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Mathematical Communication and Its Relation in Statistics

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Abstract
This study aims to describe mathematical communication ability in undergraduate students of Civics Major who take basic statistics course in study year 2016/2017 at Universitas Negeri Medan. The design of this experiment study was using pre-test and post-test control group design. In this study, the experimental group received Knisley Model and the control group received Conventional Learning. The data then collected by using test of mathematical communication ability. Based on data analysis, it can be concluded that there is a difference of average improvement of mathematical communication ability between students in both groups. Thus the Knisley Model can be an alternative learning model to implement in undergraduate students.
Keywords: Mathematical Communication, Undergradate Students, Statistics, Knisley Model

1. Introduction

Mathematical communication is one of proficiency that students must have. Through mathematical communication students can communicate their thinking by clarify and expand Ontario Ministry of Education (2005). According to Greenes and Schulman (in Armiati, 2009), the importance of communication because of several things, they are to express ideas through conversation, writing, demonstration, and visual painting in different types; understand, interpret and evaluate ideas presented in writing or in visual form; construct, interpret, and relate various forms of representation of ideas and relate them; making observations and conjectures, formulating questions, carrying and evaluating information; produce and state arguments persuasively. Greenes and Schulman (in Armiati, 2009) and Van de Walle (2003) state that "the best way to connect with an idea is to try to convey the idea to others." The ability of mathematical communication is a very supportive thing a teacher in understanding the ability of students in learning mathematics. The same thing is also explained by Baroody (1993) that there are two reasons why communication is important. The first reason is that mathematics not just a tool of thought, a tool for finding patterns, solving problems or drawing conclusions, but also an invaluable tool for clearly communicating ideas, appropriately, and succinctly. The second reason is the learning of mathematics is a social activity and also as a vehicle for interaction between students and students and between teachers and students.

Bergeson's research indicate that students have difficulty communicating visual information performance level in communicating a three-dimensional environment (eg. a building made of small blocks) through two-dimensional tools (eg. paper and pencil) or vice versa. Osterholm (2006) finds that students seem to have difficulty articulating the reason for understanding a passage. When asked to state the logical reasoning of his or her understanding, the student sometimes only focuses on a small part of the text and declares that this passage (the problem containing the individuated) does not understand, but facial gives no excuse for his statement.

NCTM (2000) stated that the ability of mathematical communication are: (1) develop and consolidate students ' mathematical thinking through communication; (2) communicate its mathematical thoughts clearly and coherently with other students or teachers; (3) analyze and evaluate mathematical thinking and other strategies; (4) use of mathematical language to express mathematical ideas appropriately. In line with that, Sumarmo (2008) stated that the activities included in the mathematical communication which are: (1) declare a situation, pictures, diagrams, or real objects into the language, symbols, ideas, or mathematical models; (2) explain the ideas, situations, and mathematical relationships verbally or writing; (3) listen, discuss, and write about mathematics; (4) read with understanding a written mathematical representation; (5) make a conjecture, formulate arguments, formulate a definition, and generalizations; (6) reveal a description or paragraph mathematics in their own language.

Introduction of Statistics is a basic science that needs to be mastered more widely and deeply by students, or aspiring scientists. Therefore it is necessary to develop a better model of learning, attracting interest, motivation, and fun. One option is the use of the Four Stage Math Learning Model developed by Knisley and produces teaching materials using print and visual media. The advantages of this learning model is to make it easier to identify the level of student understanding that has been achieved when learning is lower (Knisley, 2003). Similar opinion expressed by Mulyana (2009), Knisley's learning model has advantages such as raising the students spirit to think actively, helping the conducive learning atmosphere because students rely on individual discovery, bringing the excitement in the learning process because students are dynamic and open from various directions. Based on the above description Knisley learning model deserve to be a reference for the development

of introductory materials Statistics at the level of higher education.

In recent time, the research results shows shows that everyone has their own learning style (Felder in Knisley, 2003). In line with Felder, Eyring, Johnson, & Francis (in Knisley, 2003) states that students who can be fast learners can build their own strategies to understand the concept. It means that anyone who is able to understand the learning styles of himself is the one who can understand the lessons faster and better. One of teacher competences is understand the content of mathematics and its strategy to be learned to students. Learning in groups such as revealed by Knisley model can improve the ability of communication. It is similar with Lee opinions' that whole-class discussions enable students to learn new vocabulary and become confident users of the new words or phrases. Group work lessons help students explain, develop and name mathematical theories. Students should be encouraged to make observations about mathematical patterns.

Hoyles (1985) research suggested that discussion promotes mathematical understanding. According to Hoyles, classroom communication is important in students' development of conceptual understanding. Students do find difficulty communicating in maths, but talking about maths helps them remember and use mathematical ideas. Mathematical communication is one of the part of high-level thinking that covers characteristic the ability to resolve problems where no algorithm has been taught, which requires justification or explanation and allows for more than one solution (Senk in Thompson 2012).

Based on the background of the problems that have been stated before, in general the formulation of the problem in this study is "How to develop teaching materials Introduction to Statistics based on Knisley's mathematical model as an effort to improve the communication skills of Student Civics? The specific formulation of the problem are:

1. How is the order of introduction of introductory materials Statistics based on concepts, axioms, principles, and procedures?
2. How is the Introduction to Statistical materials developed to improve students' mathematical competence in accordance with the Knisley Model to improve the ability of mathematical communication?

This learning activity in general aims to develop mathematics teaching materials in accordance with the Knisley Model so that the competence of students' mathematical communication increases. Objectives are obtained through the identification of needs and development of teaching materials, media selection to present teaching competencies materials, application of teaching materials, as well as evaluation and dissemination of products developed. In this study, the identification of needs and development of teaching materials. Thus the objectives of the study are as follows:

1. The compilation of instructional sequences Introduction to Statistics based on concepts, axioms, principles, and procedures that can help develop the competence of math communication of Civics students through the Knisley model.
2. Preparation of Introduction to Statistics materials that can help develop students' mathematics through Model Knisley in the form of handouts, student activity sheets.

2. Theoritical

2.1 Mathematical Communication

The ability of mathematical communication is the student's ability to explain an algorithm and a unique way to solve problems, construct and explain graphs, words or sentences, equations, tables, and physical presentation (Schoen, Bean & Ziebarth, 1996). In addition, Greenes and Schulman argue that mathematical communication is the ability to (1) express mathematical ideas through speech, writing, demonstration, and visualize them in different types, (2) the ability to understand, interpret and evaluate ideas presented in written, oral, or in visual form, (3) constructing, interpreting and linking a variety of representations of ideas and relationships. Sumarmo (2013) also stated that the ability of mathematical communication is an ability that can include and contain various opportunities to communicate in the form of: (1) Reflecting real objects, drawings, and diagrams into mathematical ideas, (2) Model situations or problems using oral, written, concrete, graphic, and algebraic methods, (3) Declare everyday events in language or mathematical symbols, (4) Listening, discussing, and writing about math.

The indicators of mathematical communication in this study are (1) the ability to express mathematical ideas through writing and demonstrate them and visualize them visually; (2) the ability to understand, interpret and evaluate mathematical ideas in writing or in other visual forms; and (3) the ability to use terms of mathematical notations and structures to present ideas, describes relationships with situational models.

Knisley's learning model is a learning model developed by Jeff Knisley in lectures on mathematics (Calculus and Statistics). Jeff Knisley is an assistant professor of mathematics at East Tennessee State University. Knisley developed a model of learning that he adopted from David Kolb's learning model known as Kolb's model or experiential learning Kolb in his research journal A Four-Stage Model of Mathematical Learning. Knisley assumes that David Kolb's learning model is a mathematics learning style. Here are the steps or steps in Knisley's learning model

1. Concreate-Reflective: The teacher explains the concept figuratively in a familiar context based on terms related to concepts that learners already know. At this stage the teacher acts as a storyteller or storyteller.
2. Concrete-Active: Teachers provide the task and encouragement for learners to explore,
3. Experiment, measure, or compare so as to distinguish this new concept with a concept concept that has been known. At this stage the teacher acts as a mentor and motivator.
4. Abstract-Reflective: Learners make or choose statements related to new concepts, give counter examples to deny wrong statements, and prove true statements together with teachers. At this stage the teacher acts as a source of information.
5. Abstract-Active: Learners practice (practice) using new concepts to solve problems and develop strategies. At this stage the teacher acts as a coach or coach.

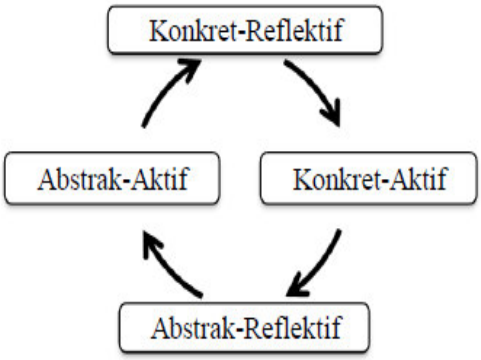

Figure 1. The Mathematical Learning Model Cycle

From the results of Kolb's model, Knisley created the model that related with Kolb's model. There are four steps in Knisley's model (2003), they are : (1) Allegorization is activity which is the first step where the students are asked to think about and consider new ideas that they receive from a friend of their group to formulated a general thing that they know; (2) Integrator is the situation where learners are asked to solve problem, based on the knowledge that they have, they try to calculate, measure, draw and do a comparison to see the difference of new concept and prior concept; (3) Analyzer is step where students are encouraged to solve problems using logic and gradually in accordance with the initial allegations that get the solution; (4) Synthesizer is where learner resolve the problem with a new concept that has acquired the students to solve the problem with develop new strategy. The role of the teacher in each steps are very important in the early step as a conduit of information and increase to mentor and motivator for students to find a new concept of the information provided. Even in the final of the teachers or instructor can solve every problem of students based on the concepts they are already familiar.

McCarthy (in Knisley, 2003) advocates classroom learning ideally through every stage of the four learning processes. While the role of teachers based on the Kolb learning cycle is at least four different roles from mathematics teachers. MPMK which contains exploration, elaboration, and confirmation activities that adhere to the learning paradigm. This paradigm is in line with a learning as understanding view that has many advantages: (i) generative, (ii) supports memory, (iii) reduces the need to remember, (iv) increases transfers, and (v) affects beliefs,(Hiebert & Carpenter, 1992).

2.2 Statistics Course

Statistics is a science that deals with methods for data collection, presentation, analysis and conclusions. This statistical method can be divided into two, namely the descriptive statistics (descriptive statistics) and inductive statistics. In the material distribution of data grouped students difficult to change the data from the form of distribution tables to graphs or vice versa. For example:

Table 1. Frequency Table

No.	Class	Frequency	Cum Freq
1	0 - 4	3	3
2	5 – 9	5	8
3	10 – 14	8	16
4	15 – 19	8	24
5	20 – 24	4	28
6	25 – 29	2	30
7	30 - 34	1	31
	Sum	31	-

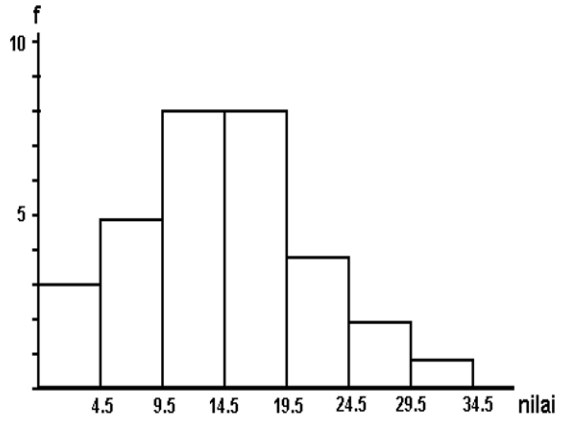

Figure 2. Histogram from Table 1

Whereas the above problems are fundamental, the student should have understood. To create a Histogram of the picture above we must be able to determine the boundary of the bar that is the edge of the class. The edge of the class is 1 = (4 + 5) / 2 = 4.5. Edge of class 2 = (9 + 10) / 2 = 9.5 and so on.

A little bit different for drawing polygon beside we can make the point of the scribe by determining the middle value of the class i.e:
Middle value of class to 1:
= (0 + 4) / 2 = 2.
The middle grade of the 2nd grade:
= (5 + 9) / 2 = 7 etc.

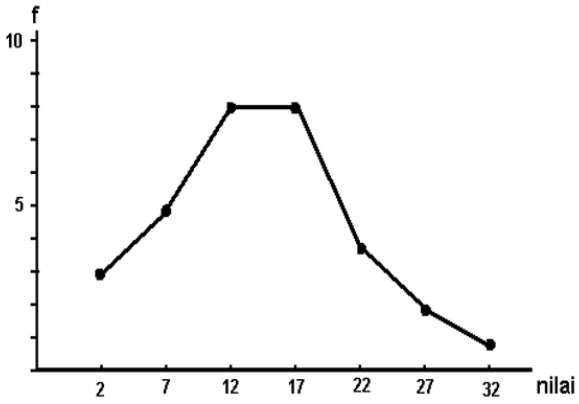

Figure 3. Line Diagram

By doing the four learning steps Knisley made the introductory course of statistics become more easily understood by the students. At the concrete stage of active lecturers explain the concept of statisti with language that is more easily understood by students and make cases that are surrounded by students. Referring to the table above, the lecturer gives an understanding of the class edge and the middle value.

Table 2. Frequency Table with Boundary

No.	Class	Frequency	Cum Freq
1	0 – 4[a]	3	3
2	[b]5 – 9	5	8
3	10 – 14	8	16
4	15 – 19	8	24
5	20 – 24	4	28
6	25 – 29	2	30
7	30 – 34	1	31
	Total	31	-

[a]Lower bound and [b]Upper bound

At the concrete-active stage, the lecturer asks the students to collect the data as many as 40 high-rank friends one class, and asked each student to have different respondents, from the data obtained the students are asked to create a frequency distribution table of data in groups and then make it in graph.

If students can communicate their steps and answer questions about how they reached the answer, then they have a good understanding of the topic. Students need to be able to analyze the problem, find an appropriate method for solving, and then communicate those steps with the teacher or their peers. Teachers can check students' vocabulary usage through oral and written communication.

3. Method

To answer the problems in this study, the researcher was doing the experimental study. The design was used randomized control group only. The population in this study were all students of sixth semester civics major who registered in Medan State University in the academic year 2016/2017. Using random sampling, with class A as an experimental group and class D as the control group. The type of data in this study is primary data. The data was collected from the sample through the instrument test to see mathematical communication skills of students of the experimental group and control group. The instruments that used in this study is a essay test that require mathematical communication skills. Before the test was given to the students, the test validated to the experts. Three experts consulted to analyze the feasibility of matter in terms of language and level of difficulty. After the test was revised then the instrument test was ready to use in the study.

4. Results

In developing a structured instructional material, a sequence of material items, including concepts, facts, and principles, will result in a procedure for solving certain problems in a topic. From the sequences of the teaching materials and the learning model used, developed instructional materials and detailed student tasks tailored to the learning stages of the Knisley Model are concrete, concrete-active, abstract-reflective, and abstract-active. The results of the learning process are shown in Table 3 below. Table 3 connects the communication skills of Civics students in Introduction to Statistics with Knisley model.

Table 3. Percentages of Mathematical Communication Ability

No	Aspects	Control Group	Experiment Group
1	The ability to express mathematical ideas through writing, demonstrating and visualizing them visually	70,1%	69,7%
2	The ability to understand, interpret and evaluate mathematical ideas in writing as well as in other visual forms	67,8 %	81,2%
3	The ability to use terms of mathematical notations and structures to present ideas, describe relationships with situational models	59,6%	72,8%
	Average	65,83%	74,57%

Table 3 shows that the experimental class communication skills are better than the control class communication skills. The mean difference was 8.3%, the experimental class was 8.3% better than the control class. However there is one aspect of communication where the control class is better than the experimental class. In terms of the ability to express mathematical ideas through writing and demonstrate them and visualize them visually. There are several considerations analyzed in this study to see the cause of better control classes from experiments. One of them is gender, the control class is more women than men. This is in line with research conducted by Dewi (2009) indicating that written communication of female students who possess mathematical skills is delivering more accurate information than male students who have moderate math skills. The mathematical communication of female students who have math skills is more accurate and more complete conveying information in oral mathematical communication than male students who have moderate math skills. Meanwhile for the other two aspects of experimental class communication skills are much better than control classes.

Statistic subject that taught in this lecture begins with a content that has been studied at senior high school level. From the discussions with students A, he said that “I have many difficulties to learn statistic, why do there must be a statistic again mam, whereas social students avoid mathematics?” Then, I as lecture continued asking them, I asked “What make you dislike mathematics?” Students B said, “Mathematics can’t be applied in daily life, just a dizzying count”. Lecture said, “Have you ever came to your friends without notice? Are you sure you will meet your friend? What percentage of possibilities will you meet with your friends? Here is the role statistics science, by studying the statistics, especially the probability you will know probability you will meet with your friends or not meet, just 50% -50%”. In addition, the statistics learned at this level make you more fully understand about the percentage and the failure of the students that you teach in classroom learning next time, the failure due to the material or teaching models. Another students said, “Does everyone should be able to read bar charts or tables? How important do they understand the tables and diagrams? Is there any more easy way to read and get information again only by reading the words and sentence?”. Based on discussion with the students, it can be concluded that the student in social major prefer read the text to reading the information based on the table or the diagram. They also assume that mathematics is not important subject because in the teaching and learning process, when they become a teacher, at the time, they just teach about the values, laws and government regulations. Even though the symbol in mathematics is part of the language that can be used to communicate.

Notes or learning using the tasks that have been developed to get a positive response from the students. Based on the questionnaire distributed to students, the profile of Introduction to Statistics learning activities

using the Knisley Model, the students felt that: Learning by using the Knisley Model encourages students to be active in learning. Opportunities of sharing make the learning atmosphere more fluid, not tense and nervous during the learning and create student courage. Such lecture models are perceived as new and different learning experiences, so it takes time for them to adapt. Learning habits tend to be constructive, faster when done together through other math courses. The results of this study are similar to the findings of Goddess that the ability of mathematical communication to be increased with the election of a fairly good learning model. Examples of learning models conducted by Goddess is with peer tutor learning model can improve the ability of mathematical communication. One attempt to as in the first aspect is to habituate learning tend to be kontruktivis, will be faster when done together through other math lectures.

5. Conclusion

Statistics is a part of mathematics, the language of mathematics as one of the way of communication. The language is universal and symbolic that can be understood by everyone in the world. Notes by using teaching materials and student tasks that have been developed following the stages Knisley model is quite effective in improving the mathematical communication skills of civics students in the course Introduction to Vector. Develop teaching material of mathematics subject matter on mathematics and mathematics education projection and present it according to Knisley Model. Communication is a key part of students' learning. The communication skills that students learn now can benefit them in the future. According to the National Council of Teacher of Mathematics (NTCM), "Changes in the workplace increasingly demand teamwork, collaboration, and communication" (NCTM, 2000). Understanding vocabulary can help to become better communicators. "Teachers can stimulate students' growth of mathematical knowledge through the ways they ask and respond to questions" (Piccolo, Harbaugh, Carter, Capraro, & Capraro, 2008).

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