What are the difficulties in statistics and probability?

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Abstract. Statistics and probability are part of school math. But in reality, there are still many students who get poor grades in the subject. This study aims to find out on which indicators student experience difficulties in statistics and probability. The research method used was quasi-experimental with a total sample of 115 respondent. The result show that respondents' difficulties in statistics and probability were difficulties in probabilistic reasoning, combinatorial reasoning, and proof of variability in random variables. Based on the result obtained, to be able to understand statistic and probability properly, good mathematical logical thinking skill are needed.

1. Introduction
Statistics and probability are the material contained in school mathematics subjects. In completing statistical and probability questions it takes the ability to analyze facts and ideas, generalize explain, give reasons, hypothesize, and arrive at a conclusion. All of these things can be done if your individual is able to think logically. Logical thinking is the key to making decisions and solving statistical and probability problems. Basically, mathematical logical thinking is an essential ability that is possessed and developed by students who study mathematics. Through logical thinking students can use reasoned skills in making predictions on the basis of their experience so students will learn mathematics meaningfully [1].

The definition of logical thinking has been put forward by experts who define logical thinking as a process of using reasoning to be consistent think according to the rules of logical inference, thinking from general to specific to parse a problem to obtain an argument [2,3]. Several studies have been carried out relating to the ability to think logically which contains statistics and probabilities including TOLT, GALT, Lawson Test, and Lengeot tests, the results of which show that not all 11-year-old students are able to reach Piaget's formal operations, and abstract reasoning is not universal [4,5]. This study examines the difficulties of students from statistics and probability from the standpoint of mathematical logical thinking.

2. Method
This research is a quasi-experimental study with the aim to find out the difficulties of students in solving statistical problems and probabilities in terms of aspects of mathematical logical thinking. The study sample was a class XI student from two classes randomly selected class based on the qualifications of upper and middle level schools selected purposively with a total of 115 respondents. The instrument in
this study is an essay question about statistics and probability in terms of the aspects of mathematical logical thinking. Furthermore, the scores of the tests are processed to obtain information about the validity, reliability, distinguishing power, and difficulty level of questions. Questions made validated by team experts.

3. Result and discussion
Logical thinking indicators include: drawing conclusions based on the proportion of two or more components (proportional reasoning), drawing conclusions based on inference rules (propositional reasoning), drawing conclusions based on a combination of several elements (combinatorial reasoning), drawing conclusions based on the chance of an event (probabilistic reasoning) and proof. [2,4-6]. The linkages of indicators of logical thinking and indicators of statistical and probability material are presented in Table 1.

Table 1. Grid and Item the Problem Questions of Mathematical Logical Thinking Ability in Statistics and Probability Subjects.

| No | Material Indicator | Ability Indicator | Question |
|----|-------------------|-------------------|----------|
| 1  | Identify data according to data characteristics through rules and formulas and interpret them | Proportional Reasoning | The following is the value of the math and physics test results of a class illustrated in a bar chart. Based on the diagram above, calculate the average mathematical value and the average physics value. Which questions are more difficult? Explain! |
| 2  | Apply various concepts and principles of combination and permutation | Combinatorial Reasoning | On a math exam, students are asked to work on 8 questions from 10 available questions. Which method has more choices in the case below: a. Choose to work on 8 questions. b. Choose questions that are not done. c. Explain the concepts involved in the two questions above! |
| 3  | Proving variance | Proof | Given $X$ and $Y$ are both discrete random variable which is free with the joint probability $f(x, y)$ for $X = x_1, x_2, x_3, ..., x_n$ and $Y = y_1, y_2, y_3, ..., y_n$. Prove it $\sigma_{X+Y}^2 = E[(X - \mu_x)^2] + 2E[(X - \mu_x)(Y - \mu_y)] + E[(Y - \mu_y)^2]$. |
Table 1. Cont.

| No. | Indicatore                                                                 | Reasoning | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|-----|---------------------------------------------------------------------------|-----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 4   | Identifying and using various measures of central tendency of data         | Correlational Reasoning | A group of students take a math and physics test. The number of students who obtained grades between 7.5-10 there were 15 people for math tests and 10 people for physics tests. Those who obtained scores between 5.5 - 7.4 there were 19 people for math tests and 18 people for physics tests. While those who scored 3.5 - 5.4 were 6 for the math test, 12 for the physics test. Without calculating analytically, choose the appropriate answer a. The average math test is classified as: 1) good; 2) medium; 3) less b. The average physics test is classified as: 1) good; 2) medium; 3) less c. Mathematical test 1) more difficult; 2) equally difficult; 3) easier tests from physics d. Between mathematical and physical abilities: 1) there is a high association; 2) there are moderate associations; 3) there are low associations; 4) unpredictable. |
| 5   | Applying the concept of random variables                                  | Probabilistic Reasoning | A dairy company has a dose of clean weight in one 350 ml can. Of every 100 cans of milk produced, 5 cans of milk are less than the amount. Suppose we buy 8 cans of milk. Which is the biggest chance of the four events below? Include the formula or concept used! a. At most 2 cans of milk are not exactly the size; b. At least 7 cans of milk are exactly the size; c. All milk cans are not exactly the size; d. All milk cans are exactly the size.                                                                                                                                                                                                                     |
The results of the analysis show that students experience difficulties in indicators: applying various concepts and principles of combination and permutation (combinatorial reasoning), proving variety (proof), identifying and using various measures of data concentration (correlational reasoning). Student difficulties in these indicators occur because students are not accustomed to solving problems related to proof. The question of proof is a mathematical task that is rarely done by students. In addition, there are still many students who are mistaken about the concept of permutations or combinations that must be used to solve combinatorial problems. This is consistent with studies that have been done that show that mathematical logical thinking ability is relatively difficult mathematical tasks for high school students and even for some students [7, 8]. Similarly, some studies report similar findings are logical thinking ability of students classified between less and being [9, 10].

From the point of view of learning, logical thinking can be a tool to develop students’ cognitive processes, find misconceptions, and obtain information about student learning levels to advance the teaching-learning process. So that the teacher can improve the ability to think logically with a variety of learning strategies that eventually students get used to working on statistical and probability problems.

4. Conclusion
The ability to think logically includes high-level mathematical abilities that have not been mastered by students. This is because students are not used to doing this in the learning process. To overcome the difficulties of students in completing tasks mathematical logical thinking skills need to be designed innovative mathematical learning that gives students the opportunity to implement and develop mathematical logical thinking skills.

Acknowledgment
Thank you to the Chancellor of IPI Garut, Dean of FITS and Chair of the Mathematics Education Study Program who facilitated this seminar.
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