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Analysis of Student Error in Statistical Subject: A Case Study for Online Learning

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Abstract

Statistics is a core subject for most courses at the university level. Most students apply statistics in producing final-year projects. During the period of online learning, it was found that student's performance in this subject has decreased. Therefore, this study was conducted to descriptively examine the errors committed by students in the subject of statistics. A total of 54 students in the semester of October - February 2021 who took statistic subjects were involved in this study. Data were obtained from the online final assessment. This study focused on the topic of hypothesis based on the mean of the lowest scores obtained. Each student's answer sheet was checked and reviewed for their mistakes using the Newman method. The results of the study discovered that majority of the students could not understand the requirements of the questions related to the hypothesis test. This led them to make other mistakes including transformation and process skills. Lecturers need to focus on these errors and use teaching and learning methods more effectively. Indirectly, mastery in the field of statistics can be improved to a more excellent level.

Keywords: Statistics, Hypothesis, Newman Method, Online Learning, Descriptive.

Introduction

Statistics is a process involving the collection of data to be compiled, analysed, interpreted and inferred based on the final findings. Statistical learning has been introduced since the primary school level (Norabiatul et al., 2019). Further, statistical learning is also studied at the secondary school level and continued up to the university level (Chan & Zaleha, 2012). Statistics are not only important for learning at various levels of educational institutions but are also important to be applied in one's daily life. It is also very necessary in a study or research.

At the university level, among the statistical topics with high error rates by students is related to the topic of hypothesis (Kurnia et al., 2019). Various mistakes are made by students while answering questions related to this topic. One of them is the difficulty in understanding the intent of the questions. This is why the statistical tests used are inaccurate. There are also errors in terms of the way it works and the use of incorrect formulas. Some students do not state their conclusions at the end of their work. This is a contributing factor to the decrease in performance in the statistical subject.

Based on the final result score, it was found that the score for the hypothesis topic was unsatisfactory. This matter needs to be taken seriously as there are still students who make the same mistakes. These mistakes need to be overcome so that the same mistakes can be minimised. So, this study identifies and discusses the types of errors committed by students using the Newman method. There are five types of errors introduced by Newman in this method (White, 2009). This identification is important to find the cause of errors that are often made, which allows it to be used as a benchmark to find a solution to this problem.

Kurnia et al (2019) also applied the Newman method in their study. In the study, it was found that all the elements in the Newman method have errors from students except the first element, which was that students have no errors while reading the question. Among the recommendations presented was to improve students' cognitive skills related to the statistical topic in question. According to Fitni et al (2020), student errors analysed using the Newman method demonstrated that students learning strategies can influence the type of errors committed. Fitni et al. (2020) suggested that other researchers need to identify the learning methods used by the lecturers and the learning strategies used by the students so that it is easier to overcome the learning problems of the students.

In addition, Siti (2009) used the Newman method and found that students made significant errors for the topic of expressions and quadratic equations as the scores for students' diagnostic tests for those topics were at a relatively moderate performance rate. Although the analysis of these studies only focused on the topic stated, the objective for each researcher was similar, which is to find errors often made by students using the Newman method. Then, the researchers would find solutions to overcome this problem to minimise errors so that the same errors do not repeat.

Another study that used the Newman method was Raras (2018) who said that students make errors for all the errors introduced in the Newman method. The topic of errors analysed was similar to the study conducted by Kurnia (2019), which was related to the topic in the subject of statistics. The findings of a study by Raras (2018) found that most students did not review their solutions and the answers were given. This caused various mistakes to be made by the students, which were said to be slightly careless while answering questions.

Next, a study conducted by Suryanti, Candra & Kristiani (2020) analysed students' mistakes in solving questions at a high level. The study also used the same method used by Kurnia (2019); Raras (2018); Siti (2009); Fitni et al (2020); Suryanti et al. (2020) concluded that for the first error; reading errors were caused by students who failed to comprehend the problem statement given in the question. For the second error; the misunderstanding of the question was due to the factor that the students misunderstood the requirements of the intended question. The third mistake was the transformation error, which was due to the inability to produce an appropriate method for solving the question. Next, for the fourth error; process skills errors due to the inability to link work paths correctly. The last error, which was the error in writing the answer, was due to an error in the final answer.
Wilda (2018) also analysed similar errors to the study conducted by Suryanti et al. (2020) focusing on high-level questions. The same method was also used, which is the Newman method. The findings of the study found that comprehension errors were the highest errors compared to other errors. The causal factor was due to students' low ability and reasoning

skills in solving problems in the real context. However, the study only focused on mathematics subjects. In another study, the Newman method was used by comparing student performance between male and female students. The study found that female students have better performance in solving statistical questions compared to male students where there were still errors in problem-solving (Marwah, Ratna, & Wahyu, 2020).

Other studies that analysed student errors include that by Maisurah et al (2015) who stated that most students are still weak in mastering the basic facts and concepts of mathematics. Weaknesses in understanding basic concepts cause them to use incorrect strategies when solving math questions. This is a type of transformation error with using the wrong method when solving a problem. A study by Siti et al (2017) found that students who got low grades in Mathematics at the SPM level usually make mistakes such as mistakes on negative and positive signs, mistakes on the methods used, carelessness and complicated answers. All of these types of errors can also be categorised into the Newman method. Studies by the same researchers on groups of students taking different subjects presented that most of the students could not use the correct method and also unable to simplify the answers to the questions given. Moreover, the study of Hanapiah & Luvy (2020) concluded that student's ability in solving statistical questions is still at a low level and many students make mistakes in answering questions especially those involving calculations.

This study also analyses student errors using the Newman method to identify the errors often made in a statistical subject and then hopefully aid the lecturers to overcome the problems addressed by taking appropriate measures.

Methodology

This study was conducted on semester 5 students who took the Statistics course during the implementation of online learning. Data were obtained from final assessment papers for 54 students. The questions studied contained all topics namely Probability, Estimation, Hypothesis, ANOVA and Correlation. Student scores were analysed in advance according to the topics involved descriptively.

The study continued by selecting questions that covered the topic of hypothesis. The questions were as follow; Questions 3a (ii), 3b and 3c.

Question 3a

In a factory producing bottles of shampoo, when a process operating correctly, the average content weight of shampoo would be 20 ounces with a population standard deviation of 0.7 ounces. A random sample of 12 bottles from a single production run yielded the following content weights (in ounces):

21.4 , 19.7 , 19.7 , 20.6 , 20.8 , 20.1 , 19.7 , 20.3 , 20.9 , 19.8 , 20.5 , 19.9

Assume the population distribution to be normal

ii) Using a 5% significance level, can we conclude that the process is operating correctly based on this sample?

Question 3b, c

In a packing plant, a machine packs cartons with jars. Supposedly, a new machine will pack faster on average than the machine currently used. To test that hypothesis, the times taken for each machine to pack ten cartons are recorded. The results, in seconds, are shown in the tables.

New Machine	42.1	41.3	42.4	43.2	41.8	41	41.8	42.8	42.3	42.7
Old Machine	42.7	43.8	42.5	43.1	44	43.6	43.3	43.5	41.7	44.1

The Minitab output is shown below.

Test and CI for Two Variances: New machine, Old machine

Statistics

Sample	N	StDev	Variance
New machine	10	0.683	0.467
Old machine	10	0.750	0.562

Ratio of standard deviations = 0.911409

Tests

Method	DF1	DF2	Test Statistic	P-Value
F	9	9	0.83	0.787

Assume that data are collected from normal populations.

b) At a 5% level of significance, is it reasonable to assume that the two machines have equal population variances?

c) From your conclusion in (b), test at a 5% significance level whether or not the new machine packs faster on average. Show all necessary steps in conducting this hypothesis testing.

The student's answers were reviewed thoroughly and analysed based on the Newman method. Table 1 below shows the five levels of error using the Newman method along with a description of each level corresponding to the statistical questions studied.

Table 1.
Description for Newman Method

Number	Error	Description
1	Reading	• misunderstood the meaning of the question • did not answer the questions
2	Comprehension	• did not understand the requirements of the question, then use inaccurate statistical tests. • incorrectly selecting and using data • incorrectly or not writing the hypotheses studied
3	Transformation	• using incorrect formulas
4	Process skill	• the formula used is accurate but does not complete the test process correctly • errors in calculations • using incorrect statistical tables or misread values in statistical tables • wrong in determining the criteria for acceptance or rejection of a hypothesis
5	Encoding	• did not write conclusions

Analysis and Discussion

The bar chart in Figure 1 shows the mean scores for the topics tested in the students' final exam. The topic of ANOVA achieved the highest average score of 18 points, followed by the topics of Correlation (14.8), Estimation (13.3), and Probability (11.4). Meanwhile, the topic of the Hypothesis Test has the lowest mark of only 6.2.

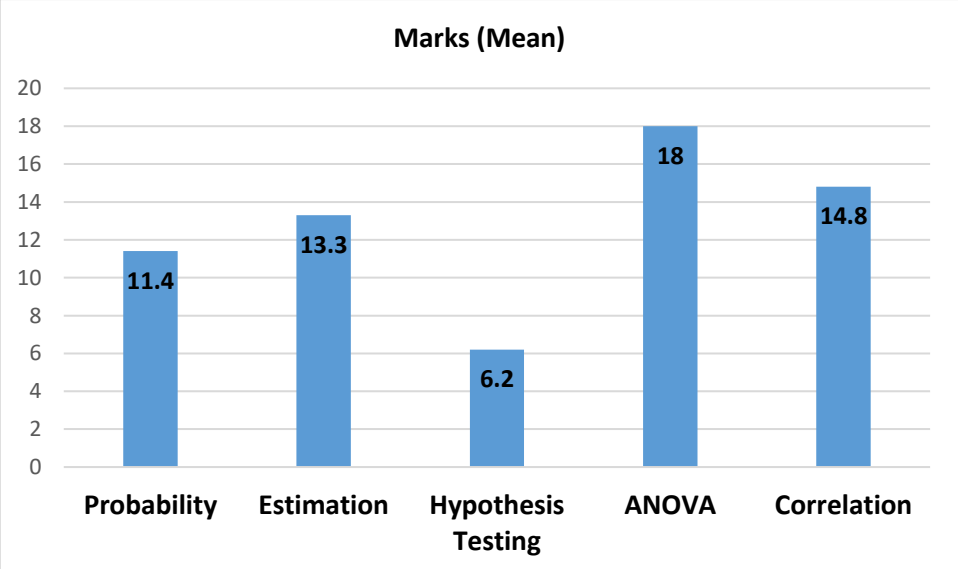


Figure 1. Mean Score Cross Chart for Topics.

From the result, it can be concluded that the most common mistakes made by students are in the topic of Hypothesis Testing. This study therefore continued by reviewing the students' answers to the hypothesis test questions. A total of 135 mistakes were made (85%). Only 15% of the respondents managed to give the right answer. Table 2 shows the results of students' errors using Newman's method as well as the number of correct answers:

Table 2.
Student Total Errors and Correct Answers

Errors/Questions	3a(ii)	3b	3c	Total (%)
1. Reading	5	2	4	11 (8%)
2. Comprehension	29	21	40	90(67%)
3. Transformation	9	3	8	20 (15%)
4. Process skill	4	8	0	12 (9%)
5. Encoding	0	2	0	2 (1%)
The answer is correct	4	20	0	24(15%)

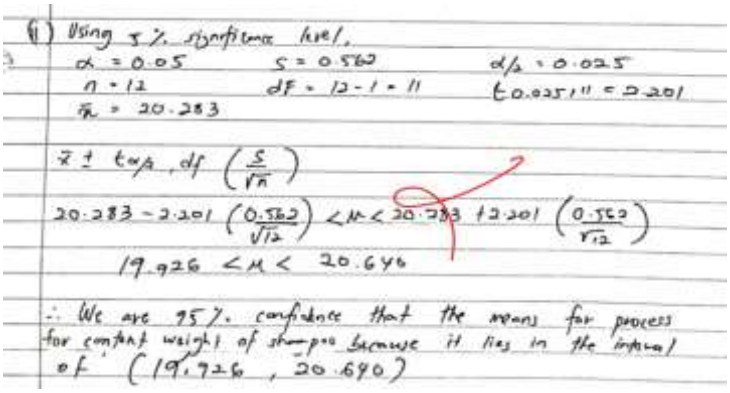
Based on the data in Table 2, it is possible to conclude that the majority of students, or 90 (67%), made errors in understanding the problem. The percentages of process and reading skills transformation errors were relatively low, and they were considered to be less significant. Only 2 (1%) mistakes were made by the students when writing the final answers. So, to better understand the types of errors mentioned in Table 2, the following examples and descriptions were provided:

1. Reading

Overall, there were small numbers of students who made misreading error. Most likely, these students did not answer the question as they were unable to correctly read and interpret the question's meaning. This could be due to a misunderstanding of the symbols used, or it could be due to a tiny change in the format of the question compared to the norm, such as when high-level questions are given online.

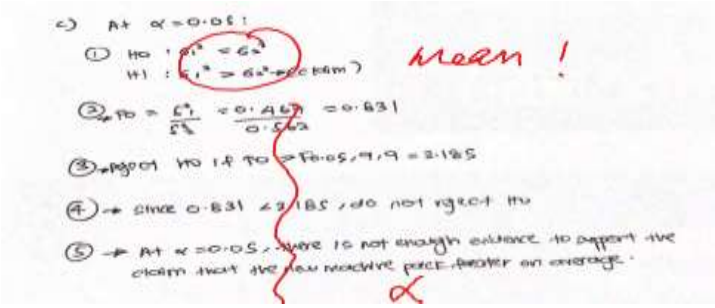
2. *Comprehension*

Question 3a(ii)



This student did not understand the problem of the given question since the student did not answer the question using a hypothesis test, yet instead, this student answered the question using a confidence interval estimate.

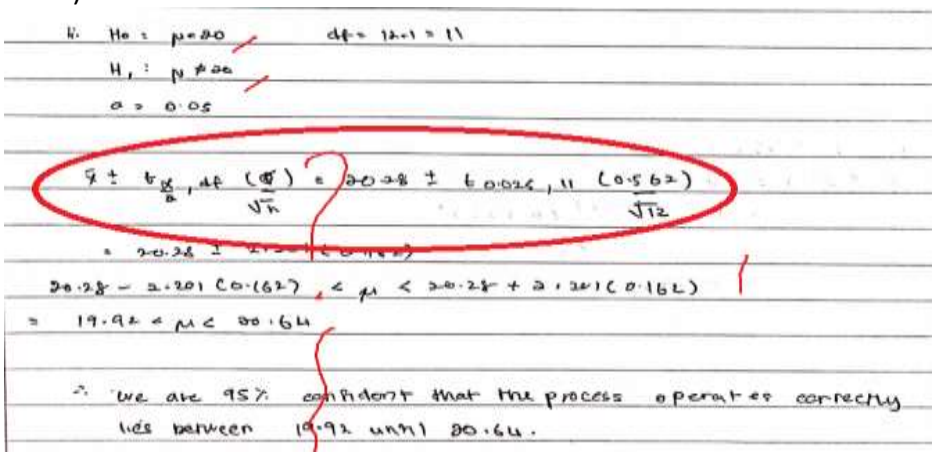
Question 3c)



The hypothesis test used by this student was incorrect. Instead of utilising a two-variance hypothesis test, students should utilise a hypothesis test that compares the difference between two means.

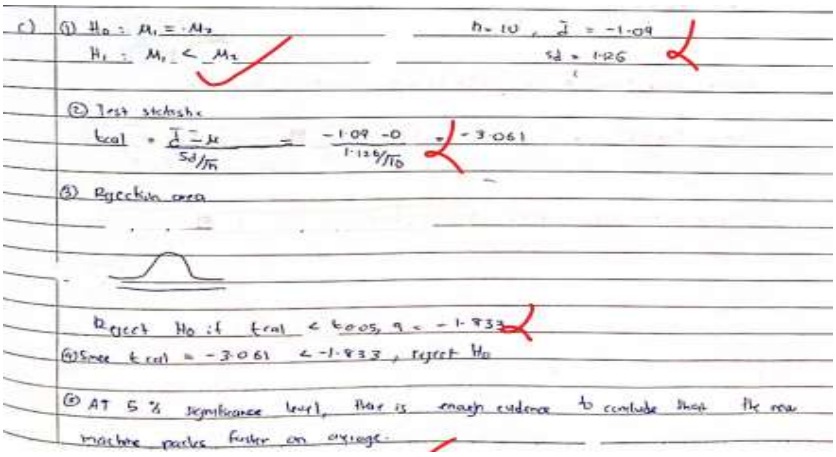
3. *Transformation*

Question 3aii)



This student used the incorrect formula. However, the test used was the correct hypothesis. In particular, the choice of the right formula still confuses these students.

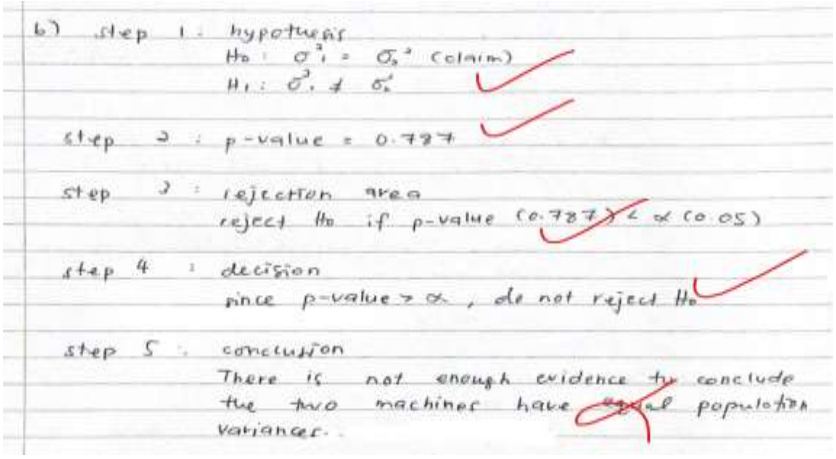
Question 3c



This student used the wrong formula as the formula used did not comply with the paired data. The students still did not understand the type of data they use.

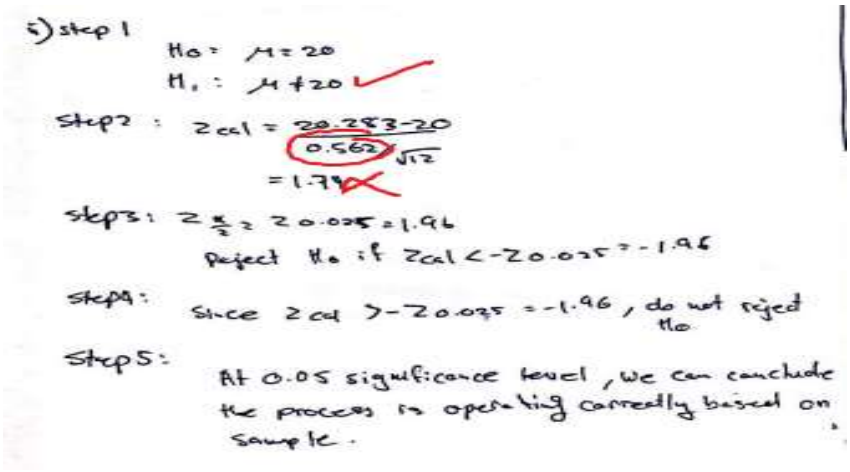
4. *Process skill*

Question 3b



Although the answer on the work route for Ho rejection area was right, this student did not provide a correct solution.

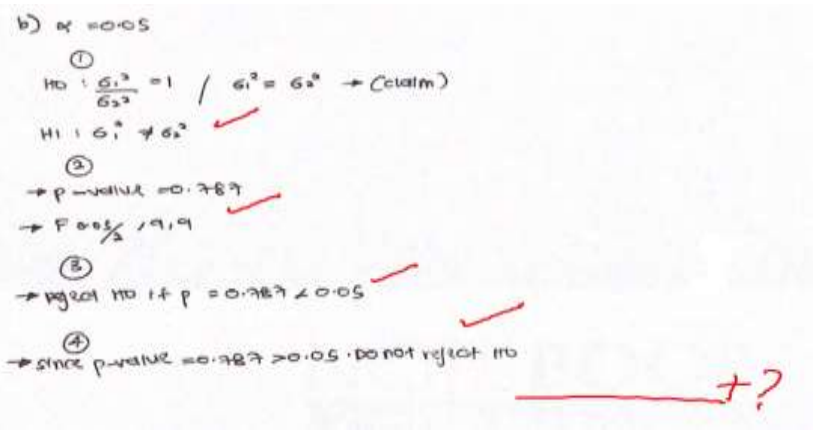
Question 3aii)



This student used the correct formula but entered an incorrect value into the formula.

5. *Encoding*

Question 3b



At the end of the answer, this student did not include a conclusion. This student most likely forgot or did not have enough time to respond to the question.

Although only 24 (15%) of the students correctly answered the question without making any mistakes, students made various errors in understanding the problem. When this happens, the next hypothesis testing method will also cause errors, especially on process skills. As a result, educators must emphasise to students the importance of understanding the problem, particularly the topic of hypothesis testing, so that the same mistakes can be avoided.

Conclusion

Overall, the analysis of students' errors in answering statistical questions related to the topic of this hypothesis revealed that students make errors in terms of reading, understanding problems, transformation, process skills, and writing the final answer, as outlined in the Newman method. All these errors are related to one's metacognitive strategy. According to Sollehah (2012), metacognitive processes can indirectly assist a student's learning by guiding

the student's thinking. It can also help the students determine the work steps to be taken as they seek to understand the situation, solve problems, and make decisions.

Educators can use this to incorporate metacognitive values into the learning process. If the student has metacognitive skills, this allows the student to have the ability to understand a problem better and subsequently able to solve the problem in an effective way (Aryo & Ida, 2016).

Educators must also improve their teaching and learning strategies to be neater and more orderly, particularly during a pandemic. This is because numerous factors and constraints must be considered during the online learning process. It is hoped that further research can be conducted to examine the real causes of errors committed by students for statistical subjects, especially on high-level questions.
After the main body of paper please insert acknowledgement of all those (personals or institutions) that have helped in conducting this study.

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