PROCEEDING ISBN : 978-602-1037-00-3

E – 27

Developing Teaching Material of Inquiry Co-operation Model for Enhancing Student' Mathematical Communication Ability

Heni Pujiastuti
Department of Mathematics Education
Universitas Sultan Ageng Tirtayasa
Banten
hpharyadi@gmail.com

Abstract

Communication is one of the factors that contribute to success in solving problem. Student with high in communication skill tend to be able to solve the mathematical problems well. However, the facts revealed by several studies and preliminary studies it is known that students' mathematical communication ability is still low. Therefore, it is required an effort to enhance students' mathematical communication ability through Inquiry Co-operation Model (ICM). To implement ICM are needed teaching material which is appropriate to ICM components and student characteristics. The purpose of this research is to develop teaching material appropriate to the learning component of the ICM and student characteristics. The method used in this research is research and development. Design validation performed by expert mathematicians and mathematics education involving lecturers and junior high mathematics teacher. Product testing and utility testing conducted on junior high school students in Serang City, Banten Province, Indonesia. Based on the result of study revealed that: (1) Teaching materials of ICM get the mean expert judgement 97.21%; (2) Teaching materials of ICM get a positive response from the students 88.11%; (3) The enhancement of student' mathematical communication ability who recived ICM better than students who received conventional learning; and (4) The enhancement of student' mathematical communication ability who recived ICM is 0.58 which is medium category. Based on the development stages can be concluded that the teaching materials of ICM judged worthy and ready for use in learning mathematics, especially on the material of Polyhedron for junior high school students.

1. Introduction

One of the goals of mathematics learning is that students are able to resolve mathematical problems. Student success in solving mathematical problems is supported by mathematical communication ability [1]. Communication ability is a prerequisite for solving mathematical problems [2]. This indicates that in order to solve problems effectively, students must have a good communication ability. Students who has a high mathematical communication ability tend to be better able to resolve mathematical problems better than students who has low communication ability.

Communication is the essence of teaching, learning, and access to mathematics [3]. Communication (language) is an important component in students' understanding of mathematical concepts [4]. Both of these statements imply that mathematical communication ability need to mastered by students. However, the facts revealed by several studies concluded that the mathematical communication ability of students is still low [5,6.7]. The results of these studies illustrate that in general mathematics learning process that occurs at this time has not been able to train and develop students' mathematical communication ability as well. This requires an effort that enables students to develop their mathematical communication ability optimally. Teachers'

efforts to do that is by presenting a model of learning that supports and training aspects of the mathematical communication ability in the learning process.

Aspects of students' mathematical communication ability can be trained through learning Inquiry Co-operation Model (ICM). ICM is a process of learning that emphasizes inquiry, discovery of a concept (knowledge), and problem resolution. The principles of ICM is that the knowledge students gain is the result of investigations (findings) of the students themselves. ICM consists of eight components of learning process, namely: *getting in contact*, *locating*, *identifying*, *advocating*, *thinking aloud*, *reformulating*, *challenging*, and *evaluating* [8]. The eight components are integrated each other and engage students to be more active in their learning.

Students' involvement in ICM can be seen from the processes that occur at each components. In the component *getting in contact*, a teacher presents a situation or mathematical problems related to the material being studied. Then in *locating* component, each student learns how to express and write down their perspective (ideas or opinions) to a given problems. This is followed by identifying the things that are necessary and are known from the given problems (*identifying*). *Advocating* component may arise when students are discussing and critiquing each other, giving advice and when providing an alternative way to other students. Furthermore, each student is guided to be able to solve the problem based on the identification result and the way they had planned (*thinking aloud*). In *reformulating* component, students are guided to solve the problem in a different way or to make a conclusion with their language. Once they understand simple problems, they are given a challenge (*challenging*) through the provision of more complex problems. In the final stage, teacher does evaluation (*evaluating*) in order to determine the quality of students' understanding in the concepts that have been studied.

Through the eight learning components of ICM, estimated students' mathematical communication ability can be trained and improved. However, to ensure that the eight components are done in the learning process, needed a teaching material support. Teaching materials in accordance with the characteristics of students and includes eight components of ICM learning. Therefore, this research aims is to develop teaching materials that support the ICM learning.

2. Theory

2.1 Mathematical Communication Ability

Communication is defined as a process of delivering a message from the communicator to the recipient (communicant) through certain media impacting [9]. Communication becomes a very important part both in mathematics and in the mathematics learning. As stated in the National Council of Teachers of Mathematics (NCTM), communication is an essential part of mathematcs and mathematics education [10]. Mathematics learning program that occurs in the classroom, from kindergarten up to grade 12 should be directed so that students able to:

a. Organize and consolidate mathematical thinking through communication;
b. Communicate mathematical thinking coherently and clearly to his friends, teachers, and others;
c. Analyze and evaluate the mathematical thinking and strategies of others;
d. Using mathematical language to express mathematical ideas clearly.

Mathematical communication ability that will be measured in this study, especially the written mathematical communication ability (writing communication). The indicators of mathematical communication ability measured is adapted to the material and thinking level of junior high school students. Therefore, the indicators used to measure students' mathematical communication ability in this study are detailed as follows:

a. Stating a situation or idea in the form of images;
b. Stating a situation or idea in the form of mathematical symbols or mathematical models and solve it; and
c. States and describe an image or mathematical model in the form of mathematical ideas.

2.2 *Inquiry Co-operation Model* (ICM)

ICM is fundamentally a process of learning that emphasizes inquiry, discovery of a concept (knowledge) and problem solving. Through the investigation process undertaken during learning, students 'as if' find themselves the concept of matter being studied. Intent 'as if' in this case that the teacher still plays an important role in the investigation process of the student. Teachers do not allow students to investigate a topic (material) freely in accordance with the wishes of students, but still directed and guided by the teacher. This is because if the students are free to explore any topic freely, feared targets set out in the curriculum material is not achieved.

As stated in first that ICM consists of eight components of learning process, namely: *getting in contact*, *locating*, *identifying*, *advocating*, *thinking aloud*, *reformulating*, *challenging*, and *evaluating*. The eight components are integrated each other and engage students to be more active in their learning. In the ICM learning process, teachers and students are active in conducting an investigation or problem-solving process. Teachers actively in a creative situation or problem will be the topic of student investigation; provide guidance or scaffolding to students; and condition so that students can express their perspective, inquired, and answer the questions raised by the teacher or other students. Meanwhile, the students are active in the investigation of a situation or mathematical problems that have been designed by teachers, revealed his perspective, asking, searching for various aternatif solving strategies, and use these strategies in solving a given problem. As for the situation or mathematical problems created by teachers can be presented in the form of teaching materials.

3. Method

This study aims to develop and produce the product in the form of teaching materials. Teaching material is expected to help students and teachers in the learning of mathematics in the classroom, so that learning becomes more effective. Therefore, this study includes research into the type of development (research and development). Methods of research and development is a research method that is used to generate and test the effectiveness of a particular product [11].

3.1 Model

The products produced in this study is teaching materials that support learning in accordance with the characteristics of ICM in particular on the subject of Polihedron for junior high school students. Development model used in this study consists of 10 steps: 1) the potential and problems, 2) data collection, 3) product design, 4) design validation,

5) design revision, 6) product testing, 7) product revision, 8) utility testing, 9) product revision, and 10) mass production [11].

3.2 Procedur

Based on the development model used in this study consisted of 10 stages, the development stages are described as follows.

a. The potential and problems

Potential use for the development of teaching materials including books, student worksheet, module, and the Internet. The principal issues that arise in the study of the low ability students' mathematical communication due to limited books, worksheets, modules, or teaching materials that are able to train aspects of students' mathematical communication ability. Therefore, in this study developed teaching materials appropriate to the learning components of ICM, in particular to the subject of Polihedron that can assist in the training of students' mathematical communication ability.

b. Data collection

At this stage of collecting the necessary materials in the process of materials development. The materials were collected among which the material problems, exercises, images, photos, fonts will be used in the teaching materials. Materials needed in this stage is obtained from sources such as the library, the Internet, and photographs taken directly from the surrounding environment. The photos of students taken directly during a limited test and during classroom activities.

c. Product Design

The drafting of teaching materials that describe the appearance of each page.

d. Design Validation

Validation of teaching materials is done by presenting the experts, including content and pedagogy experts. This test is intended to assess the feasibility of teaching materials of ICM based on the viewpoint of expert judgement.

e. Design Revision

Suggestions and criticisms are obtained based on the judgement of content and pedagogy experts, used to improve and enhance teaching materials that have been made and standards needs of students and teachers in the learning activities.

f. Product Testing

Teaching materials have been improved based on the advice of content and pedagogy experts, then tested on a limited basis. The test is performed to obtain a general description of teaching materials from the viewpoint of users (students).

g. Product Revision

Based on the small scale test results, furthermore improvement of teaching materials. This is done to improve the description of concepts or materials that are considered difficult to understand by student and other things that are still considered to be less. In addition, the revisions made to enhance the quality of teaching materials product that can be used in the utility testing of teaching materials on a wider scale. Thus, the shortcomings and weaknesses of the teaching materials can be repaired and can produce a good teaching material.

h. Utility Testing

After teaching material product improvements based on test results limited, furthermore testing the product in a wider scale. This is done to determine the effectiveness of teaching materials that support the ICM learning.

i. Product Revision

After testing on a wide scale, further improvement of teaching materials that support ICM learning for the final stage. These improvements made to enhance any shortcomings and weaknesses found during the learning process is carried out at the time of utility testing stage.

j. Mass Production

Teaching materials of ICM that have been finished, then reproduced and distributed free of charge to a number of junior high school mathematics teachers and students in the Serang City, Banten Province.

3.3 Data Collection and Analysis

One of the instrument used in this study is a questionnaire. Questionnaire used to determine the extent of eligibility of products generated (teaching materials of ICM). The questionnaire used consists of content expert questionnaire, pedagogy expert questionnaire, and student questionnaire. After the questionnaire data collection, data analysis stage then performed. Processing of questionnaire data is done by using a Likert scale. Likert scale is used to measure the attitudes, opinions, and perceptions of a person or group of people about social phenomena. Each respondent was asked to respond to statements with response options: Strongly Agree (SA), Quite Agree (QA), Agree (A), Disagree (D), and Strongly Disagree (SD). Scores for each positive statement that SA, QA, A, D, and SD respectively 5, 4, 3, 2, 1, while the opposite is true for negative statements.

Another instrument used is observation sheet, mathematical communication ability test. Observation sheet was used to observe the learning process uses teaching materials of ICM, namely during product utility test. Meanwhile, mathematical communication ability test instrument used to determine and compare the enhancement of communication ability of students who reccceived ICM with students who received conventional learning. Data of students' mathematical communication ability are analyzed based on the results of preconditions test.

3.4 Indicator

Indicator in this research that the teaching materials of ICM, especially on the subject of Polyhedron for junior high school students completed with the percentage of expert and student responses on a wide scale test reached more than 70% [12].

4. Result and Discussion

4.1 Teaching Material of ICM Design

After going through several stages of development, the design teaching materials of ICM produced, particularly on the Polyhedron material for junior high school students. The material presented in these teaching materials not only in the form of text and images, but also comes with illustrations and problems related to students' daily lives. The initial design of teaching materials that support ICM learning consists of 4 sub-topics, namely Cube, Cuboid, Prisms, and Pyramid. The description of teaching materials of ICM design as follows:

1) Media storage : CD-R and Paper 80 gr.
2) Size : A4
3) Thickness : 76 pages (including cover)
4) Format : *Portabel Document Format* (PDF)

5) File size : 2,728KB
6) Font : *Book Antiqua* dan *Arial*
7) Material : Polyhedron
8) *Software* : *Adobe Reader* 9

Scheme of teaching materials:

1) Cover
2) Sub-topic1: Cube
3) Sub-topic 2: Cuboid
4) Sub-topic 3: Prism
5) Sub-topic 4: Pyramid

This teaching materials begins with the display cover page, preface, and learning instructions. At the beginning of a dish containing a cube and its sub-topic covers the learning objectives to be achieved in this sub-topic. Sub-topic 1 contains material entitled "worksheet 1 Cube" and "Worksheet 2 Cube" which includes elements of the cube, the definition, the nets of the cube, the cube surface area, and volume of the cube. Sub-topic 2 contains material entitled "Worksheet 3 Cuboid" and "Worksheet 4 Cuboid" which includes cuboid elements, definitions, the surface area of the cuboid, and the cuboid volume. Sub-topic 3 contains material entitled " LKS 5 Prism" and "LKS 6 Prism" which includes the prism elements, definitions, nets prisms, prism surface area and volume of prisms. Sub-topic 4 contains material entitled "LKS 7 Pyramid" and "LKS 8 Pyramid" which includes the pyramid elements, definitions, nets pyramid, pyramid surface area, and volume of a pyramid. End of each sub-topic contains summaries and practice problems (challenges). At the end there is a reference of teaching materials.

4.2 Result of Judgement Expert

The initial design of teaching materials produced were further tested through the testing stages as follows:

a. Content Expert Judgement

Tey are 8 content expert that involved in judge these teaching materials consisting of 6 lecturer of mathematics education and 2 mathematics teachers. The experts are expected to provide advice on the judgement of teaching materials from the viewpoint of the material and mathematical concepts. Based on the content expert judgement results obtained the mean percentage is 96.79%.

b. Pedagogy Expert Judgement

Pedagogy expert differ with content expert. Pedagogy experts involved in judge teaching materials, consisting of 6 lecturer of mathematics and 2 mathematics teachers. The experts are expected to provide pedagogy aspects and advice related to judge the teaching materials from the viewpoint of the learning process, language, and student characteristics. Based on the test results obtained by the mean percentage of pedagogy experts is 97.63%.

4.3 Result of Testing Product

a. Product Test Result

After the expert judgement and repaired the teaching materials, then conducted of teaching materials on limited testing to 18 students from two different schools, 9 students from SMPN 2 Kota Serang and 9 students from SMPN 11 Kota Serang. On this

stage process was conducted in a relatively comfortable room at each school, so that students can learn these teaching materials carefully and thoroughly. That room was prepared one day prior to the limited test. Before the test, students are given instructions on how to use teaching materials of ICM. After the students finished studying teaching materials, students were given a questionnaire to determine the extent of students' response to teaching materials of ICM. Based on limited test revealed that students' response to the teaching materials of ICM is 94.66%.

c. Utility Test Result

Utility test conducted at two different schools. One class is students of SMPN 2 Kota Serang and other classes are students of SMPN 11 Kota Serang. For comparison, in each school were taken one other class, thus the total students who studied in these stage are four classes. The total students involved in this study are 152. They are 81 students of SMPN 2 Kota Serang, 40 students who received ICM (experimental group) and 41 students who received conventional learning (control group). Furthermore, they are 71 students of SMP 11 Kota Serang, 34 students in the experimental group and 37 students in the control group. Overall, they are 74 students in experimental group and 78 students in control group. Utility test was conducted in 12 sessions, including pretest and posttest. Pretest and post-test is done to know the difference between the enhancement students' mathematical communication ability who received ICM and students who received conventional learning.

To assess the learning process that occurs, conducted classroom observations at each meeting by the observer. In this study the role as an observer is a mathematics teacher at each school. After the students finished studying teaching materials, students were given a questionnaire that aims to determine students' response to teaching materials of ICM. The following is utility test result of teaching materials:

1) Data of Student' Mathematical Communication Ability (MCA)

The mean scores of students' MCA is obtained based on the pretest and posttest. Recapitulation of students' MCA test result can be seen in Table 4.1.

Table 4.1 Recapitulation of students' MCA test result

Schools	Stat	ICM				Konvensional			
		Pretes	Postes	<g>	*n*	Pretes	Postes	<g>	*n*
SMPN 2	$\bar{x}$	9,63	25,83	0,60	40	9,37	20,34	0,42	41
	s	2,90	6,38	0,22		3,42	7,22	0,21	
SMPN 11	$\bar{x}$	10,12	25,35	0,58	34	10,27	19,38	0,35	37
	s	2,69	7,09	0,24		3,02	6,47	0,21	
Total	$\bar{x}$	9,85	25,61	0,58	74	9,79	19,88	0,37	78
	s	2,80	6,68	0,22		3,25	6,84	0,21	

Note: SMI is 37

From the table above it is known that prior to the study, the experimental and control group students have the same mathematical communication ability. After the learning process, students' mathematical communication ability on the experiment group (ICM) and the control group (conventional) are increased. However, after statistically tested, enhancement of students' mathematical communication ability who received ICM better than students who received conventional learning. In particular, the

enhancement of students' mathematical communication ability can be seen in the following figure.

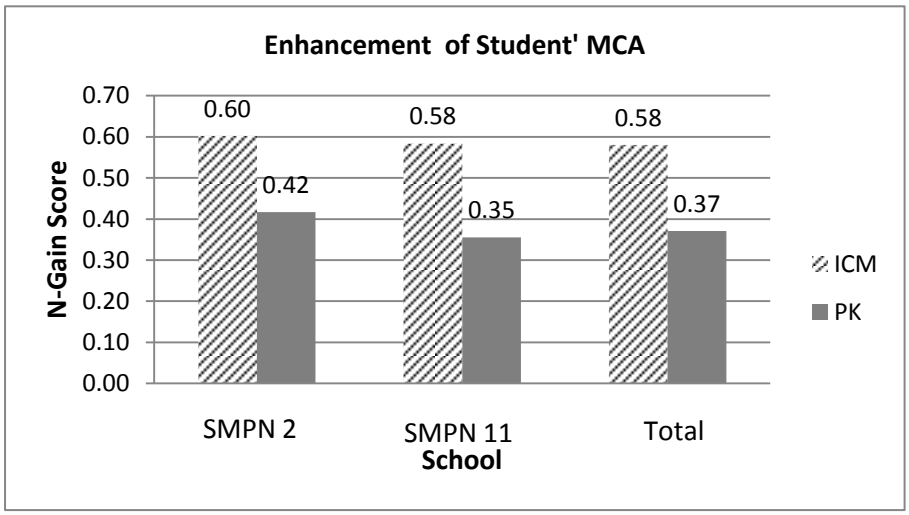

Figure 4.1 Enhancement of Student' Mathematical Communication Ability

2) Results of Student Questionnaire

Students were given a questionnaire based on utility testing is known that the mean measured ten aspects of the assessment classification is very strong. It can be seen from the total percentage is 88.11%. Its means that teaching materials of ICM get a positive response from students.

d. Teaching Material of ICM Product

The final product of the teaching material is revised from the first teaching materials product design that have been produced. The final product was the result of some improvements in terms of writing, illustration, issues, activities, summaries, a glossary, and additional indexes that exist in the teaching materials of ICM. The final product of teaching materials of ICM consists of 4 sub-topics; Cube, Cuboid, Prisms, and Pyramid. The final product of teaching materials such as the following:

Teaching Material of ICM:

1) Media storage : CD-R and Paper 80 gr.
2) Size : A4
3) Thickness : 84 pages (including cover)
4) Format : *Portabel Document Format* (PDF)
5) File size : 2,969KB
6) Font : *Book Antiqua* dan *Arial*
7) Materials : Polyhedron
8) *Software* : *Adobe Reader* 9

Scheme of teaching materials:

a) Cover
b) Sub-topic 1: Cube (Worksheet 1 dan 2)
c) Sub-topic 2: Cuboid (Worksheet 3 dan 4)
d) Sub-topic 3: Prism (Worksheet 5 dan 6)
e) Sub-topic 4: Pyramid (Worksheet 7 dan 8)

5. Conclussion

Teaching materials is needed to support the implementation ICM learning optimally. Therefore, in this study developing a teaching material in accordance with characteristics of ICM learning, particularly on the subject of Polyhedral. From the results of this study revealed that: (1) Teaching materials of ICM get the mean expert judgement 97.21%; (2) Teaching materials of ICM get a positive response from the students 88.11%; (3) The enhancement of student' mathematical communication ability who recived ICM better than students who received conventional learning; and (4) The enhancement of student' mathematical communication ability who recived ICM is 0.58 which is medium category. Based on the development stages can be concluded that the teaching materials of ICM judged worthy and ready for use in learning mathematics, especially on the material of Polyhedron for junior high school students.

6. Recommendation

Based on the results of study, some suggestions can be given including:

a. The situation or mathematical problems presented in teaching materials should be to suit the level of students thinking skills and student learning environment, so that able to encourage all students to think and actively involved in learning process.
b. The ability and speed of students learning relatively different. To overcome these differences, teachers can ask some of students more able to help other students who are less intelligent, in learning or solve problems in the teaching materials.

References

[1] Stacey, K. (2005). The Place of Problem Solving in Contemporary Mathematics Curriculum Document. *Journal of Mathematical Behaviour*, 24, 341-350.
[2] Hulukati, E. (2005). *Mengembangkan Kemampuan Komunikasi dan Pemecahan Masalah Matematika SMP Melalui Model Pembelajaran Generatif*. (Unpublished doctoral dissertation). UPI, Bandung.
[3] Lindquist, M.M & Elliott, P.S. (1996). Communication an Imperactive for Change: A Conversation with Mary Lindquist. *Communication in Mathematics K-12 and Beyond*. Virginia: NCTM.
[4] Lim, L. & Pugalee, D.K. (2005). *Using Journal Writing to Explore* "*They Communicate to Learn Mathematics and They Learn to Communicate Mathematically*". Retrieved from http://www.nipissingu.ca.oar/new issue-V722E.htm.
[5] Pujiastuti, H. (2012). *Analisis kemampuan pemecahan masalah dan komunikasi matematis siswa SMP di kota Serang.* Preliminary Study Report: unpublished.
[6] Kadir. (2010). *Penerapan Pembelajaran Kontekstual Berbasis Potensi Pesisir Sebagai Upaya Peningkatan Kemampuan Pemecahan Masalah, Komunikasi, dan Keterampilan Sosial Siswa SMP*. (Unpublished doctoral dissertation). UPI, Bandung.
[7] Purniati, T. (2004). *Pembelajaran Geometri Berdasarkan Tahap-tahap Van Hiele dalam Upaya Meningkatkan Kemampuan Komunikasi Matematik Siswa SLTP*. (Unpublished doctoral dissertation). UPI, Bandung.
[8] Alrø , H. & Skovsmose, O. (2002). *Dialogue and Learning in Mathematics Education*. New York: Kluwer Academic Publisher.

[9] Effendy, O.U. (2007). *Komunikasi: Teori dan Praktek.* Bandung: Remaja Rosdakarya Offset.
[10] NCTM. (2000). *Defining Problem Solving.* Retrieved from http://www. learner.org/channel/courses/teachingmath/.html.
[11] Sugiyono. (2010). *Metode Penelitian Pendidikan*. Bandung: Alfabeta.
[12] Tim Puslitjaknov. (2008). Metode Penelitian Pengembangan. Jakarta: Pusat Penelitian Kebijakan dan Inovasi Pendidikan Badan Penelitian dan Pengembangan Departemen Pendidikan Nasional.