based on three forms of error, namely conceptual errors, procedural errors, and technical errors. Initially, the GEFT test was given to students in the third semester of the 2021/2022 academic year, which consisted of 10 students consisting of 7 female students and 3 male students. The GEFT test is used to obtain data regarding cognitive style students have namely Field Dependent (FD), Field Intermediate (FM) and Field Independent (FI) cognitive styles. The GEFT test instrument used for the test is a standard instrument. The results of grouping student cognitive styles are presented in table 4 below:

Table 4. Results of Grouping Student Cognitive Style

Cognitive Style	GEFT Score	Number of Students
Field Independent (FI)	0 – 9	3
Field Intermediate (FDI)	10 – 13	4
Field Dependent (FD)	14 – 18	3

Based on table 4 above, it shows that as many as 10 students who took the GEFT test were divided into three parts, namely 3 students were included in the Field Independent (FI) category, 4 students were in the Field Intermediate (FDI) cognitive style, and 3 students were included in the Field Intermediate (FDI) category. Dependent (FD). Of the 10 students, 9 students were taken for each cognitive style category, 3 subjects were taken who would be given a diagnostic test to find out errors in working on essay questions in number theory courses. The diagnostic test used consists of 3 questions as follows:

1. Prove that $5^{2n} - 1$ is divisible by 3.
2. Show that $3^{15} \equiv 1 \ (mod\ 11)$, which is given $3^3 \equiv 5 \ (mod\ 11)$.
3. Determine x and y so that you get $314\,x + 159\,y = 1$.

The results of the analysis of the answers of 9 students in working on number theory questions in the form of essay questions with written answers obtained results in the form of the percentage of student errors in working on number theory questions in accordance with the error scoring rubric, the results were obtained for students who were in the Field Dependent (FD) category in Table 5 follows:

Table 5. Field Dependent (FD) Student Error Precentage

Error Type	Question Item	Field Dependent Student			Total		Error Precentage
		FD 1	FD 2	FD 3			
Conceptual	No. 1	1	1	3	5		
	No. 2	2	2	2	6	16	40.7%
	No. 3	3	1	1	5		
Procedural	No. 1	2	1	3	6		
	No. 2	1	2	1	4	14	48.1%
	No. 3	2	1	1	4		
Technical	No. 1	2	1	3	6	16	40.7%
	No. 2	2	2	2	6		

Error Type	Question Item	Field Dependent Student			Total	Error Precentage
		FD 1	FD 2	FD 3		
	No. 3	2	1	1	4	

Table 5 shows the score for each question on each Field Dependent (FD) subject where the final result is the percentage of errors for each form of error. For errors that are mostly made by students in the Field Dependent (FD) category, there are 48.1% procedural errors. As for concept and technical errors as much as 40.7%. This shows that students in the Field Dependent (FD) category still do not take the right and correct steps in solving number theory problems.

Furthermore, the results of student error analysis in the Field Intermediate (FDI) category are summarized in table 6 below:

Table 6. Intermediate Field Student (FDI) Error Percentage

Error Type	Question Item	Field Intermediate Student			Total		Error Percentage
		FDI 1	FDI 2	FDI 3			
Conceptual	No. 1	2	1	1	4		
	No. 2	2	2	3	7	18	33.3%
	No. 3	2	2	3	7		
Prosedural	No. 1	3	2	2	7		
	No. 2	2	2	2	6	20	25.9%
	No. 3	2	2	3	7		
Technical	No. 1	3	2	2	7		
	No. 2	2	3	2	7	20	25.9%
	No. 3	2	2	2	6		

Based on table 6, the results of the analysis for errors for each question and subject in the Field Intermediate (FDI) group obtained the most error data made in the form of conceptual errors as much as 33.3%. As for procedural and technical errors as much as 25.9%. This shows that students in the Field Intermediate (FDI) group still do not correctly use theorems/concepts in number theory questions.

For students who are in the Field Independent (FI) category, the results of the analysis related to errors in number theory questions are in table 7 below:

Table 7. Percentage of Student Field Independent (FI) Errors

Error Type	Question Item	Field Independent Student			Total		Error Percentage
		FI 1	FI 2	FI 3			
Conceptual	No. 1	3	1	2	6		
	No. 2	2	2	2	6	21	22.2%
	No. 3	3	3	3	9		

Procedural	No. 1	2	2	3	7		
	No. 2	2	2	2	6	22	18.5%
	No. 3	3	3	3	9		
Technical	No. 1	3	2	2	7		
	No. 2	2	2	2	6	20	25.9%
	No. 3	2	2	3	7		

Table 7 shows that students in the Field Independent (FI) category have many errors in the form of technical errors as much as 25.9%. For procedural and conceptual errors, the percentage of errors is 18.5% and 22.2%. This is because FI students make many calculation mistakes in the process of working on number theory problems. This agrees with Sahriah (2012) that students when studying material can understand concepts and procedures, but students often make mistakes in math problems caused by not being careful with calculations or computations.

Furthermore, to summarize the results of the analysis related to the percentage of errors made by all students based on cognitive style categories, the results are obtained in table 8 below:

Table 8. Student Errors Based on Cognitive Style

Error Type	Percentage of Student Errors Based on Cognitive Style		
	FI	FDI	FD
Conceptual	40.7%	33.3%	22.2%
Procedural	48.1%	25.9%	18.5%
Technical	40.7%	25.9%	25.9%

Based on table 8, it was found that the percentage of errors in the conceptual type of students in the FI category made the most mistakes by 40.7%, while students in the FDI category were 33.3% and students in the FD category were 22.2%. Furthermore, errors in procedural and technical types were also mostly made by FI category students as much as 48.1% and 40.7%, while for FDI students each type of error was 25.9% and students in the FD category presented procedural and technical type errors as much as 18.5% and 25.9%. So that it can be concluded for the category of students who make a lot of mistakes as a whole are students in the FI category.

The results of the analysis of the percentage of errors for each item and the percentage of errors in students in terms of cognitive style are summarized in table 9 below:

Table 9. Percentage of Errors for Each Question Item

Error	Question	Students According to Cognitive	Total	Percentage

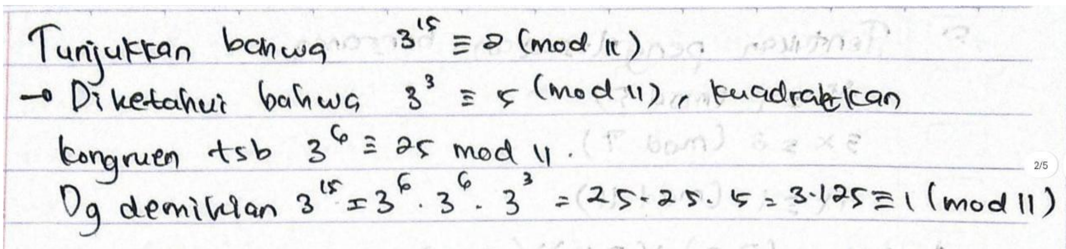
Type	Item	Style				
		FD	FDI	FI		
Conceptual	No. 1	5	4	6	15	44.4%
	No. 2	6	7	6	19	29.6%
	No. 3	5	7	9	21	22.2%
Procedural	No. 1	6	7	7	20	25.9%
	No. 2	4	6	6	16	40.7%
	No. 3	4	7	9	20	25.9%
Technical	No. 1	6	7	7	20	25.9%
	No. 2	6	7	6	19	29.6%
	No. 3	4	6	7	17	37.0%

From table 9 it can be seen that the percentage of errors made by students of the mathematics study program in solving 3 number theory questions experienced the most conceptual errors, namely 44.4%, the highest procedural errors, namely 40.7%, and the number of technical errors, namely 37.0%. So that it can be concluded that the highest student error in solving number theory questions is conceptual error, which is 44.4%.

The following are the results of written answers to the results of students working on math problems, especially number theory and the mistakes made in working on these problems:

1. Conceptual Error

According to Ardiawan (2015) conceptual understanding of mathematics is as a representation of creative mathematical ideas that are presented creatively to assist in solving mathematical problems. Having a conceptual understanding means that it is related to conceptual mistakes that students can make in working on problems where conceptual understanding is needed. Where according to Kiat (2005) errors that occur because students do not understand the concepts involved in the problem, meaning that students do not know what concepts are appropriate to be able to solve mathematical problems are called conceptual errors.



English Version

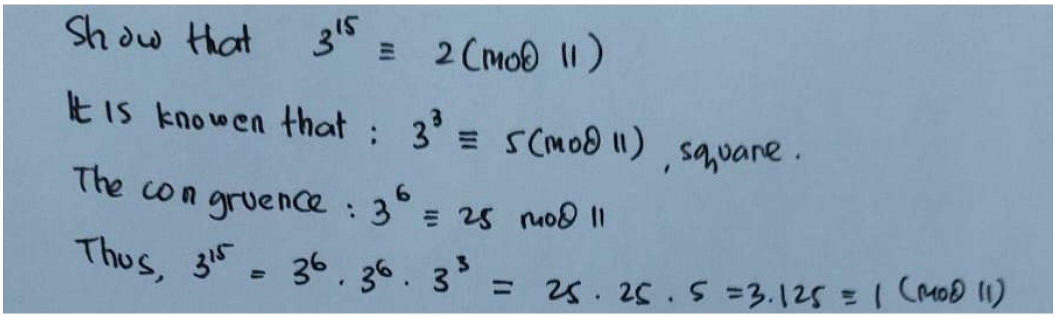


Figure 1. Conceptual Error

Figure 1 is the answer to question no. 2 which contained a conceptual error. A conceptual error made by students is using inappropriate concepts or theorems to answer a mathematical problem, they should use the congruence theorem, namely:

If $a \equiv b(mod\ m)$ than $a^n \equiv b^n(mod\ m)$ for n is a positive integer.

But the results obtained are correct. The exact calculation steps are as follows.

Prove that $3^{15} \equiv 1\ (mod\ 11)$, which is know as $3^3 \equiv 5\ (mod\ 11)$.

$3^3 \equiv 5\ (mod\ 11)$.

$(3^3)^2 \equiv 5^2(mod\ 11)$ --- squared

$3^6 \equiv 25(mod\ 11)$

$3^6 \equiv 3(mod\ 11)$

$(3^6)^2 \equiv 3^2(mod\ 11)$ --- squared

$3^{12} \equiv 9(mod\ 11)$

So obtained:

$3^{15} = 3^{12}.3^3 \equiv 9\,.5(mod\ 11)$

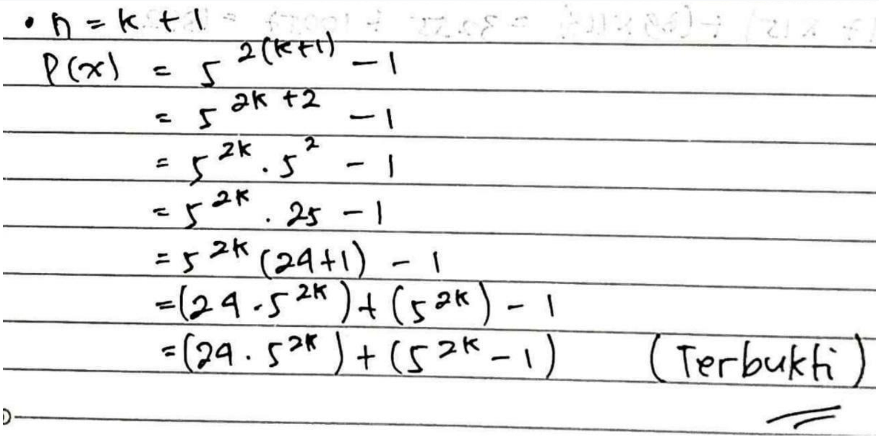
$3^{15} = 3^{12}.3^3 \equiv 45\ (mod\ 11)$

$3^{15} = 3^{12}.3^3 \equiv 1\ (mod\ 11)$

So it's prove that $3^{15} \equiv 1\ (mod\ 11)$

2. Procedural Error

In solving mathematical problems, procedural errors are often made by students in solving problems. According to Kiat (2005) procedural errors are errors that occur due to the inability of students to manipulate or algorithms when solving math problems, even though they have understood the concept behind the given problem. The following is a snippet of student answers that experience procedural errors in Figure 2.



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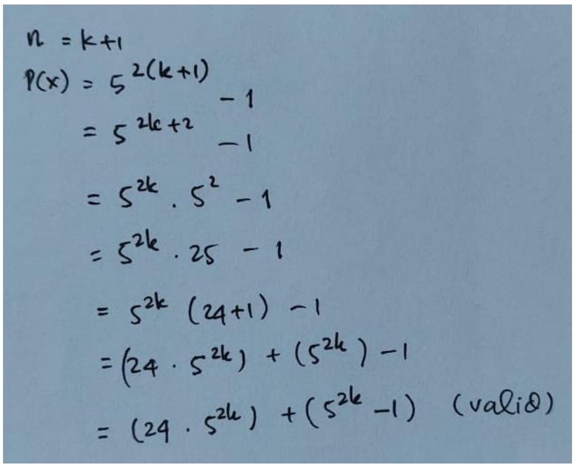


Figure 2. Procedural Error

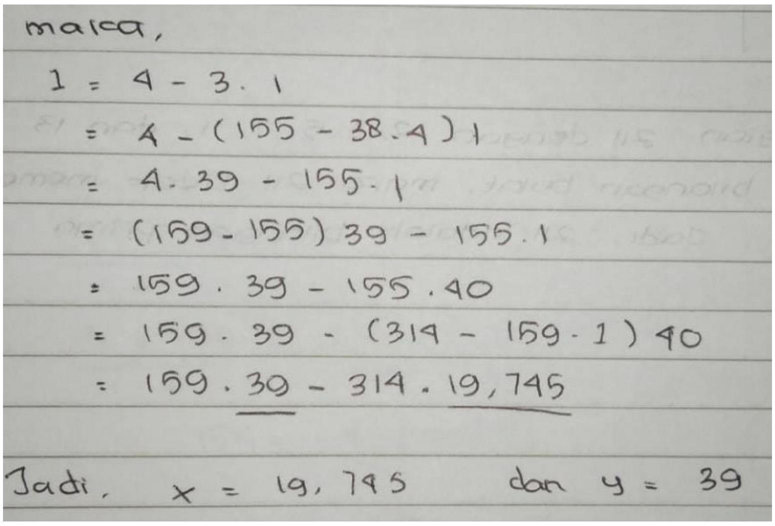
Based on Figure 2 which is the answer to question no. 1 shows that students know the concepts or theorems used, but students cannot continue solving problem no. 1 which should be followed by:

because $(5^{2k} - 1)$ is assumed to be divisible by 3 *) and 24 is a number divisible by 3 then $(24 \,.\, 5^{2k})$ is also divisible by 3 **).

From *) and **) it is evident that $(24 \,.\, 5^{2k}) + (5^{2k} - 1)$ is completely divisible by 3.

3. Technical Error

In solving mathematical problems besides conceptual and procedural errors there are also technical errors. Technical errors are errors made due to carelessness or occur due to lack of knowledge of mathematical content in other topics (Kiat, 2005). According to Jana (2018) technical errors occur due to errors in mathematical operations, so that if you encounter a related problem, a continuous error occurs. The following is a snippet of a student's answer who made a technical error in Figure 3.



English Version

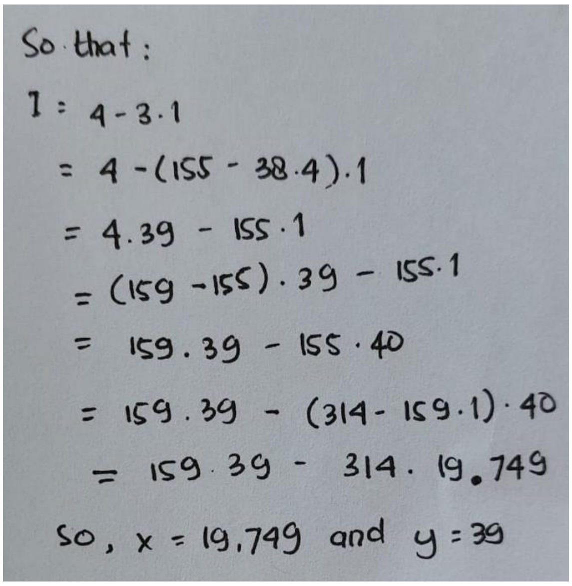


Figure 3. Technical Error

Figure 3 shows a fragment of the answer to question no. 3 from one of the students who made a technical error, where in fact the student was right in determining the theorem or concept used so that the steps in the process were correct, but in the final result there was a calculation error. So the final result should be as follows:

$1 = 159.39 - (314 - 159.1)\,40$

$1 = 159.39 - 314.40 + 159.40$

$1 = 159.79 - 314.40$

So that the value is obtained $x = -40$ and $y = 79$.

The results of interviews with students show conclusions regarding the factors that lead to errors in solving number theory questions that students do are as follows:

1. Students do not master and understand concepts, theorems and definitions in number theory courses so that students cannot solve problems in number theory questions.
2. Students are not careful in calculations which causes the final result to be wrong.
3. Students do not understand the problems in the questions so they have difficulty solving problems in number theory questions.
4. Students are not used to working on types of questions that are outside the sample questions given by the lecturer, so they find it difficult to solve these questions.
5. Students are less active in the lecture process to ask questions or material that they do not understand.
6. Lack of practice in working on number theory questions so that students make mistakes in conceptual, procedural and calculation forms.

Furthermore, related to student errors in working on number theory questions in terms of cognitive style, it can be seen that the mistakes made by students for each category of cognitive style have different types of errors. Based on the results of the analysis above, the results show that students who fall into the Field Dependent (FD) category make many procedural errors. Furthermore, students in the Field Intermediate (FDI) category made many conceptual errors, while students in the Field Independent (FI) category made many technical or calculation errors. The results of this study are in line with (Restu, 2017; Yunis et al, 2018) which obtained the result that the mistakes made by students in the cognitive style category each had a different type of error for the Field Dependent (FD), Field Intermediate (FDI), Field Dependent (FD) categories. and Field Independents (FI).

Based on table 8 it shows that of the three categories of students based on cognitive style the most mistakes made when solving 3 number theory questions were students in the Field Independent (FI) category. Meanwhile, based on table 9, the most common mistakes made by all 9 students in solving number theory questions were conceptual errors of 44.4%.

CONCLUSION

Based on the results of the analysis and discussion of this study, it was concluded that the errors that were mostly made in each category of cognitive style were different, namely: students in the Field Dependent (FD) category made many procedural errors as much as 48.1%, for students in the Field Intermediate (FDI) category) made many conceptual errors as much as 33.3%, and students in the Field Independent (FI) category made many technical errors as much as 25.9%. Furthermore, from the three categories of students according to cognitive style, the Field Dependent (FD) category made the most mistakes for all forms of conceptual, procedural, and technical errors. For the form of errors that were most often made of all the students studied, conceptual errors were 44.4%.

There are several factors that cause students to make mistakes in solving math problems, especially in Number Theory courses, the most common mistakes are: 1) Students do not master and understand concepts, theorems and definitions in number theory courses so students cannot solve problems in number theory problems; 2) The students' inaccuracy in the calculations causes the final results to be wrong; and 3) Students do not understand the problems in the questions so that they have difficulty solving problems in number theory questions.

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