Development of Problem Based Learning Tools to Improve Mathematical Communication Skills and Self Efficacy of Students

Imam Syafi'i[1,*] Mulyono[2] Asmin[3] Anil Hakim Syofra[4]

[1]*Postgraduate Mathematics Education Students, Universitas Negeri Medan, Medan, Indonesia*
[2,3]*Postgraduate Mathematics Education Lecture, Universitas Negeri Medan*
[4]*Mathematics Education Lecturer, Universitas Asahan, Asahan, Indonesia*
[*]*Corresponding author. Email:* imamsyafii1104@gmail.com

ABSTRACT

This study aims to: (1) Determine the validity of problem-based learning tools developed to improve mathematical communication skills and self-efficacy of students of SMK Pelayaran Buana Bahari Medan; (2) Knowing the practicality of problem-based learning tools developed to improve mathematical communication skills and self-efficacy of students of SMK Pelayaran Buana Bahari Medan; (3) Knowing the effectiveness of problem-based learning tools developed to improve mathematical communication skills and self-efficacy of students of SMK Pelayaran Buana Bahari Medan; (4) Knowing the increase in mathematical communication skills of students of SMK Pelayaran Buana Bahari Medan by using problem based learning tools that have been developed; (5) Knowing the increase in self-efficacy of students of SMK Pelayaran Buana Bahari Medan after using problem-based learning tools that have been developed. This research is a development research using the Thiagarajan, Semmel and Semmel (4-D) development model. Problem-based learning device trials were conducted twice to obtain quality devices. The first trial (trial I) was conducted in class X NAUTIKA-A and the second trial (trial II) was conducted in class X NAUTIKA-B SMK Pelayaran Buana Bahari Medan. The results showed: (1) the developed problem-based learning tools have met the valid, practical, and effective criteria in terms of their respective criteria; (2) there is an increase in students' mathematical communication skills who are taught using problem-based learning tools in the first trial obtaining an average pretest score of 63.33 and posttest 76.67, and an increase in the second trial with an average pretest score of 73.33 and posttest 86.67; (3) the achievement of self-efficacy of students who were taught using problem-based learning tools in the first trial obtained an average value of 71.87 and increased in the second trial with an average score of 80.10.

Keywords: Development of learning tools, approach mathematical communication skills, student self-efficacy, 4-D model

1. INTRODUCTION

Mathematical communication is a central force for students in formulating mathematical concepts and strategies. [1] Mathematical communication is also a forum for students to communicate with their friends to obtain information, exchange ideas and discoveries as well as assess and sharpen ideas. Mathematical communication skills are an important part of mathematics, because it can help students and teachers in the learning process. Besides, the ability of mathematical communication is one of the mathematical power (mathematical power). Mathematical power includes process standards, content stands and mathematics

abilities. Baroody (1993: 100) explains that there are two important reasons why communication in mathematics needs to be developed among students. First, mathematics as language, meaning that mathematics is not only a tool to aid thinking, a tool for finding patterns, solving problems or drawing conclusions, but mathematics is also a valuable tool for communicating various ideas in a clear, precise and careful. Second, mathematics learning as social activity, which means that it is a social activity in learning mathematics, mathematics is also a vehicle for interaction between students, as well as communication between teachers and students.

Students' mathematical communication skills need to be trained and accustomed to students because communication skills are a provision for students to express their ideas or ideas to solve math problems or problems found in everyday life either orally or in writing. [2] The same thing was also stated by Rahmi, Nadia, Hasibah and Hidayat (2017) in their research that "One of mathematical skills that must be possessed by the students is the ability of mathematical communications", which implies that one of the mathematical abilities that must be possessed by students are mathematical communication skills. They also added "In order student's mathematical communication skills to develop well, then in the process of learning mathematics, teachers need to provide opportunities for students to be able to improve their ability to communicate mathematical ideas", which means that in order for students' mathematical communication skills developing well, then in the process of learning mathematics the teacher needs to provide opportunities for students to be able to improve their ability to communicate mathematical ideas.

[3] Besides mathematical communication skills, the ability in other aspects that are affective and no less important than mathematical communication skills is the ability to sell efficacy (student confidence in solving problems). According to the Chief Examiner's report (2005,2006,2007) (in Risnanosanti, 2016: 127) shows that "There are several factors that can be manipulated to improve mathematics learning outcomes. One of the factors that is personal and can help improve mathematics learning outcomes is self-efficacy towards mathematics. Bandura (1994: 2) states that self-efficacy is a person's belief in his ability to produce something. This trust is shown by its performance when performing a certain task or demand. Self-efficacy is very important because people who have high self-efficacy will work hard in doing a task or job and build positive motivation related to the task or work that is being done (Brown et al, 2005: 137). With regards to learning, of course it is hoped that students have high self-efficacy, meaning that students have high confidence that they are able to complete their lesson assignments and overcome various problems related to the lesson .

Self-efficacy is very important because high self-efficacy abilities will cause someone not only to try to get something or the knowledge needed, but they will find other knowledge related to the task or job they are doing and they are very motivated to get it. the results of a better and more perfect work (Schunk, DH, 1995: 113). Several studies have shown that self-efficacy is important in determining academic achievement. For example, Bouchey and Harter (2005: 677) state that the level of student self-efficacy will greatly affect the learning outcomes they get in a particular field. A student who feels capable of doing something will have an impact on the success of the student in completing what he is doing.

[4] Goulao (2014: 245) *"There are several studies that show a correlation between the level of self –efficacy and academic results". The results of his research also show that "The analysis of the data indicated that students' level of self-efficacy is high and a significant relationship exists between self-efficacy and academic achievement". This implies that there is a significant relationship between self-efficacy and academic achievement. Thus it can be said that a student's self-efficacy is able to support his learning ability.*

[5] Then from the results of Skaalvik's research, Federici & Klassen (2015: 135) states that "The result of this study has both theoretical and practical implications. They clearly demonstrate that student motivation both interest and motivated behavior is strongly predicted by self-efficacy and moderately predicted by teacher emotional support. This implies that the results of this study have theoretical and practical implications, namely clearly showing that students are motivated both by their interests and behavior through self-efficacy and teacher emotional support.

[6] According to Arends (in Sari, 2015: 3), "Problem-based teaching is a learning approach where students work on authentic problems with the intention of compiling their own knowledge, developing inquiry and higher-order thinking skills, developing independence and self-confidence.

However, problem-based learning (PBM) also has weaknesses as stated by Trianto (2009: 96), namely "(1) complex learning preparation (tools, problems, concepts); (2) Difficulty looking for relevant problems; (3) Frequent misconceptions; and (4) time consumption, where this model requires sufficient time in the investigation process.

Before the teacher teaches in the classroom, namely as a preparation stage, a teacher is expected to prepare any materials that want to be taught, such as preparing a syllabus, planning the implementation of learning, preparing teaching aids to be used, preparing questions and directions to lure students to be more active in learning, understanding the student's condition, understanding the strengths and weaknesses of students, and learning the students' initial knowledge, all of which will be decomposed in their implementation in the learning tool. Wijaya (2011) in his research shows that the initial ability of teachers in preparing lesson plans is low because teachers are confused in formulating lesson plans because the subjects taught are different from their backgrounds and do not have the initiative in compiling lesson plans.

The lesson plans made by the teacher also do not contain models, methods that can activate students in the learning process. In addition, the lesson plans used in these schools have not detailed student activities and teacher activities during the learning process.

From the cases in the field, it can be seen that there are no learning tools that match the expectations above. Most teachers consider learning tools only as a requirement for completing school administration. So that the teacher does not make thorough preparation when going through the learning process. Like a book which is a supporting learning device. [7]Akbar (2013: 33) states that:

A good textbook is: (1) accurate (accuracy); (2) appropriate (relevance); (3) communicative; (4) complete and systematic; (5) oriented student centered; (6) side with the ideology of the nation and state; (7) correct language rules, textbooks written using correct spelling, terms and sentence structures; (8) legible, textbooks with high readability contain sentence length and sentence structure according to the reader's understanding.

From the observations, textbooks used in SMK Pelayaran Buana Bahari Medan have several weaknesses such as in student books there is no learning objective and the problems given have not led to improving students' mathematical communication skills. This can be found from alternative solutions that are not in accordance with mathematical communication indicators.

Then another learning tool that supports the learning process is the Student Activity Sheet (LKS). [8] According to Trianto (2011: 222) "Student Activity Sheets (LAS) which are also known as Student Activity Sheets (LKS) are a set of basic activities that must be carried out by students to maximize understanding in an effort to form basic abilities according to the indicators of achievement of learning outcomes taken".

The 2013 curriculum demands a change from LKS to Student Worksheets (LKPD). The difference between LKS and LKPD other than students and students is that LKPD contains short material content with more interactive and contextual questions for students (Sasmito, 2015: 73)[9]. That way, LKPD is a learning tool designed to help students understand the subject matter through a structured activity with various problems given. LKPD should be prepared by providing questions that can make students more active and encourage students to develop mathematical abilities such as mathematical communication skills [10-11].

Based on the description above, the researchers are interested in conducting research with the title "Development of Problem Based Learning Tools to Improve Mathematical Communication Skills and Self Efficacy of Students of SMK Pelayaran Buana Bahari Medan".

2. METHOD

This research includes development research (depelopment research). This study uses a 4-D development model by Thiagarajan, Semmel and Semmel (1974)[12], which includes 4 stages, namely define, design, develop and disseminate. and researchers developed learning tools through problem-based learning models (PBM) on the material of Three Variable Linear Equation Systems (SPLTV). The learning tools developed are the Learning Implementation Plan (RPP), Student Books (BS), Student Worksheets (LKPD), Learning Ability Tests, especially the Mathematical Communication Ability Test (TKKM) and Student Self Efficacy Questionnaires.

3. RESULT AND DISCUSSION

3.1 Learning Tool Validity

Analysis of the validity of the learning device was scored by 5 experts consisting of 3 lecturers and 2 mathematics teachers. The results of the analysis of the validity of the learning tools are as follows:

Table 1. Summary of learning tool validation results

Device	The average value of the total validity	Validation Level
RPP	4.48	Valid
LKPD	4.44	Valid
Student Book (BS)	4.45	Valid

The validity criteria are as follows: $4 \leqslant Va < 5$: Valid

After being declared valid, the learning tools and instruments were tried out (field evaluation) in class X-Nautika A at SMK Pelayaran Buana Bahari Medan. However, in the first trial, one of the indicators of the practicality of the learning device did not meet the practical criteria, namely the classical completeness of mathematical communication skills. Data on classical completeness of mathematical communication skills in the first trial is shown in Table II below.

Table 2. Classical completeness level of mathematical communication skills in trial I

Categori	Pretest		Postest	
	Total Student	*Percentage*	*Total Student*	*Percentage*
Completed	19	63,33%	23	76,67%
Not complete	11	36,67%	7	23,33%
total	30	100%	30	100%

The percentage of classical completeness criteria for students' mathematical communication skills is presented in Fig. 1.
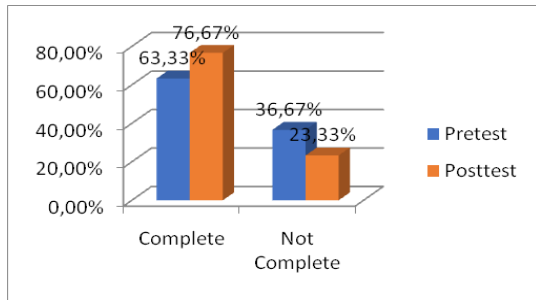
Fig.1. Percentage of classical completeness of mathematical communication ability in trial I

Based on the data in table ii and fig. 1, it can be seen that the classical completeness of the results of the students' mathematical communication skills in the posttest has not yet fulfilled the classical completeness because it only obtained a 76.67% percentage of completeness

3.2 Evaluation

Based on the results of the analysis of the learning tools in the first trial, data showed that the learning tools could not be said to be effective. For this reason, before the second trial was conducted, a revision would be made to the LKPD used in trial I. Revisions would be made based on the results of the analysis in trial I. Then the research continued to trial II.

3.3 Learning device practicality data

3.3.1 Data on the implementation of learning tools

The average value of the observation of the implementation of the learning tools for each meeting in the second trial is shown in table iii below.

Table 3. Average value of observation of learning device implementation in trial II

Aspects Observed and Assessed	$\overline{P_2}$ Meeting To			$\overline{P_3}$
	I	II	III	
Implementation of RPP	3,81	4,13	4,44	3,63
Implementation of LKPD	3,63	3,88	4,25	3.92
Student Book Implementation (BS)	3,50	3,88	4,00	3,79

Based on Table 3, it is found that the overall average of 3 (three) observers on the implementation of RPP is 4.13, LKPD is 4.00 and student book (bs) is 3.92 which is in the high category ($3 \leq \overline{p} \leq 4$).

The average value of the observations of the learning device implementation for each meeting in trials i and ii is shown in the following figure
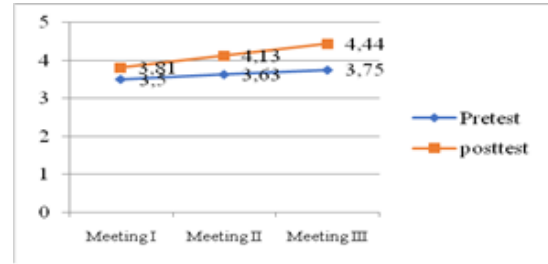

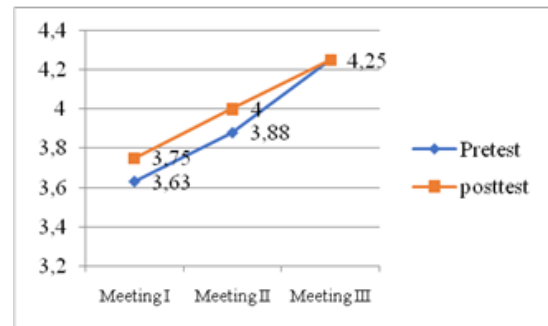**Fig.2.** RPP implementation score in Each Trial I and I

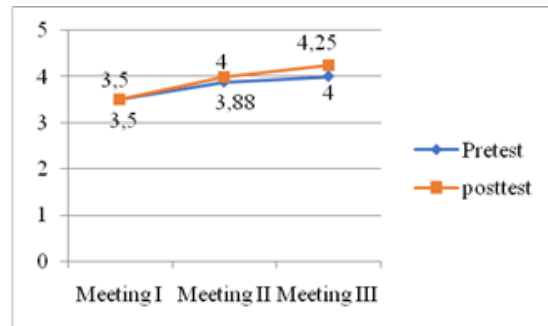**Fig.3**. LKPD implementation score in Each Trial I and II

Fig.4.Student Book (BS) implementation score in Each Trial I and II

3.4 Learning Device Effectiveness Data

3.4.1 Classical student learning completeness

The results of classical completeness of students' creative thinking abilities in the second trial can be seen in Table IV below.

Table 4. Classical completeness levels of mathematical communication skills in trial II

Category	Pretest		Posttest	
	Total Student	Persentage	Total Student	Persentage
Completed	22	73,33%	26	86,67%
Not complete	8	26,67%	4	13,33%

Category	Pretest		Posttest	
	Total Student	*Persentage*	*Total Student*	*Persentage*
total	30	100%	30	100%

The percentage of classical completeness criteria for students' mathematical communication skills is presented in Fig. 5.
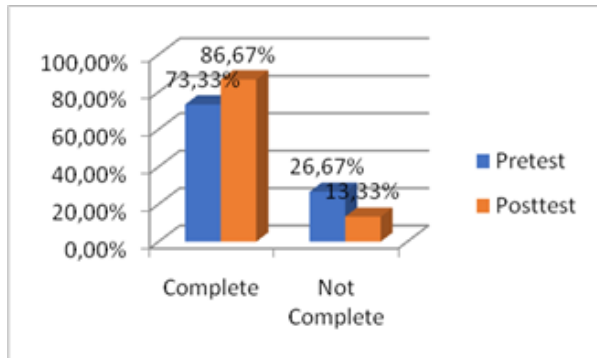

Fig.5. Percentage of Classical Completeness of Students' Mathematical Communication Ability in Trial II

Based on the data in Table V and Figure V, it can be seen that the classical completeness of students' mathematical communication skills in the posttest II trial was 86.67%. Thus, the posttest results of mathematical communication skills had met classical completeness.

3.4.2 Completeness of learning objectives

The following will describe the number of students who achieved the completeness of the learning objectives for each meeting in Trial II.

Table 5. Achievement of learning objectives in trial II

Question number	Students Who Achieve Completion of Learning Objectives		Information	
	Pretest	**Postest**	**Pretest**	**Postest**
1	**70,00%**	**93,33%**	**Not Reached**	**Reached**
2	**50,00%**	**86,67%**	Not Reached	Reached
3	**46,67%**	**80,00%**	Not Reached	Reached

From table 5 it can be seen that in the posttest results the students have reached the "Achieved" criteria on each item.

3.4.3 Learning time

From the results of time attainment at each meeting for trial II in using problem-based learning tools to improve mathematical communication skills and self-efficacy of students of SMK Pelayaran Buana Bahari Medan, it is obtained that time is efficient, namely learning using problem-based learning tools to improve

mathematical communication skills. and the self-efficacy of students of SMK Pelayaran Buana Bahari Medan is the same as the usual learning.

3.5 Increase in Creative Thinking Ability in Trial II

The increase in creative thinking skills in the second trial will be seen through the N-Gain of the pre-test and post-test results. The results of the N-Gain calculation of trial II are presented in Table VI

Table 6. Summary of n-gain results of mathematical communication ability trial II

N-Gain	Interpretation	Total students	%
$g > 0.7$	High	4	13,33%
$0.3 < g \leq 0.7$	Moderate	19	63,33%
$g \leq 0.3$	Low	7	23,34%

4. CONCLUSION

1. Learning tools oriented to the developed learning model based on the practical criteria. The criteria for practicality were evaluated from: (1) the validator's assessment of the learning device could be used easily, (2) the implementation of the learning device in the second trial reached $4 < P \leq 5$ with a very high category.

2. Students 'mathematical communication skills increased by 86.67% using the developed problem-based learning tools. The improvement was reviewed based on the acquisition of students' post-test scores from try I to try II.

3. Student self-efficacy increased by or 80.1% using the developed problem-based learning tools. The increase was reviewed based on the acquisition of students' self-efficacy questionnaire scores from try I to try II.

REFERENCES

[1] Ansari, B.I (2012). Komunikasi Matematik dan Politik Suatu Perbandingan Konsep dan aplikasi. Banda Aceh:Pena.

[2] Ulfah, M., Harahap, M. B., & Rajagukguk, J. (2018, December). The Effect of Scientific Inquiry Learning Model for Student's Science Process Skill and Self Efficacy in The Static Fluid Subject. In 3rd Annual International Seminar on Transformative Education and Educational Leadership (AISTEEL 2018). Atlantis Press.

[3] Risnanosanti. 2016. Self Efficacy Mahasiswa Terhadap Matematika dan Pembelajaran Berbasis

Kegiatan Lesson Study. Jurnal Elemen Vol 2 No.2 hal 127-135.

[4] Goulao, M. 2014. The Relationship between Self-Efficacy and Academic Achievement in Adults' Learners. Athens Journal of Education August 2014.

[5] Skaalvik, E.M., Federici,R.A & Klassen, R.M. 2015. Mathematics Achievement and Self-efficacy: Relations with Motivation for Mathematics. International journal of Educational Research,72:129-136.

[6] Sari, D. T., Kristiani & Wardani, D.K. 2015. Penerapan Model PBL untuk Meningkatkan Kemampuan Berpikir Kritis dan Hasil Belajar Siswa pada Materi Ekonomi di SMA Negeri 3 Surakarta Tahun Pelajaran 2014/2015. Prosiding Seminar Nasional Pendidikan Ekonomi & Bisnis. ISBN: 978-602-8580-19-9.

[7] Akbar, S. (2013). Instrumen Perangkat Pembelajaran. Bandung:Remaja Rosdakarya

[8] Trianto. (2009). Mendesain Model Pembelajaran Inovatif Progresif, Konsep, Landasan dan Implementasinya pada Kurikulum Tingkat Satuan Pendidikan (KTSP). Jakarta: Kencana Prenada Media Group

[9] Sasmito, Luncana Faridhoh, dan Ali Mustadi (2015). Pengembangan Lembar Kerja Peserta Didik Tematik-Integratif berbasis Pendidikan Karakter Pada Peserta Didik Sekolah Dasar. Jurnal Pendidikan Karakter. V (1):70-81.

[10] Kartika, Y., Wahyuni, R., Sinaga, B., & Rajagukguk, J. (2019, July). Improving Math Creative Thinking Ability by using Math Adventure Educational Game as an Interactive Media. In Journal of Physics: Conference Series (Vol. 1179, No. 1, p. 012078). IOP Publishing.

[11] Jonny, H. P., Rajagukguk, D., & Rajagukguk, J. (2020, January). Computational Modelling Based on Modellus to Improve Students' Critical Thinking on Mechanical Energy. In Journal of Physics: Conference Series (Vol. 1428, No. 1, p. 012042). IOP Publishing.

[12] Thiagarajan, S.,Semmel, D. S.,&Semmel, M. I. (1974). Instructional Development for Training Teachers of Exceptional Children: A sourcebook. Indiana: Indiana University