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## **The Development of Learning Material Using Problem Based Learning to Improve Mathematical Communication Ability of Secondary School Students**

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### **Abstract**

The purpose of this study is to determine: (1) increasing mathematical communication skills among students by problem-based learning, and (2) answering process students in solving mathematical communication problems by problem-based learning. The research was conducted in SMP Negeri 23 Medan, with 80 students as subjects. This study was development research. The object of this research was a learning material about statistics materials based on a problem-based learning developed which were Teacher Handbook, Student Book, Student Worksheet, and student's mathematical communication skills test. The instrument used consisted of a test of mathematical communication skills. The instrument has been declared eligible in content validity and reliability coefficients. Based on the results of the analysis obtained, found that: (1) There was increasing students' mathematical communication skills by problem-based learning, and (2) Answering process of students in problem-based learning in trial 2 was more varied compare to trial 1.

**Keywords:** Problem-Based Learning; Mathematical Communication Ability; Answering Process.

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## **1. Introduction**

Mathematics education issues are closely related to the problem of learning mathematics itself. In the learning process, the lack of concept's mastery will affect students could not develop the concept held to resolve the problem, which caused students to tend to memorize formulas and steps to resolve given conventionally. One of the key factors of learning quality is teacher competence. Teacher efforts in empowering various variables are important to achieve learning goals expected. Teacher creativity are required in developing interesting and varied learning materials and ability to choose a model or approach to learning that can motivate students to be active and participate in learning. The development of learning instrument is teacher's responsibility in school, since teacher creativity in developing good learning material will create a meaningful learning. To create an attractive learning, teachers are required to create teaching materials such as Teacher Handbook, Student Handbook and Student Worksheet.

Learning materials ideally not only provide materials instantly, but also able to lead students in mastering the concepts learned. The habit of using mathematics handbook resulted teachers to have difficulty or not accustomed to prepare learning materials independently. Teacher also less prepare in providing interesting learning instrument which cause less effective and monotonous learning. The development of learning materials is expected according to the standard process established by the National Council of Teachers of Mathematics (NCTM). Standards process in Mathematics which established by NCTM is one of purpose learning Mathematics achievement. Mathematical abilities standards set by the NCTM, namely mathematical abilities, including problem solving, reasoning, communication, connections and representation, which should be owned by every student.

This study specifically examines one of mathematical abilities set by the NCTM, namely mathematical communication skills. NCTM [7] states that mathematical communication is a way of sharing ideas and clarifying understanding. Through communication, ideas become objects of reflection, refinement, discussion, and amendment. When students are challenged to communicate the results of their thinking to others orally or in writing, they learn to be clear, convincing, and precise in their use of mathematical language. Shanon [16], defines communication as a form of human interaction that mutually influence one another, intentionally or unintentionally, and are not limited to the shape in the form of verbal communication, but also in terms of facial expressions, painting, art, and technology. Rosenthal and Ogden [13] found that of the 383 responded, 64.8 percent agreed with the statement: "Greater emphasis should be placed on communication skills", suggesting that the majority of students valued communication skills learning.

In reality there yet arise problems faced by the students, especially the lack of student's mathematical communication skills. Therefore, the skill to communicate becomes the special demands in mathematics. In order to student's mathematical communication skills can develop properly, then teachers need to provide opportunities for students to be able to improve their ability to communicate mathematical ideas. Pimm [10] states that children who are given the opportunity to work in a group in collecting and presenting data, they show good progress when they are listening to each other's ideas, discuss them together and then deducing the opinion of the group.

Improving student's mathematical communications skills in mathematics learning process could not be separated from the learning model selection. In this connection, teachers as educators should be able to choose learning model as well as the appropriate media in the learning process to obtain the expected learning outcomes. Teachers should develop activities in learning by innovate an interesting learning model and create learning situations that involve students actively. Teachers should develop activities in learning is to innovate an interesting learning model and create learning situations that involve students actively. The ability of teachers to develop and implement learning materials need to be improved for the sake of change or for the better results of student achievement. One alternative model of learning that can improve communication skills are Problem-based Learning.

According to explanation above, it can be seen that the student's mathematical communication skills are very important in the learning process, but less of a focus on learning itself. Therefore, teacher's role as facilitator is very important to achieve the expected learning goals. In addition to the selection of applied learning models, it is necessary to develop learning materials in accordance with the model applied. To be able to apply problem based learning model effectively, it is necessary to have instruments that support effective learning. Based on explanation above, therefore it is necessary to develop learning materials using Problem-based learning to improve student's mathematical communications skills.

## **2. Theoretical Basis**

### ***2.1 Mathematical Communications Skills***

NCTM [7] says that mathematical communication is a way of sharing ideas and clarifying understanding. Schoen [2] argues that the mathematical communication skills is the ability of describing an algorithm and a unique way of solving the problem, the student's ability to construct and explain the real-world phenomena graphically, words/ sentences, equations, tables and show in physically or ability of students to give conjectures about geometric drawings. Baroody [2] suggests five aspects of communication, namely: (a) Representation (representing); (B) Listening; (C) Reading; (D) Discussing; (E) Writing. Baroody [3] explained that there are two reasons why student's communications in mathematics play an important role and needs to be improved in the study of mathematics. First, *mathematics as language*, mathematics means not only means as a tool to find patterns, resolve problems or draw conclusions, but as well as a valuable tool to communicate ideas in a clear, precise and meticulous. Second, *mathematics learning as a social activity*, meaning that mathematics as a social activity in learning, mathematics as well as a vehicle for interaction among students, and also the communication between teachers and students.

There are several indicators to measure student's mathematical communication skills in mathematics. Greenes and Schulman [11] formulate mathematical communication skills in three areas, namely: (a) express mathematical ideas through speech, writing, demonstrations, and describe it visually in a different type; (B) understand, interpret, and assess the ideas presented in writing, orally, or in visual form; and (c) construct, interpret and connect diverse representation of ideas and relationships. In line with the foregoing, Eliot and Kenney [12] summarizes indicators of mathematical communication skills includes: (a) declare a situation,

drawings, diagrams or real world situations into the language of mathematics, symbols, ideas, and mathematical models ; (B) explain and read meaningfully, express, understand, interpret, and evaluate an idea of mathematics and mathematics show in oral, written, or visual; (C) listen, discuss, and write about mathematics; and (d) states an argument in his own language.

NCTM [11] states mathematical communication skills indicator consists of three, namely: (a) the ability to express mathematical ideas orally, in writing, as well as visually depict; (B) the ability to interpret and evaluate mathematical ideas both orally and in writing; and (c) the ability to use terms, symbols, and its structures to model mathematical situations or problems.

## **2.2 Problem Based Learning**

Jaisook [4] states PBL has a meaning in the form of challenges and issues related to real life that encourages students to observe the knowledge from various sources related to the problem, as well as collaborate and exchange views in solving problems. In problem-based learning, students discuss with classmates to solve complex problems that help develop knowledge such as problem solving, communication, and self-assessment skills. Wilkerson and Gijsselaers [6] states that the PBL is characterized by student-centered approach, teachers as "facilitators not giver". Students must identify their learning needs, plan, lead class discussions, and assess their own work and the work of classmates. Arends stated that PBL is designed to help teachers provide as much information to the student through a problem. PBL helps students to develop thinking skills and troubleshooting skills, learn adult and independent learners [5]. Characteristics of problem-based learning process according to Barrow and Tamblyn [1] are: (a) Begin with a focus on the problem; (B) the investigation and early identification of learning needs of students; (C) Learning skills and knowledge in accordance with the requirements; (D) Application and reflection; (E) Improvement and development; and (f) Conclusions and integration of learning into student's knowledge and skills. Tan [14] mentions the key idea of problem-based learning as follows: (a) The problem is the beginning of the learning process; (B) There is a complex real-life problems and can develop into a real problem; (C) There are many different perspectives to look at each problem, and we need to use a variety of disciplines to solve it; (D) issue focuses on determining the object of study and to learn more about the object; (E) the responsibility of students can be developed with leading themselves to learn by acquiring various kinds of information; (F) There are various forms and places resources associated with the learning process of learning; (G) PBL is a collaborative learning which include communication, cooperation, and work in small groups. Student ability can be developed by having intense interaction between friends and present their ideas in the group; (H) development in examining the issue. Therefore, teacher only acts as a facilitator and adviser by raise questions to encourage a better understanding; (I) The study should be concluded by the knowledge based problem.

## **3. Research and Methods**

This study was a development research using a Thiagarajan's development model. Teaching and learning materials developed in this research were Teacher Handbook, Student Book, Student Worksheet, and Learning Skill Test which was student's mathematical communication skills. This study was conducted at SMPN 23

Medan, held for five (5) hours of lessons or 3 (three) meetings. Subjects in this study were students of class VII SMPN 23 Medan academic year 2016/2017. The object of this research was a learning instrument about statistics materials based on a problem-based learning developed which were Teacher Handbook, Student Book, Student Worksheet, and student's mathematical communication skills test. This study was held in two phases, the first phase was the development of learning instruments. Development of learning instruments include (i) validity of Teacher Handbook and the Student Book; (ii) the validity of Student Worksheet; and (iv) the validity of the student's mathematical communication skills instrument test. The second phase was the implementation of learning instruments that were considered eligible based on the test results. Development Model of learning materials used was Thiagarajan, Semmel, and Semmel ie 4-D models that consists of four phases: define (definition), design (design), develop (development) and disseminate (spread).

## 4. Result and Discussions

### 4.1 Result

Result of mathematics communication test as show at Table 1.

**Table 1:** Result of Mathematical Communication Test

Trial	Maximal score	Minimal score	$\bar{x}$	Completed	Uncompleted
1 <sup>st</sup>	97,22	41,67	75,89	70%	30%
2 <sup>nd</sup>	100,00	58,33	85,33	92%	8%

From Table 1 we had conclusion that  $\bar{x}$  in 2<sup>nd</sup> trial was 100 greater than the 1<sup>st</sup> trial that was 97,22. This showed that problem-based learning could help students to increase their performance. We're findings that there was significant difference in the mathematical communication test scores for the 1<sup>st</sup> trial compared to 2<sup>nd</sup> trial. This showed that based on esulf of mathematical communication test, students from 2<sup>nd</sup> trial showed improvement in learning process.

### 4.2 Discussions

Observe the result that showed above, problem-based learning had significant effect for mathematical communication ability students'. Theoretically, according to Shoenfeld, Boaler, Krulik, and Rudnick, PBL had superiorities:

- Describes a learning environment where problems drive the learning. That is, learning begins with a problem to be solved, and the problem is posed in such a way that students need to gain new knowledge before they can solve the problem.
- Rather than seeking a single correct answer, students interpret the problem, gather needed information,

identify possible solutions, evaluate options, and present conclusions.

- Problem-based learning is a classroom strategy that organizes mathematics instruction around problem solving activities and affords students more opportunities to think critically, present their own creative ideas, and communicate with peers mathematically [8].

Based on table 1 showed that  $\bar{x}$  in 2<sup>nd</sup> trial was 100 greater than the 1<sup>st</sup> trial that was 97,22 and when reviewed from its completeness in classical, category value of mathematical communication ability in 2<sup>nd</sup> trial was 92% while 70% in 1<sup>st</sup> trial. The completeness obtained from the 1<sup>st</sup> not completed yet the requirement of completeness in classical, while in the 2<sup>nd</sup> trial had completed the requirement of classical completeness. Students were able to draw conclusions from the knowledge found with guidance and instruction from teacher based on PBL questions.

This result in line with Winter [15] that said “students’ newly acquired knowledge of social problems and cultural ideas was intertwined with mathematical ideas they could apply to represent salient features of the situation mathematically, reformulate the problem in mathematical terms, and use the mathematical ideas that they had learned to solve the problem. In learning theory, this result in line with Piaget observation. Piaget observed the activities of children and later developed tasks to test developmental growth in the children. From this observation came Piaget’s idea that cognitive development occurs in stages and that this development progresses through active interaction with the environment and the development of “schemes”. This “active interaction” is one of the major components of PBL [9].

## **5. Conclusion and Suggestion**

### **5.1 Conclusion**

Based on data analysis and research findings during problem-based learning which emphasizes mathematical communication skills, the researchers obtained the following conclusions:

- There was increasing students' mathematical communication skills by problem-based learning. This is proved from the results of different between 1<sup>st</sup> trial and 2<sup>nd</sup> trial, results of mathematical communication skills of students with problem-based learning in 2<sup>nd</sup> trial was 100 greater than the problem-based learning in 1<sup>st</sup> trial that was 97,22. When reviewed from its completeness in classical, category value of mathematical communication skills in 2<sup>nd</sup> trial was 92% while 70% in 1<sup>st</sup> trial.
- Answering process of students in problem-based learning in trial 2 was more varied compare to trial 1. This was shown by better answers of students' in solving mathematical communication tests.

### **5.2 Suggestion**

Based on the research conclusions that have been described, regarding those matter, here are some suggestions for all parties involved in the use of problem-based learning in the process of learning mathematics in particular. The advices are as follows.

- Problem-based in learning mathematics which emphasizes the mathematical communication skills can be used as an alternative for implementing innovative math learning.
- Teachers are expected need to add insight into the theories of learning and innovative learning model in order to implement them in mathematics learning so that learning basic in regular basis can be left as an effort to improve student learning outcomes.
- Problem-based learning emphasizing the communication skills of mathematics is still very unfamiliar to teachers and students, therefore, need to be socialized by the school or institution associated with the hope of improving the results of students' mathematics learning, especially increasing the ability of mathematical communication.
- Problem-based learning issue can be used as an alternative to improve mathematical communication skills of students so that it can be used as input for the school to be developed as a learning strategy that is effective for the subject of mathematics others.

## References

- [1] Eng, C. Swee. Problem-Based Learning – Educational Tool or Philosophy. Australia: The University of Newcastle, pp. 4, 2000.
- [2] Hasratuddin. Mengapa harus Belajar Matematika?. Medan: Perdana Publishing, pp 115-118, 2015.
- [3] Husna, R. “Peningkatan Kemampuan Pemecahan Masalah dan Komunikasi Matematik melalui Pendekatan Matematika Realistik pada Siswa SMP Kelas VII Langsa.”. Jurnal Pendidikan Matematika Paradikma, Vol 6 No.2, pp 175-186, 2013.
- [4] Jaisook, S. “A Mathematics Instructional Model by Integrating Problem-Based Learning and Collaborative Learning Approaches”. Silpakorn University Journal of Social Sciences, Humanities, and Arts, Vol. 13(2) : 271-294 pp. 289, 2013.
- [5] Khoiri, W., et al. “Problem Based Learning Berbantuan Multimedia dalam Pembelajaran Matematika untuk Meningkatkan Kemampuan Berpikir Kreatif”. Jurusan Matematika FMIPA UNNES, ISSN 2252-6927 pp. 116, 2013.
- [6] Loague, K. “Problem-Based Learning”. Speaking of Teaching, Winter 2001 Vol.11, No. 1 pp. 1, 2001.
- [7] National Council of Teacher of Mathematics. “Principles and Standars for School Mathematics”. Internet [www.nctm.org/Standards-and-Positions/Principles-and-Standards/](http://www.nctm.org/Standards-and-Positions/Principles-and-Standards/) 2000 [April 25<sup>th</sup>, 2017]
- [8] Padmavathy, R.D. “Effectiveness of Problem Based Learning In Mathematics”. International Multidisciplinary e-Journal, Vol-II, Issue-I, Jan-2013, ISSN 2277 – 4262, pp. 46, 2013.
- [9] Pagander, L & J. Read. “Is Problem-Based Learning (PBL) An Effective Teaching Method?

Department of Culture and Communication”. LINKÖPING,. ISRN LIU-LÄR-L-A-114/15-SE pp. 9, 2014.

- [10] Pimm, D. *Speaking Mathematically: Communication in Mathematics Classrooms*. London: Routledge & Kegan Paul pp. 108, 1996.
- [11] Prayitno, S. “Identifikasi Indikator Kemampuan Komunikasi Matematis Siswa dalam Menyelesaikan Soal Matematika Berjenjang pada Tiap-Tiap Jenjangnya”, presented at KNPM V Surabaya, Indonesia pp 385, 2013.
- [12] Qodariyah, L, Heris H. “*Mengembangkan Kemampuan Komunikasi dan Disposisi Matematik Siswa SMP Melalui Discovery Learning*”. *Edusentris, Jurnal Ilmu Pendidikan dan Pengajaran*, Vol. 2 No. 3 December pp. 244, 2015.
- [13] Rosenthal J, Ogden J. “Changes in Medical Education: The Beliefs of Medical Students”. *Med Education*, 32:127–32, 1998.
- [14] Tan, O.S. “Problem-based learning innovation: Using problems to power learning in the 21st century”. Thomson Learning pp 30-31, 2003.
- [15] Winter, D. “Infusing Mathematics with Culture: Teaching Technical Subjects for Social Justice”. *New Directions for Teaching and Learning*. Vol. 2007, Issue 111 pp .97-106, 2007.
- [16] Wiryanto. *Pengantar Ilmu Komunikasi*. Jakarta: Grasindo pp. 73, 2004.