

Examining Prospective Teachers' Mathematical Communication Skills in Statistics

1st Djamilah Bondan Widjajanti
*Mathematics & Natural Science
 Faculty*
 Yogyakarta State University
 Yogyakarta, Indonesia
 djamilah_bw@uny.ac.id

2nd E. Listyani
*Mathematics & Natural Science
 Faculty*
 Yogyakarta State University
 Yogyakarta, Indonesia

3rd M. Susanti
*Mathematics & Natural Science
 Faculty*
 Yogyakarta State University
 Yogyakarta, Indonesia

4th W. Setyaningrum
*Mathematics & Natural Science
 Faculty*
 Yogyakarta State University
 Yogyakarta, Indonesia

Abstract—The mathematical communication skill is an important thing to support the teachers' role as facilitators in helping students to master 21st-century skills. The efforts to improve the skill must be well prepared since they are still as prospective teachers. The communication skill involves some aspects. Therefore, to improve the skill of prospective teachers, it must be identified what aspects need to be improved. This study aims to describe students' mathematical communication skills in Statistics. The mathematical communication skills in this study refer to the students' skills to 1) present the data or information into table or diagram correctly, 2) use mathematical terms, symbols/notations, charts, diagram, illustrations or formulas correctly, 3) solve the problems correctly and systematically, and 4) provide the correct reasons or explanations on the solution they got. The participants of this study are 35 students of Mathematics Education Department, Yogyakarta State University who enroll in Statistics course during September – December 2016. The data of this study are collected from the midterm exam and final exam of the semester. The research shows: 1) the students' mathematical communication skills in Statistics are at the medium level; 2) the ability to use correct mathematical terms, symbols/notations, charts, diagram, illustrations or formulas seems to be the lowest one among the four skills measured in this study; and 3) most students have difficulties in solving problems related to probability. The results indicate that the students' mathematical communication skills are serious issues that need to be addressed.

Keywords—*prospective math teachers, communication skills, statistics*

I. INTRODUCTION

To survive and succeed in the 21st century, a person is required to master the skills such as: 1) life and career skills, 2) learning and innovation skills, 3) information, media, and technology skills [1]. A good quality education can master these skills. Therefore, every teacher in the school is obliged to realize good quality education, at least in their respective class, likewise with the math teacher.

To realize a good quality education, one of the skills that must be mastered by mathematics teachers is the skill of scientific communication because having this skill makes math lesson easier for students. Mathematics teachers who do not have adequate mathematical communication skills,

for example, cannot give an explanation when there are students who ask the origin of a formula, or inconsistent in using symbols, or less precise in making illustrations/sketches, can make students more difficult learn math. It is indeed not desirable. The difficulties in learning mathematics can reduce the motivation of students to learn, whereas some research results indicate that there is a positive correlation between motivation and learning achievement [2-4]. To improve students' learning motivation, this mathematical communication skill of math teacher needs to get attention.

Some experts mentioned about the importance of mathematical communication skills. Mathematical communication skills play a crucial role in mathematics class. It is an essential part of mathematics and mathematics education [5-6]. Mathematical communication skills is an essential process for learning mathematics because through communication, students reflect upon, clarify and expand their ideas and understanding of mathematical relationships and mathematical argument [7].

The importance of mathematical communication skills in mathematics education is reflected by the fact that this aspect is included in mathematics activities in the mathematics curricula in many countries. In Indonesia, one of the objectives of why mathematics is given in school is so that the students are able to communicate some ideas with symbols, table, diagram or other media to clarify the situation or problem. For students, involving in mathematic communication, either with a teacher or his friends, either orally or written, either at the same time with the learning process or outside the class, will give many advantages to improve their mathematical understanding [5]. Besides, the use of mathematical language helps students gain insights into their thinking and develop and express their mathematical ideas and strategies, precisely and coherently, to themselves and the others [8].

Noting the importance of mathematics teachers having adequate mathematical communication skills, it is also important to pay attention to the education for prospective math teachers. Efforts to improve mathematical communication skills of prospective math teachers should

be done continuously and integrated through lectures. One of them can be through the lectures of Statistics.

Statistics is a general course that must be taken by students at university level, including students of Mathematics Education Program, Faculty of Mathematics and Natural Sciences, Yogyakarta State University, Indonesia. Statistics courses are becoming increasingly important because the need for statistical-literacy in the future will also increase [9]. In the current era of information technology, statistics will help someone to filtering the information by analysis of data, not just opinions.

Statistics, which contains the following topics: 1) Descriptive statistics; 2) Probability; 3) Random variables; 4) Sampling distribution; 5) Confidence interval; and 6) Hypothesis testing, are suitable to develop students' mathematical communication skill because the discussion of the topics use symbols, drawings, tables, diagrams, and explanations. However, as the first step, lecturers need to know how to develop students' mathematical communication skill in Statistics, it must first be identified how is the level of mathematical communication skill possessed by the students, and what aspect is weakest and needs to be improved. For this purpose, this study was conducted.

II. METHODS

The type of this research is descriptive. The subjects of this research were 35 first-semester students of Mathematics Education Study Program, Yogyakarta State University, Indonesia, who took Statistics course during September – December 2016.

The purpose of the research is to identify which aspects of the communication skills of the prospective mathematics teachers that need to be improved. The mathematical communication skills in this study refer to the students' skills to 1) present the data or information into table or diagram correctly, 2) use mathematical terms, symbols/notations charts, diagram, illustrations or formulas correctly, 3) solve the problems correctly and systematically, and 4) provide the correct reasons or explanations on the solution they got.

The instrument has been developed in the form of two sets of students' mathematical communication skill test in Statistics. Three lecturers of Statistics have validated the instrument. Problems/questions in the form of essays, given at the middle (ME) and the final exam of the semester (FE), each of 5 numbers, each was done within 100 minutes. The instrument for ME and FE are both reliable, with the coefficient of Alfa-Cronbach reliability 0.71 and 0.72, respectively.

Table 1. The Specification of Mathematical Communication Skills at ME and FE

No	Indicators	Question Number		Maximum Score	
		ME	FE	ME	FE
1.	Present the data or information in table or diagram correctly	2, 5	2, 4,5	280	420
2.	Use mathematical terms, symbols/notations, charts, diagram, illustrations or formulas correctly	1,3,4,5	1,2,3,4,5	560	700
3.	Solve the problems correctly and systematically	1,3,4,5	1,2,3,4,5	560	700
4.	Provide the correct reasons or the explanations of the solution they got	1,3	4,5	280	280

Table 2. Capabilities Categorization

Percentage of achievements (%)	Category
0 – 29	Very Low
30 – 49	Low
50 – 64	Medium
65 – 79	High
80 – 100	Very High

The specification for ME and FE is presented in Table 1. The calculation of the maximum score for each indicator has been calculated from the number of questions for the indicator multiplied by the maximum possible score (= 4), then multiplied by the number of students (= 35). Categories of mathematical communication skills were determined using criteria in Table 2. Percentage of achievement has been calculated from total score achievement obtained divided by the total maximum possible score. From the data that has been collected, the following can be described are: 1) the category of the communication skills of students who were the subjects of this research, 2) the aspects in which students tend to be weak, 3) examples of mistakes made by students.

III. RESULTS AND DISCUSSION

Based on ME and FE data from 35 students, students' mathematical communication skill in Statistics can be

described as follows as in Table 3. From Table 3 it can be seen that the standard deviation is relatively small and the data distribution tends to be normal. Besides, Table 2 categorize students 'mathematical communication skills in Statistics. It conveyed that the students' mathematical communication skills in Statistics are in the medium level. Although there has been an increase in achievements in the final exam, it is still in the medium category. This result need to be followed up by the lecturers of Statistics. The lecturers must improve their learning to improve the communication skills of students in Statistics.

To be able to choose the right way of improving students' mathematical communication skills in Statistics, keep in mind the results of each indicator and what factors are reasonably suspected as the cause. More details, results for each indicator are presented in Table 4.

Table 4 showed that the achievement of students' mathematical communication skill on each indicator is only included at the medium level, and the ability to use correct

mathematical terms, symbols/notations, charts, diagram, illustrations or formulas seems to be the lowest one among the four skills measured in this study. In fact, for this second indicator, the achievement in ME is only at the "low" level. The results of this study are similar to the results of Widjajanti's research on Discrete Mathematics courses

which conclude that students tend to be low on the use of charts, pictures, and illustrations [10]. Regarding that results, it becomes important for the education program of prospective mathematics teacher to explicitly include communication standards in their learning process, as contained in the NCATE/NCTM Program Standards [11].

Table 3. Descriptive Statistics for Mathematical Communication Skills Score

Statistics	ME	FE	Total (ME + FE)
Mean	25.3	37.8	63.06
Standard Deviation	8.8	10.2	2.9
Kurtosis	-0.54	-0.04	-0.08
Skewness	0.04	-0.15	-0.19
Minimum	8	14	26
Maximum	43	60	99
Sum	864	1323	2207
Possible Minimum	0	0	0
Possible Maximum	48	60	108
Possible Sum	1680	2100	3780
% achievements	52	63	58

Table 4. Achievement of Mathematical Communication Skills for each Indicator

Indicators	ME			FE			Total		
	Ach	%	Cat	Ach	%	Cat	Ach	%	Cat
Present the data or information in table or diagram correctly	143	51	Medium	278	66	High	421	60	Medium
Use mathematical terms, symbols/notations, charts, diagram, illustrations or formulas correctly	278	49	Low	431	62	Medium	709	56	Medium
Solve the problems correctly and systematically	309	55	Medium	436	62	Medium	745	59	Medium
Provide the correct reasons or explanations of the solution they got	154	55	Medium	178	64	Medium	332	59	Medium
Total	884	52	Medium	1323	63	Medium	2207	58	Medium

One of the problems used to measure the achievement of the second indicator is as follows: "Dari catatan tahun-tahun sebelumnya diketahui bahwa hanya 30% dari peserta tes TOEFL yang dapat mencapai skor 500 pada tes yang dilakukannya pertama kali. Diketahui bahwa bulan depan ada ten mahasiswa yang akan mengikuti tes TOEFL untuk pertama kalinya. Jawablah pertanyaan berikut menggunakan notasi yang tepat. Berapa peluang bahwa: a) Sekurang-kurangnya ada 3 mahasiswa yang mencapai skor 500, dan b) Tidak ada mahasiswa yang mencapai skor 500." Translated in english as follows: "From the records of previous years, it is known that only 30% of TOEFL test participants can achieve a score of 500 on the first test. It is known that next month ten students will take the TOEFL test for the first time. Answer the following questions using proper notation. What is the probability that: (a) There are at least three students who achieve 500 scores, and (b) No student reaches a score of 500."

This question requires students to answer it using the right notation. However, most students do not use proper notation, including in writing what is known and what is asked. One example of student answers is seen in Fig. 1 as follows.

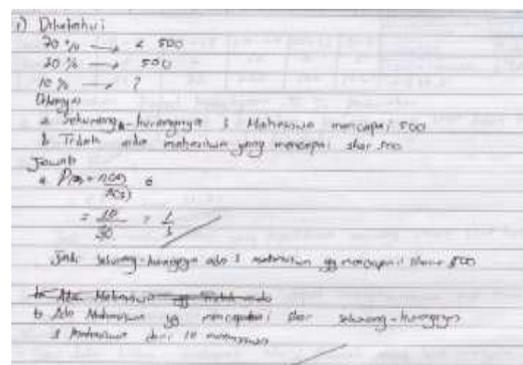


Fig. 1. Example of student answer

As shown in Fig. 1, it can be seen that the wrong answer from the student starts from the wrong writing. Suppose he wrote it as follows. X is the number of students who achieved a score of 500 on their first test. Then he writes what is required in the correct notation, namely: (a) $P(X \geq 3)$ and (b) $P(X = 0)$, it is possible he can answer the problem correctly. Similarly, student answers are shown in Fig. 2 below.

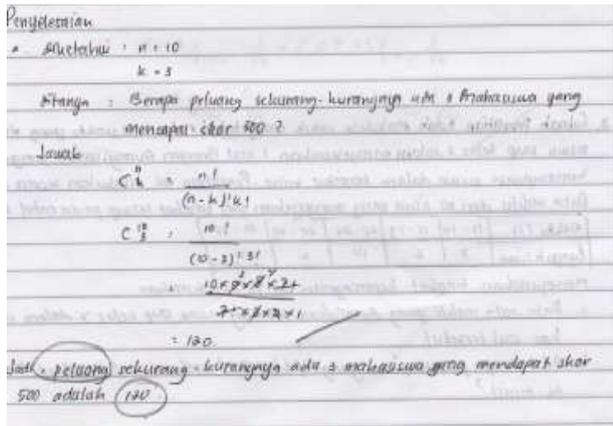


Fig. 2. Example of student answer

These two wrong answers from students, we can conclude that not only their mathematical communication skills that need to be improved but also their understanding of the concept, especially for the Probability material, related to the use of Permutation and Combination formulas. From the student exam results, both at ME and FE, it is also known that the students' mastery of Probability material is relatively weak.

The topic about probability is difficult not only for the students but also for the teachers. For mathematics teachers, the topic of Probability also includes one of the most challenging topics to teach. According to Keeler and Steinhurst (2001), the probability unit in a first statistics course is challenging to teach because there is not much time, the concepts and mechanics are complicated, and the students do not see the relevance of their learning [12].

The results of this study reinforce the notion that probability problem-solving skills are closely related to students' ability in representation/communication [13]. It concludes that students who were able to use the coordinated approach by using multiple representations had better results in probability problem-solving.

The weakness of mathematical communication ability of this first-year student, besides influenced by concept understanding is also influenced by the habits of students at the previous school level. Many high school teachers do not familiarize students to write a complete answer. Besides, how teachers ask, or what words/phrases teachers use to ask, can also influence the development of students' mathematical communication skills.

Another cause is the habits of students practicing multiple choice questions. However, if the students work too often on multiple choice questions, then they will reduce their chances of answering the problem with the correct phrase and symbol. Although the national exam is in the form of multiple choice, a high school mathematics teacher should train his students to solve math problems completely, including using terms, symbols/notations, charts, diagram, illustrations or formulas correctly.

Many methods/strategies/approaches can be chosen by teachers/lecturers to improve students' mathematical communication skill. The results of Melianingsih and Sugiman show the effectiveness of the open-ended and

problem-solving approach in improving mathematical communication skills of junior high school students [14]. Similarly, Hodiyanto's research results show the effect of the problem-solving approach in improving mathematical communication skills of junior high school students [15].

Not only are open-ended and problem-solving approaches can improve students' mathematical communication skills. The result of Hidayati's research also shows the effectiveness of Setting Think Pair Share in Discovery Learning Approach and Problem-Based Learning regarding students' mathematical communication skills [16]. In contrast, the results of Widjajanti's research show the influence of Problem-Based Collaborative Strategies in developing students' mathematical communication skills in a Discrete Mathematics course [11].

IV. CONCLUSION

This research shows: 1) the students' mathematical communication skills in Statistics are at the medium level; 2) the ability to use correct mathematical terms, symbols/notations, charts, diagram, illustrations or formulas seems to be the lowest one among the four skills measured in this study; and 3) most students have difficulties in solving problems related to probability. The results indicate that the students' mathematical communication skills are serious issues that need to be addressed.

Based on the results of this study, it is suggested to mathematics teachers/lecturers to choose the right method/strategy/learning approach and to give many opportunities to the students to write a complete answer. The habit of writing down what is known, what is being asked, and explaining using terms, symbols/notations, charts, diagrams, illustrations or formulas correctly is essential to improve mathematical communication skills. A task such as "calculate" should start to be reduced by math teachers, since such questions are less likely to develop students' mathematical communication skills. Although in the end, the students have to do the calculation, the question can be replaced in such a way that besides the ability to perform counting operations, students also develop skills in mathematical communication. Teachers/lecturers are advised to use word/command like "why", "give reason", "what if ...", "simply", "draw", "explain", and so on.

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