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Analysis of Statistical Thinking Ability of Mathematics Students Based on Artist Test

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abstract

This study aims to determine the statistical thinking skills of mathematics students and their differences based on gender, school origin, and semester level. To map the statistical thinking skills using the modified Artist test standards. The development of students' statistical thinking skills is one of the focuses of learning mathematics in Higher Education. Students' statistical thinking ability is absolutely necessary to be able to think scientifically. Statistical thinking is the ability to think inductively. The population in this study were all mathematics students, while the sampling was based on proportional random sampling. The data analysis technique uses the t-test, Anova, and Least Significance Difference (LSD) as a follow-up test. Based on the results of the analysis carried out, it was found that students 'statistical thinking skills were classified as low which was below the value of 60 on a scale of 100. These results indicated that students' statistical thinking skills were still low, especially the ability to communicate data and draw conclusions. Another result shows that there is a difference in the ability to think statistically at the semester level, while there is no difference between sex and school origin. For semesters, third-semester students do better than other semesters.

Keywords:
Statistical thinking, The artist test, Student performance evaluation

INTRODUCTION

The development of students' statistical thinking skills is one of the focuses of learning mathematics in Higher Education. According to S. Suriasumantri, (2003), statistical thinking is a part of scientific thinking in which there is a part of logical and systematic thinking. Judging from the pattern of thinking, scientific thinking is a combination of deductive thinking and inductive thinking. Therefore scientific reasoning awakens to the process of deductive logic and inductive logic. Mathematics has an important role in deductive thinking, while statistics have an important role in inductive thinking.

The concept of logic is more related to mathematics and rarely associated with statistics. Whereas only deductive logic is related to mathematics, while inductive logic is actually related to statistics. This creates the impression as if the function of mathematics is higher than statistics in scientific studies. Statistically has the same position in drawing inductive conclusions as mathematics in drawing deductive conclusions. Likewise, deductive and inductive conclusions both have an equally important position in scientific study.

Based on observations, the statistical thinking ability of mathematics students at IAIN Syekh Nurjati Cirebon is still low, especially in the dimensions of decision making and decision making to a problem. The cause of the low ability is due to the weakness of students in inductive thinking. This is because mathematics students are accustomed to deductive thinking or deductive logic. Besides, the concept of mathematical logic that is taught does not generate inductive logic.

Graduates of the mathematics major as teacher candidates to solve every problem and improve their work ethic require statistical thinking skills. To measure the ability to think statistically includes the CAOS test (A Comprehensive Assessment of Outcomes in Statistics) and ARTIST (the Assessment Resource Tools for Improving Statistical Thinking). The CAOS test emphasizes all aspects of statistics while ARTIST is an assessment during the learning process. From these 2 types of tests, the researcher took the modified ARTIST test to measure the statistical thinking ability of Mathematics students at IAIN Syekh Nurjati Cirebon.

The ability to think statistically is able to give quantitatively the level of accuracy of the conclusions drawn, which is basically based on a very simple principle, namely that the larger the sample is taken, the higher the level of accuracy of the conclusion. Conversely, the fewer samples are taken, the lower the level of accuracy. Statistics also give us the ability to know whether a causal relationship between two or more factors is accidental or really related in an empirical relationship. So in this case statistics serves to increase the accuracy of our observations in decision making by avoiding pseudo-accidental relationships.e

In statistical thinking skills, inductive logic is very important to master so that students can use their level of accuracy in drawing conclusions from the math problems they encounter. Statistical thinking skills can be found in all areas of mathematics and are important in everyday life, as noted by H.G. Wells (S. Suriasumantri, 2003) that one-day statistical thinking will become a necessity for humans as well as reading and writing.

This study analyzed the statistical thinking abilities of mathematics students, based on semester level, gender, and school origin. Then predict which one is better. The abilities in question include the ability to describe data, communicate data, analyze data, and draw conclusions.

LITERATURE REVIEW

Snee (1999), explain the next phase in the history of statistics is the development of statistical thinking. The push for this evolution was provided by individuals in the American Statistical Association (e.g. Moore, 1990) and the quality management field in the early 1990s. Statistics education research on statistical thinking is still in its early stages (Garfield & Ben-Zvi, in press). In a four-dimensional framework, Wild and Pfannkuch (1999) aimed to characterize statistical thinking in empirical research. This framework was developed using historical, quality management, psychology, epidemiology, and statistics education literature, as well as interviews with statisticians and undergraduate statistics students.

Wild and Pfannkuch (1999), statistical thinking has four dimensions: an investigative cycle, styles of thinking, an interrogative cycle, and dispositions. The four dimensions encompass both generic and specific statistical thinking habits and are active within the thinker at the same time. The five key parts of statistical thinking found were: identification of the necessity for data, transnumeration, variation consideration, reasoning with statistical models, and integrating the statistical with the contextual.

Many questions for learning, teaching, and the curriculum arise when studying the framework and these types of thinking, such as: How are these types of thinking manifested in starting students? Are there specific educational methods that can elicit such thinking? How can the teacher entice pupils to recognize and respond to this thinking? How does a curriculum document communicate such a way of thinking? The framework's objective was to characterize statistical thinking rather than describe students' growth in statistical thinking, logical thinking and it was not designed to address teaching.

Statistical thinking is the ability to understand and understand statistical processes as a whole. The statistical process in question is the process of collecting data, describing data, organizing data, representing data, analyzing and interpreting data. Besides, according to Watson, Collis, Callingham, & Moritz, (1995) divides the level of statistical thinking into four, namely Idiosyncratic, Transitional, Quantitative, and Analytical.

Watson et al., (1995) establish Deming's Theory of Knowledge as the original source of the definition of statistical thinking. In-depth knowledge has 4 parts, namely: 1) Appreciation for the system; 2) Knowledge of variation; 3) Knowledge of theory: and 4) Psychology. Furthermore, Britz, et.all, (1997) said that: There are three principles of statistical thinking, namely: 1) All work occurs in a process system "; 2) There is variation in all processes, and 3) Understanding and reducing variation is the key to success.

Previously, Snee, (1993) said: "..., statistical thinking is used to describe a thought process that recognizes the nature that there is variation everywhere, identifies, characterizes, quantifies, controls, and reduces to provide unique opportunities in an improvement. "... Every business activity consists of a collection of interconnected processes where input, control variables, and output depend on variations. This leads to the conclusion that statistical thinking should be used routinely at all levels of the organization. ')

Furthermore, Snee, (1990) defines statistical thinking as a thought process, which recognizes that variation is around us and is present in everything we do, all work a series of interconnected processes, and identify, characterize, measure, control, and reduce variations provide opportunities for improvement.

In the domain of quality control and process improvement, Snee, (1990) defines statistical thinking as: "statistical thinking as thought processes, which recognize that variation is all around us and present in everything we do, all work is a series of interconnected processes. , and identifying, characterizing, quantifying, controlling, and reducing variation provide opportunities for improvement ". (Statistical thinking is a thought process, which recognizes the variations that are around us and present in everything we are doing, all work a series of interconnected processes, and identify, characterize, measure, control, and reduce variation provide opportunities for improvement). Furthermore, Shaughnessy, (1996) stated that there are 4 (four) statistical thinking processes, abbreviated as DORA, namely: 1) Describing Data Displays (D); 2) Organizing and Reducing Data (O); 3) Representing Data (R), and 4) Analyzing and Interpreting Data (A).

Several years later Pfannkuch & Wild, (1998) stated that four elements can be used as a foundation for statistical thinking, namely: 1) calculating variation; 2) constructing and reasoning from the model; 3) have basic knowledge in the statistical domain and context domain, and 4) perform synthesis or integration.

A broader definition of statistical thinking put forward by DelMas, (2004) states that statistical thinking is the ability to understand statistical processes as a whole including the process of collecting data, creating questionnaires, determining variables, and the ability to answer existing problems. To better understand statistical thinking, the following steps can be taken:

1. Have good reasoning on how to select data so that it can be used to answer existing problems.
2. Have the ability to answer problems well based on existing data, in different ways and get results that are not much different.
3. Have a good understanding of the statistical process as a whole including any calculations involved in the process.
4. Have a good understanding of the data and be able to analyze the data properly.
5. Having reasoning to solve problems statistically based on existing data, and interpreting it in general decision making.
6. Has broader reasoning towards statistics, and does not rely only on books.

From the opinions of these experts, indicators of statistical thinking can be formulated, namely:

1. Collect data
2. Describe the data
3. Translating and reducing data
4. Data analysis and interpretation
5. Communicating data
6. Data synthesis or integration
7. Decision making

This indicator is a parameter of the ARTIS test model that is modified or adjusted to the culture of the Mathematics student at Syekh Nurjati Cirebon.

METHODS

The population in this study were all mathematics students from the first level to the final level. While the sample uses a stratified proportional random sampling technique. The sample is a combination of strata or stratified and proportional samples. According to Triyono, (2018) strata sample is a form of random sample in which the population or population elements are divided into groups or levels of objects. In detail the population and sample in this study are as follows:

Table 1
Population and Sample

Semester	Sum of Student	Proporsi	n	n fix
I	115	22.95	25.51	25
III	115	22.95	25.51	25
V	158	23.55	35.05	36
VII	153	30.54	33.94	34
Total	501	100.00	120.00	120.00

This research is quantitative and experimental. The procedure for collecting data through observation and distributing the ARTIST test to students. The research variables were: 1) Indicators of statistical thinking skills measured through the ARTIST test, 2) Gender, school origin and semester level. From these variables the research design can be made in the form of a factorial design as follows:

Variabel X

Variabel Y	X1	x2	x3
Y1			
y2			
y3			
y4			
y5			
y6			
Y7			

Figure 1
Factorial Desain

Data Processing Flow

1. Initial data analysis to determine the pattern and nature of the data. The data pattern is intended to determine the distribution of data and outliers. While the nature of the data is to determine the assumptions of normality and homogeneity as the basis for the application of parametric or non-metric statistical tests. If the data is normal and homogeneous, the test to be used is the parametric test, while if the assumption is not met, the non-metric test will be used.
2. Conducted a descriptive analysis of the ARTIST test results based on gender,

school origin and semester level. This analysis aims to determine the size of data centering and distribution as well as presenting data in graphs and tables.

3. Conducted a discriminant analysis to determine differences in ARTIST test results based on sex, school origin and semester level.
4. Carry out further tests to find out whether there are differences and which one is the best.

RESULT AND DISCUSSION

The ARTIST test referred to in this study is the ARTIST test that has been modified and adapted to the cultural culture of Cirebon IAIN students. The results of the ARTIST test tested on IAIN students from levels I to IV based on descriptive statistics are presented in the following table:

Tabel 2
Descriptive statistical thinking skills

N	Mean	Median	Std. Deviation
120	56.26	55.71	4.62

Table 2, shows that the mean value is 56.26, the median is 55.71 and the standard deviation is 4.62. From the three data centering measures, it can be assumed that the data is quite good and spreads normally, because the median and mean values are almost the same and have a relatively small standard deviation. In addition, the scores obtained by students have low diversity, meaning that the scores for statistical thinking skills obtained by students are not much different.

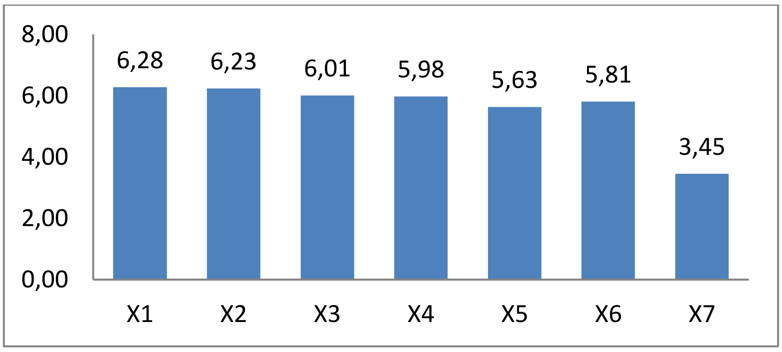

Figure 2
Average indicator of statistical thinking ability

Figure 2, shows the average X2 indicator (describing the data) has the highest average value compared to other indicators. This means that mathematics students understand in describing data, both qualitative and quantitative data. While the X7 indicator (drawing conclusions) is still weak, this is indicated by the average value of 3.45.

The comparison of students' average statistical thinking skills based on gender is shown in the following table form:

Table 3
Descriptive statistical thinking skills Based on gender

Gender	N	Mean	Median	Std. Deviation
Male	59	56.5132	55.7100	4.70256
Female	61	56.0187	55.7100	4.57067

Based on table 3, the mean value for both men and women is still below the value of 60, so it can be concluded that their statistical thinking ability is still weak. The mean value of men is greater than the mean of women, but the standard deviation is smaller than that of women, this shows that the statistical thinking ability of male and female students is the same or one level.

Comparison of the average statistical thinking ability between schools of origin, is presented in the following table form:

Table 4
Descriptive statistical thinking skills
based on school origin

Asal Sekolah	N	Mean	Median	Std. Deviation
SMA	57	57.02	56.43	6.71
MA	51	56.50	55.71	4.38
SMK	12	55.89	55.71	4.37

From table 4, it is found that the mean scores of all three schools are below the value of 60, so it can be concluded that their statistical thinking ability is still low. The mean value of students from high school is greater than others, but the standard deviation is smaller, this shows that the ability to think statistically of students based on their school origins is the same or nothing is better.

The subsequent comparative analysis was based on the student semester level. The results are shown in the following table:

Table 5
Descriptive statistical thinking skills
based on semester level

Semester's Level	N	Mean	Median	Std. Deviation
I	27	55.3967	55.7100	4.23599
III	27	56.1072	55.7100	2.05092
V	29	59.8415	60.0000	4.54157
VII	37	54.4022	52.8600	5.07716

Table 5, shows that the students' statistical thinking skills for all semeseter levels have a score below 60, this shows that their statistical thinking skills are still low. Semester 1 students do better than semester 7, while semester 5 and semester students are equally good (one level).

Data analysis

1. Differences in the ability to think statistically based on gender
   To find out differences in the ability to think statistically based on gender, a statistical hypothesis can be formulated as follows:
   Ho: There is no difference in the ability to think statistically between men with woman.
   Hi: There are differences in the ability to think statistically between men and women.
   Decision making is based on the significance value (opportunity value). If the significance value is less than 0.05 (error rate), then Ho is rejected. If the significance value is greater than 0.05 then Ho is accepted. The test statistic used is the t test (average difference test). Based on the results of data processing, the following results were obtained:

Table 6
Independent t-test

Variabel	t-test for Equality of Means		
	t	df	Sig. (2-tailed)
Statistical Thinking Ability	0.584	118	0.560

   From the t-test table, a significance value of 0.560 is greater than 0.05, so that Ho is accepted. This means that there is no difference in the ability to think statistically between the sexes of men and women.
2. Differences in the ability to think statistically based on the school's origin
   The second hypothesis to determine the ability to think statistically based on the origin of the school is as follows:
   Ho : $\mu_1 = \mu_2 = \mu_3$
   Ha : $\exists! \mu_1 \neq \mu_2$
   Decision making is based on the opportunity value (significance value), that is, if the opportunity value is less than 0.05, then Ho is rejected. If the opportunity value is greater than 0.05 then Ho is accepted. From the results of data processing, the following results were obtained:

Table 7
Anova

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	8.682	2	4.341	.410	.664
Within Groups	1237.684	117	10.578		
Total	1246.367	119			

   The table shows a significance value of 0.664. This value is greater than 0.05, so that Ho is accepted. This means that there is no difference in students' statistical thinking abilities based on their school origins. But statistically, the descriptive average score of the statistical thinking ability test scores of students from SMA is higher than students from MA and SMK. From these two results, it can be concluded that the difference in the average score of the students' statistical thinking ability tests, inferentially, cannot be said to be different.

3. Differences in the ability to think statistically based on semester levels

   The third hypothesis to determine the ability to think statistically based on the semester level is as follows:

   Ho : $\mu_1 = \mu_2 = \mu_3 = \mu_4$

   Ha : $\exists! \mu_1 \neq \mu_2$

   The decision making is based on the opportunity value (significance value), that is, if the opportunity value is smaller than 0.1, then Ho is rejected. If the probability value is greater than 0.1 then Ho is accepted. From the results of data processing, the following results were obtained:

Table 8
Anova

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	494.838	3	164.946	9.340	.000
Within Groups	2048.574	116	17.660		
Total	2543.412	119			

From table 8, the significance value is 0.00 less than 0.05, so that Ho is rejected and Ha is accepted. This means that it can be concluded that there are differences in students' statistical thinking abilities based on semester levels. To find out which semester level is better, it is necessary to carry out further tests. The advanced test used is the Laest Significance Difference (LSD) test. Based on the results of data processing, the following results were obtained:

Table 9
LSD test

(I) Semester Level	(J) Semester Level	Mean Difference (I-J)	Std. Error	Sig.
I	III	-4.44481*	1.14375	.000
	V	-.71057	1.12385	.528
	VII	.99450	1.06366	.352
III	I	4.44481*	1.14375	.000
	V	3.73424*	1.12385	.001
	VII	5.43932*	1.06366	.000
V	I	.71057	1.12385	.528
	III	-3.73424*	1.12385	.001
	VII	1.70508	1.04224	.105
VII	I	-.99450	1.06366	.352
	III	-5.43932*	1.06366	.000
	V	-1.70508	1.04224	.105

Based on table 9, it can be explained as follows:

1. Comparison of the ability to think statistically between semesters I and III obtained a significance value of 0.000 which is greater than 0.05, meaning that there is a difference. Furthermore, between the first semester and the fifth semester, a significance value of 0.528 is greater than 0.05, meaning that there is no difference in the ability to think statistically. For semester I and semester VII, the significance value is 0.352, greater than 0.05, so it can be concluded that there is no difference in the ability to think statistically.
2. The ability to think statistically between semester III and semester V has a significant difference. This corresponds to a significance value of 0.001, less than 0.05. While for semester III with VII the significance value is 0.000, less than 0.05, so it can be concluded that there is a significant difference.
3. For semester V to semester VII, a significance value of 0.105 is obtained, greater than 0.05, so it can be concluded that there is no significant difference in ability.

From the interpretation of the differences in each semester, it can be concluded that in general, the statistical thinking ability of semester III students is better than that of other semester students. This is because the third semester students have just received statistics courses, so their memories are still good..

CONCLUSION

Comparison of the students' statistical thinking skills in mathematics, there is no difference between the sexes of men and women. For the statistical thinking ability of mathematics students based on high school origin is not better than those from other schools in other words there is no difference. Then for semester III student levels are better than other semesters. The results of the student's statistical thinking ability test are classified as low which is below the value of 60 on a scale of 100. These results indicate that students' statistical thinking skills are still low, especially the ability to communicate data and draw conclusions.

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