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# Error analysis in solving inferential statistics problems for psychology students

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**Abstract.** Inferential Statistic is a topic in Advanced Statistics lectures which aims to perform various statistical techniques. For psychology students, understanding statistics is not easy, marked by none students who answer correctly all the questions. This research was a descriptive qualitative research with the subject 40 psychology students who took Advanced Statistics in C class. This study aimed to describe forms of errors made by students in solving inferential statistics problems based on Newman analysis stages. The results showed that there were 4 stages of student errors in inferential statistics. 1) Errors in comprehension occurred because students could not read statistics tables or read outputs in the questions. 2) Transformation errors occurred because students were not appropriate in applying/selecting the type of test statistics used or writing hypotheses. 3) Process skill errors occurred because students were less careful in calculating and inability to interpret and interpret the results of calculations. 4) Errors in the encoding stage occurred because students did not answer correctly or inappropriately in drawing conclusions in hypothesis testing. The most common mistakes were errors in process skills especially students couldn't interpret results. This error supported the results of previous studies which concluded that interpreting quantities in statistics was a common problem when students learn statistics.

**Keywords:** Error analysis, Inferential Statistics, Solving Problems, Newman's Error Analysis, Psychology Students



## 1. Introduction

Statistics is one of the sciences used in various fields. Statistics is very synonymous with data. In the academic field, a researcher will always be faced with data. Therefore every researcher in all fields will definitely study statistics as a basis for analyzing data.

In general statistics are used for the following two things. Statistics is used (i) to describe succinctly the terms of the shape, central tendency, and dispersion of their simple frequency distribution, and (ii) to make decisions about the properties of the statistical population on the sample statistics (Chow, 2002) The first function is known as descriptive statistics, while the second function is known as inferential statistics.

Descriptive statistics involves tabulating, depicting, and describing sets of data. These sets may be either quantitative, such as measures of height or test scores (characteristics that are continuous—differences are in degree, not kind), or the data may represent qualitative or categorical characteristics, such as sex, college major, or personality type. Large quantities of data generally must be organized and summarized before they are comprehensible. Descriptive statistics serves as a tool for describing and summarizing, and reducing to manageable form the properties of an otherwise unwieldy mass of data (Glass & Hopkins, 1996).

Inferential statistics is a formalized body of methods for solving another class of problems. This general class of problems involves attempts to infer the properties of an entire set of data from inspection of only a small sample. Thus the purpose of inferential statistics is to find out information for a population from the characteristics of a sample of the population. The descriptive characteristics of a sample can be generalized to the entire population, with a known margin of error, using the techniques of inferential statistics. Thus the purpose of inferential statistics is to find out information for a population from the characteristics of a sample of the population. The descriptive characteristics of a sample can be generalized to the entire population, with a known margin of error, using the techniques of inferential statistics (Glass & Hopkins, 1996).

At the college level, Statistics course is usually divided into three area; descriptive statistics, probability theory, and inferential statistics. Typical content of an inferential statistics is estimating parameters and testing hypothesis (Garfield and Andrew, 1988).

Researchers including researchers in the field of psychology will definitely need these two types of statistics. In the psychology study program, these two types of statistics are specifically discussed in the Statistics and Advanced Statistics course. Statistics course discusses descriptive statistics while Statistics continues to discuss Inferential Statistics.

Although statistics are very important and needed by academics, not all psychology students like mathematics including statistics. This is felt by most psychology students when they will begin Statistics courses in the previous semester. From the results of the questionnaire, 25 of the 40 students had negative perceptions of statistics. Students consider material statistics that are difficult, frightening, complicated because of the many calculations and formulas that cause anxiety and worry.

This perception results in less maximum student learning outcomes. The average score of final exam for Advanced Statistics Course is 65.4 in the range of 0-100.

The average score of final exam indicates that students have difficulties in understanding the material of Advanced Statistics. Student difficulties can be explained by mistakes when they solve some problems. The types of errors in Advanced Statistics are predictors for improving subsequent learning and are used as a basis for improving concepts. Therefore it is important to make a diagnosis to find out the types of student errors in Advanced Statistics.

One of the procedure to diagnose students' error when they solve mathematics problems is NEA (Newman's Error Analysis). Newman's analysis method has five stages to determine errors that students might make in solving story problems. The stages are (1) reading, (2) comprehension, (3) transformation, (4) (process skill, and (5) encoding (Newman, 1997).

Indicators of errors based on the Newman error analysis procedure are:

### 1. Reading

- a. Cannot read the words in the question

- b. Cannot interpret words that are considered difficult
2. Comprehension
    - a. Do not write down what is known
    - b. Don't write down what was asked
    - c. Cannot understand the sentence on the question that was asked
    - d. Write symbols without explanation
    - e. Write things in brief but not clear
    - f. Write down what was asked but not according to the question asked
  3. Transformation
    - a. Cannot change information on the problem into a mathematical sentence and cannot
    - b. explain the change process
    - c. It is not appropriate to change information on questions into mathematical sentences
    - d. It is not appropriate to choose the formula or theory used
  4. Process skills
    - a. Error in computing
    - b. It doesn't exactly explain the computational process
    - c. It is not appropriate to proceed with the settlement procedure
  5. Encoding
    - a. Do not write answers
    - b. Write incorrect answers
    - c. Write answers that are not in accordance with the context of the problem
    - d. Does not include appropriate units

In addition, many references address issues from the inaccuracy of the use of statistical tests or from misinterpretation of the results of educational research up to now. The error is related to the hypothesis testing process. Errors in hypothesis testing are caused by misconceptions in understanding statistical tests. Study was conducted by Vallecillos (1999) found errors and learning problems that are influenced by several concepts, aspects, and their application in hypothesis testing. Errors arise due to errors at the previous level related to population and sample, the size of the data dissemination, and the sampling process that influences understanding in hypothesis testing.

Sotos (2007) in students' misconceptions of statistical inference suggests that based on the empirical evidence of many misconceptions that occur in understanding inferential statistics, namely the use of mixed methods of hypothesis testing, confusion in formulating hypotheses, confusion of rejection conditions by looking at the p-value and significance level, interpreting -value, evaluating the meaning of rejection or acceptance. Misconceptions also arise in applying and distinguishing various kinds of statistical areas (correlation analysis, analysis of variance, etc.). Considering at these empirical and theoretical conditions, researcher is interested in examining the forms of errors made by students in solving inferential statistics problems.

## 2. Research Question

What were the forms of errors made by psychology students in solving inferential statistics problems based on Newman analysis stages?

## 3. Research Method

This was descriptive qualitative research which described the forms of errors made by psychology students in solving inferential statistics problems based on Newman analysis stages.

Data collection was gathered from the final test, consisted of 5 problems about inferential statistics. The analysis data was done qualitatively by the qualitative model of Miles and Huberman which included three stages: 1) data reduction, 2) data presentation, and 3) drawing conclusions. Data reduction was done by selecting, focusing, simplifying, abstracting, and transforming the data that appear in written test. Data presentation was a step beyond data reduction to provide an organized, compressed assembly of information that permits conclusion drawing. A display could be an extended piece of text or a

diagram, chart, or matrix that provides a new way of arranging and thinking about the more textually embedded data. Data presentation, whether in word or diagrammatic form, allowed the analyst to extrapolate from the data enough to begin to discern systematic patterns and interrelationships.

#### 4. Finding and Discussion

This section provides the presentation and examples of error that were detected from the result of final test.

##### 4.1. Reading

No one reading error can be found from the result of final test. I assume that at the college stage, every student can read the problem.

##### 4.2. Comprehension Error

A comprehension error occurred when the subject failed to understand its requirement. An example of this form of error is shown below.

Question:

*Q3a. Write the estimation of regression model based on output table and give the interpretation.*

*Q3b. What is the conclusion of hypothesis test of regression model based on output table?*

A student's answer:

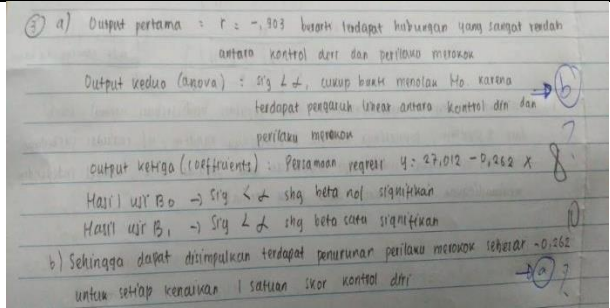
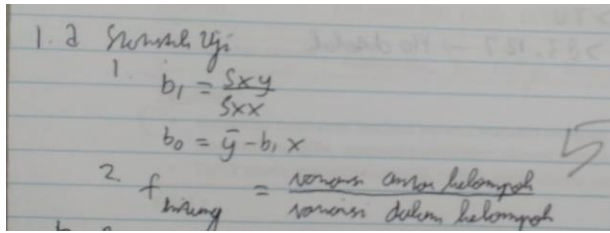
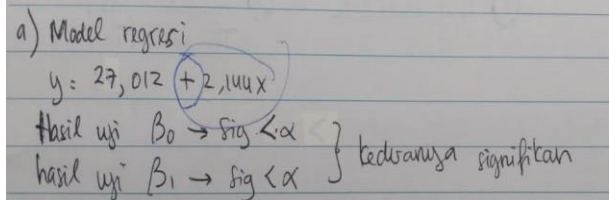
A3a.  $y = 27,012x - 0,262$

Terdapat pengaruh yang signifikan. (There is a significant influence)

A3b. *Terdapat peningkatan merokok (y) sebesar 27,012 untuk setiap kenaikan 1 skor kontrol diri (x).* (There is an increase of smoking by 27,012 for each increase in 1 score of self-control.

The answer above (A3a and A3b), showed that a student failed to understand the requirement on the problem. It made a student write the answer to question 3a to answer question 3b, and the conversely. The result of the form of comprehension error is shown in table below.

**Table 1.** The Forms and Number of Comprehension Error

Error	Subject	Frequency	Example student's answer
Understanding the output of analysis data from the problem	S3, S17	2	
Understanding the sentence on the question that was asked	S10, S15, S16, S20, S24, S27, S28, S29, S31, S33, S34, S35, S36	13	
Writing down what is known	S12	1	

4.3. Transformation Error

A transformation error occurred when the subject failed to identify the proper formula or testing analysis to successfully pursue the course of problem-solution. The error forms of this stage were error in: choosing the appropriate analysis technique, changing the problem into statistics hypothesis or writing the regression model, and writing the formula.

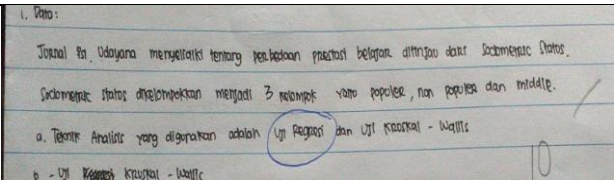
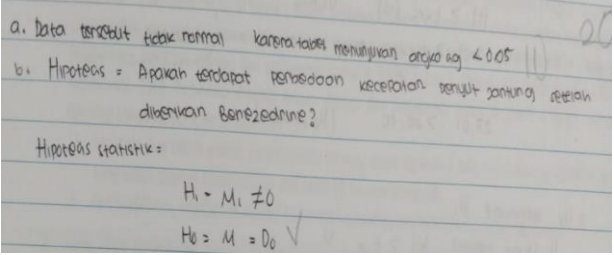
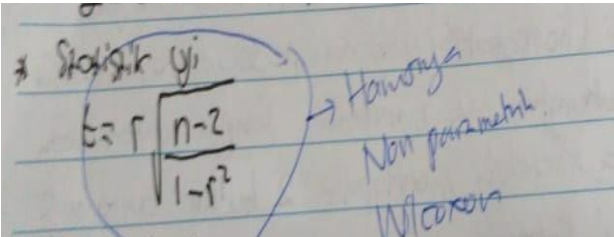
Looked at the example below.

1. Dalam jurnal psikologi Udayana (2016), terdapat penelitian yang menyelidiki perbedaan prestasi belajar ditinjau dari *Sociometric Status* di SMPN 1 Bangli. *Sociometric Status* sampel siswa dikelompokkan menjadi 3, yaitu populer, non-populer, dan *middle*. Dari hasil analisis data diperoleh bahwa terdapat perbedaan prestasi belajar yang signifikan ditinjau dari *sociometric status* di SMPN 1 Bangli. (Butuh, A.A.G.R.N & I.G.A.P.W. Budisetyani. 2016. *Perbedaan Prestasi Belajar ditinjau dari Sociometric Status di SMPN 1 Bangli. Jurnal Psikologi Udayana*, Vol 3. No.2, 301-309).
  - a. Sebutkan dua teknik analisis data/Statistika uji yang dapat digunakan saat melakukan uji hipotesis dari yang sudah dibahas untuk kasus di atas selain uji **Asumsi/prasyarat**.

A1a. Kruskal-Wallis Testing and Regression Testing (S1)

The example showed that a student failed to choose appropriate analysis technique. That error was the most type error of transformation stage as shown in table below.

**Table 2.** The Forms and Number of Transformation Error

Error	Subject	Frequency	Example student's answer
Choosing the appropriate analysis technique	S1, S2, S4, S6, S10, S11 (2x), S15, S18, S19, S24 (2x), S25, S28, S30, S31, S32, S33 (2x), S34 (2x), S40.	24	
Changing the problem into statistic hypothesis or writing the regression model	S3, S14, S21, S25, S27, S30, S34, S35, S36 (2x), S38, S39(2x), S40	14	
Writing the formula (test statistics)	S15, S17, S19, S34	4	

4.4. Process Skill Error

A process skill error happened when student failed in reading the statistics table, interpreting the quantity, computing, and doing the solving procedure. The most error was caused by error in interpreting the quantity.

For example:

Based on output,  $r = -0,91$ . What is the meaning that number?

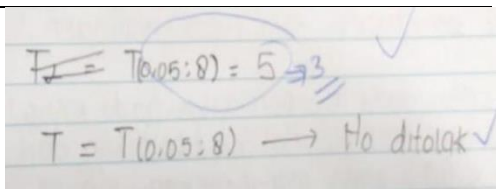
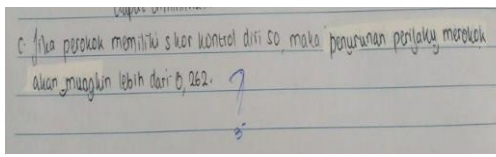
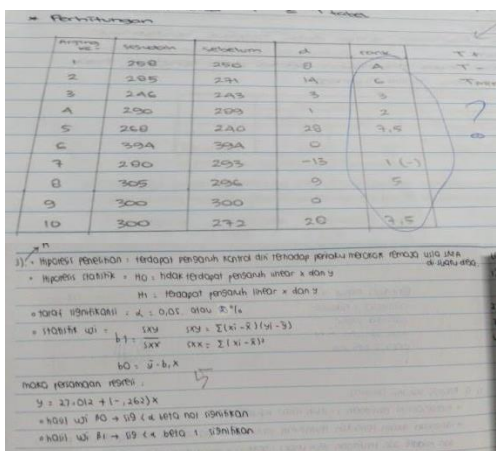
S33 Answer:

$r = -0,91$  menyatakan hubungan yang sangat lemah antara kedua variabel, karena nilainya negatif. ( $r = -0,09$  showed that that there is a very weak correspondent between two variables).

The correct answer is “there is the strong correlation between two variables, but in opposite direction”.

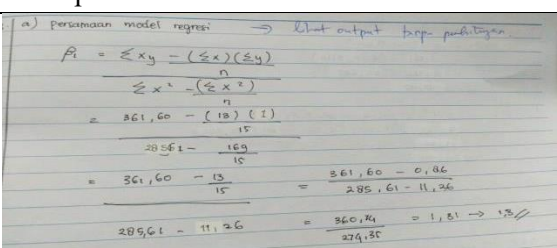
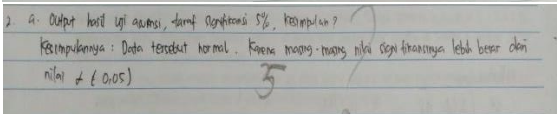
The result of type process skill was shown below.

**Table 3.** The Forms and Number of Process Skill Error

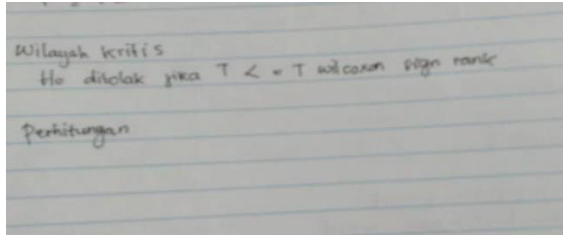
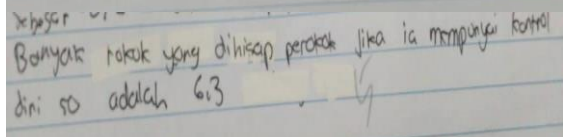
Error	Subject	Frequency	Example student's answer
Reading the statistics table	S7, S8, S17, S19, S20, S21, S22, S23, S26, S27, S28, S34, S35, S39, S40	15	
Interpreting the quantity (explaining the result)	S1, S2, S3 (2x), S4, S5 (2x), S9, S10, S11 (3x), S13, S15, S16, S17, S18 (2x), S19, S22, S25 (2x), S26, S27, S28, S29 (2x), S31, S32, S33, S34(2x), S35, S38, S39 (2x), S40	37	
Computing	S2, S3, S4, S5, S9, S12 (2x), S14, S15 (2x), S16, S17, S23, S25, S27, S29, S30, S32, S34, S35, S36, S37, S38, S39, S40	25	
Doing the solving procedure (Testing hypothesis procedure)	S11, S17 (2x), S18, S21, S24 (2x), S27, S28 (4x), S29 (3x), S33(3x), S38, S39(2x)	21	

4.5. Encoding Error

**Table 4.** The Forms and Number of Process Skill Error

Error	Subject	Frequency	Example student's answer
Writing incorrect answer (quantity)	S4, S5, S6, S10, S28, S30, S31, S32 (2x), S33 (2x), S34, S35, S36, S39, S40	16	
Conducting an conclusion	S1, S2, S5, S9, S11, S12, S19, S25, S27, S28, S34 (2x), S36, S38, S40	15	



Do not write answer	S36 (3x)	3	
Answering the question not in context	S33, S34	2	

Based on table above, the encoding error occurred when the student writing incorrect answer, conducting a conclusion, do not write the answer, and answering the question but not in context. The most error is writing incorrect answer.

For example, student write the regression model  $y = -0,91x$  or  $y = -2,62 + 27,012x$

But, the correct answer is  $y = 27,012 - 2,62x$

Table 5. provides a summary of the finding. It was determined that the errors from comprehension stage amount to 8,33%; transformation stages total to 21,88%; process skill 51,05%, encoding total to 18,75%, of the total of error.

**Table 5.** Errors committed by Psychology Students in Solving Inferential Statistics Problem

Forms of Error	Number of Error	Percent
Reading	0	0
Comprehension	16	8,33
Transformation	42	21,88
Process Skill	98	51,04
Encoding	36	18,75
<b>Total</b>	192	100

The greatest number of error occurred in process skill. Based on table 3. It's happen because students failed to interpret the quantity from the result. This result supported the research that conducted by Garfield & Ahlgren (1998), Vallecillos (1999), and Sotos (2007).

## 5. Conclusion

Based on the results of research that had been done, the researcher obtained conclusion that there were 4 stages of student errors in inferential statistics.

- 1) Errors in comprehension occurred because students failed in understanding the output, the sentences on the question, and writing down what was known (8,33%)
- 2) Transformation errors occurred because students were not appropriate in selecting the type of test statistics, writing hypotheses, or writing the formula (21,88%).
- 3) Process skill errors occurred because students were less careful in computing, inability to interpret the results, or fail to solve problem using coherent procedure (51,04%).
- 4) Errors in the encoding stage occurred because students did not answer correctly, did not writing the answer, answered the question not in context or drew conclusions inappropriately on hypothesis testing (18,75%).

The most common mistakes were errors in process skills especially students couldn't interpret results.

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