Students’ Words in Mathematical Communication in Classroom Using Lesson Study and Open Approach

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Abstract. This study aimed to investigate student’s words in mathematical communication in classroom using Lesson Study and Open Approach. The target group was 8 eleventh grade students (separated 2 groups and 4 people per group) in which studying in the Intensive Science and Mathematics English Program, the second semester of 2016 school years at Boonwattana School. The data collection tools were 5 lesson plans of probability learning unit, file note, video, voice recorder and interview note. For the data analysis, Emori [2]’s framework was used to interpret students’ mathematical communication followed by Cathcart, Samovar and Henman [1]’s framework in order to identify the type of students’ words using. The study results revealed that in the classroom using Lesson Study and Open Approach, the students express 3 characteristics and use words as detail: 1) Rigorousness, while the target group attempt to grasp problem situations and solving problem. The words were used as an express their ideas, the students communicate by using concrete words and descriptive words, after that their friends able to perceive it. 2) Economy, it was noticeable in students’ communication which was precisely explained and exactly perceived by their friends, the students communicate by using abstract words, concrete words and judgmental words after that their friends able to show evaluation and personal react which were considered. 3) Freedom, the students have independent and different thinking. The students communicate by using abstract words, concrete words and descriptive words in order to explain their ideas independently. In all of 3 characteristics, it did not found polarised words, the students did not use words to evaluate and argue their friends’ ideas as completely difference.

1. Introduction

Learning in the modern world calls for students to interact with others more. Including in the world of work and coordinating with others is very important. Communication skills are a tool to prepare the students for the real world [8]. But most of the teaching and learning management is focused on the interaction between the instructor and the learner, or students with subject matter, but ignore the relationship between the learner and the learner [7]. Most of the teaching and learning management in Thai schools was taught in the school which focuses on learning achievement do not care about the learning process of the students. It is obvious that most teachers focus on teaching by paying attention to teachers as the main way to transfer knowledge from teacher to learner by various forms such as lecture demonstration of teachers with various devices or explanation. The model of the educational activities should be emphasized so that students can learn and apply in everyday life to succeed in the future. The learning activities for students in mathematics are the same. We must strive to provide
instructional activities that students can link to solve the problem by themselves. This is an opportunity for students to learn by their potential [4].

Open Approach is a teaching approach that focuses on problem solving. Students can use their existing knowledge to solve problems that have been created until they have developed their way of thinking. Teachers must try to understand the students’ ideas that arise during problem solving in order to motivate and enhance students' ideas. Students are encouraged to share their ideas. There are 4 steps of open approach; 1) Posing open-ended problems, 2) Students’ self-learning, 3) Whole class discussion and comparison and 4) Summing-up by connecting students’ emergent mathematical ideas. There are 3 types of open-ended problem; 1) Processes are open, refers to the problem that have several solving methods, 2) Answers are open, the problem with a wide range of answers or multiple answers, and 3) Problem to problem, it means that students can develop new problem from an original problem [4]. The problem situation in the open approach is the openness in terms of having a wide range of solutions or multiple answers. This problem will allow students with different abilities to use their knowledge to solve problems manually. Once students have solved their problems, they will be able to draw their own mathematical ideas. In Thailand, open approach was integrated with lesson study by Assoc. Prof. Maitree Inprasitha since 2002 [3].

Stigler and Hiebert [9] said that lesson study was teacher development system is used in schools. Teachers develop lesson plans before teaching, bring developed plan in the real classroom and observation, reflection of the lesson and develop the lesson plans. The obvious thing is that the teacher has improved the lesson together. The important thing in the classroom is to plan for the development of the learner in the classroom and sharing knowledge with other teachers. Inprasitha, Inprasitha and Pattanajak [4] and Inprasitha, Loipha and Silanoi [5] said that lesson study was challenges in the classroom. It was the development of learning in the classroom that needs to change and sharing knowledge and problems in class with other teachers, Including the teacher's perception of the goal of teaching together. Inprasitha, Loipha and Silanoi [5] stated that lesson study has 3 phases as follows; 1) Collaboratively design research lessons (Plan), 2) Collaboratively observing the research lessons (Do) and 3) Collaboratively reflection or post-discussion (See). Based on the concept of lesson study above, it was a way to develop the teaching of a team of teachers who exchange knowledge for use in developing lesson plans that bring open-ended problems together. Then put the lesson plan into use in the classroom by a teacher and classroom observation by observing teachers, and the teachers together reflect the results of the teaching to develop the next lesson together.

Mathematical communication was integrating activities with problem solving; include discussion, talk, interaction, and reasoning related to solving mathematics problems. In addition, communication in the learning process and teaching mathematics is also an important part and need for mathematics. Because communication is a way of exchanging ideas and creating a clear understanding of mathematical problems when considering the characteristics of communication. Then consider the word “Communication” focus on the mathematical thinking process. Mathematical communication is the mathematical relationship of the participants in the communication process. Mathematical communication is also an important key to developing mathematical problems. Most teachers are interested in the amount of speech a student has, but the effectiveness of such mathematical communication has never been determined through the expressions of the words communicated, and the memory of man is to determine things through words. That is, we will know, we have to create in the form of terminology used in mathematical communication or doing something in the mathematical structure [2].

The main communication problem is caused by the use of specific words. This is because the content of the audience is not consistent with the meaning of the listener. These problems can be disappeared by explaining the idea with the use of words in the reasoning [11]. In addition, the terms used in the classroom in mathematics are based on the ability of each student to express their own words. The development of the appropriate form of the word depends on the student's choice of words to suit the context. Of course, there is a lot of information about the nature of the message itself.
Cathcart, Samovar, Henman [1] said that the choice of words and the meanings of words can express the self-concept. The concept of the messenger is used to confirm and adjust the language to suit the communication and reduce the distortion of the substance.

From the above that the mathematical communication had important skill and ability. The mathematical communication is the mathematical thought process of participants through communication. Keyword selection and word meanings can express the concept of the dispatcher and the message. Mathematical communication is also important in developing mathematical problems. In teaching and learning at the high school, students do not focus on communication, but mathematical learning management uses open approach innovation. The open approach determines the mathematical activity. Students are encouraged to express their ideas in problem solving. The mathematical instruction is consistent with the concept of mathematical learning. This is a guideline for development of mathematical learning activities that promote meaningful mathematical learning. The study of the use of words in mathematical communication of students in grade 11 using open approach is important issue to study.

2. Research Objectives
The research objective is to survey the 11-grade students’ words in mathematical communication in classroom using lesson study and open approach.

3. Research Methodology

3.1. Target Group
Target group were 8 students in grade 11, which studying in the Intensive Science and Mathematics English Program, the second semester of 2016 school years at Boonwattana School.

3.2. Research Instruments
- Lesson plans of 5 mathematics lessons on probability for 11-grade students.
- Field note for recording student's words in mathematical communication during classroom instruction.
- Interview note for taking note of students’ opinion on their mathematical communication and words using.

4. Data Collection
The researcher and research assistant were planned data collection collaboratively. Data were collected by fieldnote recording through classroom observing, video recordings during classroom instruction, and audio recording during interviews after classroom activities. Video and audio were transcript to protocols of classroom instruction and interviews.

5. Data Analysis
Data were analyzed by analytic description according to the method of protocol analysis. Data were analyzed by using frameworks of mathematical communication [2] including of 1) rigorousness 2) economy and 3) freedom, and words using [1]including of 1) abstract words, 2) concrete words, 3) descriptive words, 4) judgmental words and 5) polarized words. In analytic description, evidences of students’ voices, written works, movements, and facial expression were compound in analysis to indicate students’ words in mathematical communication. The exemplary detail of analysis could show as follows.
5.1. The students’ words in rigorousness

Table 1. shows a discussion to find the method of rolling 2 dices providing a sum mark lower than 5 as following protocol.

| Item | Subject | Answer |
|------|---------|--------|
| 75   | Salin   | Probability that is provided from rolling 2 dices has 36 methods and then we write ... what was that? Probability of a sum mark lower than 5, right? |
| 76   | Pha     | Probability of the mark … |
| 77   | Orn     | Probability of a sum mark of 2 dices providing lower than 5 must also be explained that has 10 methods. |
| 78   | Su      | So how to know it? Distribute it all? |
| 79   | Orn     | Yes, let’s write it down all. There’re 10 methods. |
| 85   | Su      | Why does it have 10 methods? |
| 86   | Orn     | It is lower than 5 marks, right? For the sum mark lower than 5 methods, first one is 1, 1, 2. |
| 87   | Orn     | It must have 1, 1, 2. |
| 88   | Salin, Orn, Su | 1, 2, 1, 3, 1, 4 |
| 89   | Orn     | This has 4 numbers. |
| 90   | Salin   | Ahh |
| 91   | Orn     | The second one has 2, 1 |
| 92   | Salin, Orn | 2, 2 |
| 93   | Orn, Su | 2, 3 |
| 94   | Orn     | The third one is … |
| 95   | Orn, Su | 3, 1, 3, 2 |
| 96   | Su      | The forth one has only 2, 1. |
| 97   | Pha     | Umm |
| 98   | Orn     | Then it decreases as 4, 3, 2, 1. And its sum is 10. |

An analysis of rigorousness of mathematical communication is seen from giving mathematical opinions during students’ conversation and answering question, which students give opinions perceptively and correctly as mathematical accuracy. From the mathematical communication protocol, students searched the methods to roll 2 dices providing the sum mark lower than 5 as shown in Item 77. Orn said “Probability of a sum mark of 2 dices providing lower than 5 must also be explained that has 10 methods”. Orn had given an opinion that there were 10 methods for rolling the dices and expressed this method by saying “1, 1” instead of rolling first dice getting 1 mark and another dice getting 1 mark. In Item 86–Item 89, all student cooperated to express the methods of rolling the dices getting lower than 5 marks as well as Orn had summarized that “it then decreases as 4, 3, 2, 1. And its sum is 10” as seen in Item 98, which indicated that rolling the dices gaining a sum mark of lower than 5. With rolling first dice presenting 1 mark, there are 4 methods. With rolling first dice presenting 2 marks, there are 3 methods. With rolling first dice presenting 3 marks, there are 2 methods. With rolling first dice presenting 4 marks, there is 1 method. The students’ idea expression about the number of methods of rolling the dices proving lower than 5 of sum marks was mathematically correct which showed that this characteristic of communication is rigorous.

In the rigorousness of mathematical communication, the students had said the words as following.
5.1.1. **Concrete words:** According to Episode 1, as analyzing the students’ concrete word using from their conversation that they used specific saying, obvious meaning and understandable explanation. These words could reduce mistake of meaning understanding. According to the protocol, in Item 77, it was seen Orn said “Probability of a sum mark of 2 dices providing lower than 5 must also be explained that has 10 methods”. It was seen in Item 77 that Orn presented her idea to roll the dices obtaining lower than 5 marks and further expressed that it would have 10 methods. This demonstrated Orn’s saying was specific into the methods to rolling the dices presenting lower than 5 marks and she said further obviously that there were 10 methods to rolling the dices presenting lower than 5 marks. This presented the students used the concrete words.

5.1.2. **Descriptive words:** According to Episode 1, as analyzing the students’ descriptive words from the conversation that the students explained the fact details. The objective is to make the receivers understand more than that of speaker. These words are neutral, not judgmental. According to the protocol, in Item 86, it was seen a phrase that “it is lower than 5 marks, right? For the sum mark lower than 5 methods, first one is 1,1, 2". This was a description to express the fact by giving an example to others to understand what there are methods of rolling the dices providing lower than 5 marks. This was the communication which purposed the receivers understand better. It indicated that the students had used descriptive words.

5.2. **Students’ words in economy**

**Table 2.** shows a discussion to find the method of rolling 2 dices which provides a sum mark higher than 5 as following protocol.

| Item  | Speaker  | Sentence                                      |
|-------|----------|-----------------------------------------------|
| 69    | Orn      | Let us find the method of a sum mark lower than 5, first? |
| 70    | Salin    | Do we use a formula?                          |
| 71    | Orn      | Not sure. It’s just to find the methods of a sum mark lower than 5 first, and then remove them from all. |
| 72    | Pha      | (Nodding off) Well, it all has 36 methods, right? |
| 73    | Orn      | Write it down, all opportunity of rolling the dices is 36 methods. |
| 74    | Su       | So what? Find the sum mark lower than 5, right? |
| 75    | Salin    | All opportunity of rolling the dices is 36 methods, and so what? The opportunities of the mark lower than 5? |

An analysis of economy of a mathematical communication character is presented from the giving mathematical opinion during students’ conversation and answering question which the students’ opinions are short communication but contain a mathematical reason. From the students’ communication about finding a number of methods that provides lower than 5 marks, in the beginning, the students found all result of the sum mark higher than 5, as seen in Item 69, which said “let us find the method of a sum mark lower than 5, first?”. Orn purposed to her group mates to find all method of rolling 2 dices first, and then find the methods of rolling the dices providing the marks lower than 5, after that, remove them from all method. Finding all method of rolling the dices providing the marks lower than 5 and then minus by the unconcerned methods is a mathematically reasonable idea expression. This indicated that the students had used word’s economy.

In the economy of mathematical communication, the students had said the words as following.

5.2.1. **Abstract words:** According to Episode 2, as analyzing students’ abstract word using from their conversation using overview, unspecific and wide meaning saying. These words are difficult to understand. From the protocol, it was seen in Item 69 that Orn said “let us find the method of a sum mark lower than 5, first?”. Orn described her own idea about finding a number of method of rolling 2 dices getting the mark higher than 5 by finding the methods of rolling the dices providing mark lower.
than 5, before, and removing them from all method of rolling 2 dices. But as seen in Item 69, Orn said “let us find the method of a sum mark lower than 5, first?” It was speaking of only a part of all solution. This made her group mates confused that what it really means by Orn’s saying. It then was seen Salin’s question in Item 70 that is “Do we use a formula?”. Orn saying in Item 69 was indicated that the students had used the abstract word.

5.2.2. Concrete words: According to Episode 2, as analyzing the students’ concrete word using from their conversation that they used specific saying, obvious meaning and understandable explanation. These words could reduce mistake of meaning understanding. From the protocol, in Item 71, Orn said “it’s just to find the methods of a sum mark lower than 5 first, and we then remove them from all”. Orn had explained the solution to find the methods of rolling the dice proving the marks more than 5, which specified to finding the all method of rolling 2 dices first and then minus with the methods of rolling the dices proving the marks lower than 5. This communication obtained the meaning of obvious solution and showed that the students had used the concrete words.

5.2.3. Judgmental words: According to Episode 2, as analyzing the students’ judgmental word using from their conversation using to evaluate and individual reaction, these words will present positive or negative reaction of messenger to receiver know the situation. From the protocol it was seen in Item 72, Pha said “(Nodding off) Well, it all has 36 methods, right?”. Pha reacted by nodding her head off and said “well”, simultaneously. This evaluation meant that she agreed with Orn’s idea as in Item 71 that Orn said “it’s just to find the methods of a sum mark lower than 5 first, and we then remove them from all”. It meant Pha showed positive reaction to Salin’s message which indicated that the students had used the judgmental words.

5.3. Students’ words in freedom

**Table 3.** shows a discussion after finding the method of rolling 2 dices which provides a sum mark higher than 5 using distribution method as following protocol.

| Item | Student | Dialogue |
|------|---------|----------|
| Item 98 | Orn | Then it decreases as 4,3,2,1. And its sum is 10. |
| Item 99 | Salin | Why don’t we draw linking map? |
| Item 100 | Su | Link the mark of first dice to that of second dice, but sum of both is lower than 5. Like this? |
| Item 100 | Orn | Mapping? Or what? Might as well do table. |
| Item 101 | Salin | Mapping is easier. It’s just link the first dice to the second dice, provide the first dice as 1 mark then link it to the marks of the second dice as 1 2 3 4 as written. Then provide the first dice as 2 marks and the second dice is 1, 2 and so on as you wrote. |
| Pha | It’s called Tree map, right? Or Tree? I’ve seen before. |
| Item 102 | Su | Like this? (Su writes the arrows to link 1 to 1,2,3,4) |
| Item 103 | Orn | It’s probably called tree map. |
An analysis of freedom of a mathematical communication character is presented from the giving mathematical opinion during students’ conversation and answering question which their giving opinions have expressed in messages or received materials or developed received materials. According to the conversation protocol in Item 98, Orn said “Then it decreases as 4,3,2,1. And its sum is 10”. It meant Orn had proposed her idea to her group mates then got result distribution approach of method of rolling the dices providing the sum mark lower than 5 that is 11,12,13,14,21,22,23,31,32,41. After they’d got the conclusion from Orn’s idea, Salin proposed her own solution as seen in Item 99 “Why don’t we draw linking map?” and proposed further idea by Orn as seen in Item 100, Orn said “Mapping? Or what? Might as well do table”. It was seen that for solution of rolling 2 dices getting the sum mark lower than 5, the students showed various ideas to solve the problem such as distribution method, tree mapping and table. This showed that the students’ mathematical communication character was freedom.

In the economically mathematical communication, the students had said the words as following.

5.3.1. Abstract words: According to Episode 3, as analyzing students’ abstract word using from their conversation using overview, unspecific and wide meaning saying. These words are difficult to understand. From the protocol, it was seen in Item 99 that Salin said “… linking map”. Salin had proposed her own idea to find the number of methods of rolling the dices proving the mark lower than 5 using drawing tree maps as said “linking map”. This described overview feature of tree map which confusing their group mates. It showed that the students had used abstract word.

5.3.2. Concrete words: According to Episode 3, as analyzing the students’ concrete word using from their conversation that they used specific saying, obvious meaning and understandable explanation. These words could reduce mistake of meaning understanding. From above protocol, in Item 100, Su said “Link the mark of first dice to that of second dice, but sum of both is lower than 5. Like this?”. Su had described the feature of “linking map” as Salin said in Item 99. Su’s description approach was to say what she understands with saying the detail of the method of finding marks of 2 dices lower than 5 using linking a couple of the 1st and 2nd dice providing the mark lower than 5. This communication was clearly in solution. It presented that the students had used concrete word.

5.3.3. Descriptive words: According to Episode 3, as analyzing the students’ descriptive words from the conversation that the students explained the fact details. The objective is to make the receivers understand more than the understanding of speaker. These words are neutral, not judgmental. According to above protocol, in Item 101, Salin said “Mapping is easier. It’s just linked the first dice to the second dice, provide the first dice as 1 mark then link it to the marks of the second dice as 1 2 3 4 as written. Then provide the first dice as 2 marks and the second dice is 1, 2 and so on as you wrote.” Salin had explained to see the fact by giving some examples to their group mates to understand her idea of drawing map to express the methods of rolling the dices getting the mark lower than 5 which this communication want the receivers understand better. This indicated that the students had used the descriptive word.

6. Results
The research result reveals the students’ words in mathematical communication. There are 3 characteristics of mathematical communication; 1) Rigorousness 2) Economy and 3) Freedom. In mathematical communication, there are 4 types of words as follows: 1) Abstract words: It was a type that students talk about or describe using broad words. There are no specific types of explanations. This type of speech is often unclear. It is difficult to understand. This ambiguous language can confuse others. 2) Concrete words: It is the type that students describe as specific and can explain what is recognized. These words make the meaning clearer. It also reduces the misunderstanding of the meaning of words. 3) Descriptive words: It is the type of student that uses material words that interest recipients and can understand the substance. This type of statement is not a verdict. It is a neutral term.
used to describe the truth that the messenger knows. And 4) Judgmental words: It is the type that students have to say to express their values and reactions. This type of word expresses the positive or negative reaction of the dispatcher to the receiver, rather than describing the situation. The results are shown in Table 1.

Table 4. The appearance of students’ words in mathematical communication in classroom using lesson study and open approach

| mathematical communication | Abstract words | Concrete words | Descriptive words | Judgmental words | Polarized words |
|----------------------------|----------------|----------------|-------------------|------------------|----------------|
| Rigorousness               | -              | ✓              | ✓                 | -                | -              |
| Economy                    | ✓              | ✓              | -                 | ✓                | -              |
| Freedom                    | ✓              | ✓              | ✓                 | -                | -              |

According to table 3, the study results revealed that in the classroom using lesson study and open approach, there are students’ mathematical communication includes 3 characteristics and the students’ words using in each characteristic as detail: 1) Rigorousness, while the target group attempt to grasp problem situations and solving problem. The words were used as an express their thinking, the students communicate by using concrete words and descriptive words, after that their friends able to perceive and understand it. 2) Economy, it was noticeable in students’ mathematical communication which was precisely explained and exactly perceived by their friends, the students communicate by using abstract words, concrete words and judgmental words, after that their friends able to show evaluation and personal react which were considered. 3) Freedom, the students have independent and different thinking. The students communicate by using abstract words, concrete words and descriptive words in order to explain their ideas independently. In all of 3 characteristics, it was did not found polarised words, the students did not use this type of words to evaluate and argue their friends’ ideas as completely difference.

7. Conclusion and discussion

The study results revealed that in the classroom using lesson study and open approach, the students expressed 3 characteristics of mathematical communication and used types of words in each characteristic. For the rigorousness, the students used concrete and descriptive words to make sense the problem situations and to express their ideas in solving mathematics problem. They can understand the problem situation and the ideas for solving problem. For the economy, the students used concrete and descriptive and judgmental words to precisely communicate their ideas. Their friends can understand the words exactly according to student’s intention. For the freedom, the students used abstract, concrete and descriptive words to communicate their different ideas. They have independent to think by themselves and explain their ideas independently. In all of 3 characteristics, it was did not found polarised words, the students did not use words to evaluate and argue their friends’ ideas as completely difference. Because in classroom using lesson study and open approach, mathematical communication is a tool for potential compiling ideas by speaking, acting and writing to express and explain the ideas. It provides the students to explain, collect, expand and share ideas with the others. Therefore, they can use the words in mathematical communication.

The research results consistent with Inpanya [3] who studied of mathematical communication between teacher and students in open approach classroom. The study results revealed that mathematical communication among teacher and students through open approach could generate three chains of mathematical communication, namely coordinate chains of mathematical communication, resonant chains of mathematical communication, and emergent chains of mathematical communication. Moreover, it consistent with Inprasitha, Pattanajak and Inprasitha [5] that studied of
student’s mathematical communication in teacher professional development. The research used qualitative research methodology consisting of ethnographic approach; teaching experiment; protocol analysis and analytic description. The study results revealed that in mathematics classrooms taught by open approach, it provides an opportunity for the students to communicate mathematics by the verbal and non-verbal language. The students have mathematical communication with 3 communication features include rigorousness, economy, freedom of thinking while they participated in communication. Additionally, the research result according with Thinwiangthong [10] found that the students have mathematical communication, includes rigorousness, economy and freedom characteristics, in small group within the context of lesson study and open approach classroom.

8. Recommendation

8.1. Recommendation for Implementation of Research Findings
This study found the students’ words in mathematical communication in classroom using lesson study and open approach. In lesson planning, the students’ words can be used as a guideline for mathematical ideas in problem solving through open approach. In lesson implementing, teachers can use words of students to understand and utilize by highlighting, expand, connect, and summarize the student's mathematical ideas. In lesson reflection, teachers can use the students’ words in mathematical communication to adjust their instruction.

8.2. Recommendation for Further Research
The further research should be the study of how teachers use the students’ words in mathematical communication to improve the lessons in context of lesson study and open approach classroom. Another one is the study of complexity and relation between words using and mathematics contents for high school students, because the high school mathematics contents is quite complex and difficult for teaching and learning by using lesson study and open approach.

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