Improving the Ability of Mathematical Reasoning and Communication Student of Vocational High School

Difia Esa Bunga¹, a) and Ariyadi Wijaya²

¹Graduate Program of Mathematics Education, Yogyakarta State University, Yogyakarta, Indonesia
²Mathematics Department, Faculty of Mathematics and Science, Yogyakarta State University, Yogyakarta, Indonesia

a) difiaesabunga@gmail.com

Abstract. This paper aims to review how to improve the ability of mathematical reasoning and communication student in vocational school. The ability of mathematical reasoning and communication is very important for students. While the mathematical communication is an important process in learning mathematics because through communication, students can reflect, clarify and expand their ideas and understanding of relationships and mathematical arguments. But the reality shows that the ability of mathematical reasoning and communication is still low. One of the efforts to improve both abilities in Vocational School students is by developing mathematics instructional package with a contextual problem based learning model. The problem presented in problem based learning is a real problem in everyday life or contextual. Because vocational education develops their students as individuals that can be sold in the labor market, the problem-based learning in this study is combined with contextual nuances tailored to the needs of students to be able to develop their knowledge in applying mathematical applications. Mathematics problem based learning with contextual nuances is a learning strategy that emphasizes the full process of student involvement in order to find the material learned and relate it to real life situations that encourage students to apply it in their lives.

I. INTRODUCTION

Education is an important thing in the effort of development of the Indonesian people as a whole. Therefore, the government always strives to improve the quality of education in Indonesia, one of which is to develop the Curriculum 2013. With this curriculum is expected to education in Indonesia will be more advanced so as to create a quality Indonesian human and able to compete in the era of globalization both in the present and future. Curriculum 2013 is a curriculum development strategy to realize effective, productive, and achieving schools, therefore, learners are given the widest opportunity to express, think and innovate. Teachers play a role to motivate and direct the learning process of learners so that learners are actively involved in the learning process.

Mathematical learning needs to optimize students' reasoning and mathematical communication skills [1]. So teachers should be able to design learning that can lead learners to improve the ability of reasoning and mathematical communication. The ability of reasoning and mathematical communication is very important for learners. This is in line with Shadiq's opinion [2] stating that mathematical material and mathematical reasoning are two inseparable matters, mathematical material understood through reasoning and reasoning understood and trained through learning mathematics. The mindset developed by mathematics as described does require and involve critical, systematic, logical, and creative thinking. The reasoning ability is not only needed by students when learning math or other lessons, but it is needed every human being when solving problems or when deciding [2]. The importance of mathematical communication in mathematics learning is mentioned in the Ontario Ministry of Education [3] that mathematical communication is an important process in learning mathematics because through communication, students can reflect, clarify and broaden their ideas and understanding of relationships and mathematical arguments.
In fact, students' reasoning and communication skills in Indonesia are still low. This can be seen from the results of research conducted by the Program for International Assessment of Student (PISA), PISA data in 2009 shows that Indonesian students ranked 61 out of 65 countries, with an average score of math skills of 371 is still far from the score the international average is 496 [4]. Then in 2012 the ranking of Indonesian students is getting worse, which is ranked 64 out of 65 countries, with an average score of 375 math skills, this score is still far from the international average score of 494 [5]. One of the causal factors among Indonesian students is generally poorly trained in solving problems with characteristics such as questions on PISA. This is because general learning has not emphasized the students' ability to develop reasoning and mathematical communication skills.

The essence of this paper is to review improving the ability of mathematical reasoning and communication student of vocational high school using problem based-learning.

II. DISCUSSION

A. Mathematical Reasoning Ability

The result of learning mathematics is caused by several factors one of them is the reasoning ability of the students. The ability of students' reasoning determines the level of mastery of the material in the learning of mathematics. According to Brodie [6] that mathematical reasoning is a reasoning about mathematics and its objects. English [7] states that "the ability to see connection and relationships among mathematical ideas and to apply this understanding to the solution a new problem is a basic component of mathematical reasoning." In line with the opinion of Ball and Bass [6] which states that: reasoning is a “basic skill” of mathematics and necessary for a number of purposes-to understand mathematical concept, to use mathematical ideas and procedures flexibly, and to reconstruct knowledge, but forgotten mathematical knowledge. These skills should have been familiarized from an early age and become a daily learning program, because through good reasoning process, students can understand how to construct and build the knowledge.

NCTM [8] mentions that "in the middle grades students should have frequent and diverse experiences with mathematics reasoning as they evaluate conjecture, construct and evaluate mathematical arguments". Byrnes [9] states that reasoning and proofing ability should be part of a program of pre-kindergarten up to 12th grade that allows students to recognize reasoning and proof as a basic aspect of mathematics, create and investigate mathematical guesses, develop and evaluate mathematical arguments and select as well as using various types of reasoning and proofing methods.

Goos, Stillman, and Vale [10] suggest that "mathematical reasoning involves making, investigating and evaluating conjectures, and developing mathematical arguments to convince one self and others that a conjecture is true". One of the best ways for students to improve their reasoning is to explain or justify the procedure (in solving problems) rather than just doing exercise questions [11]. In the process of communicating their thinking, students hone their reasoning skills. Mueller, Yankelewitz, and Maher [12] argue that ways to improve students' reasoning are by discussing false or invalid arguments. Therefore an invalid argument will encourage varied reasoning from students and can eliminate any misunderstandings that happened.

Based on the theoretical reviews on mathematical reasoning above, it can be concluded that mathematical reasoning ability is the ability to find patterns of mathematical symptoms, create, investigate, and evaluate an assumption, and convince yourself and others that these guessing are true.

B. Mathematical Communication

Mathematical communication [3] is an essential process for learning mathematics because through communication, student reflect upon, clarify, and expand their ideas and understanding of mathematical argument. NCTM [8] stated that communication is an essential part of mathematics and mathematics education. It is a way of sharing ideas and clarifying understanding. Through communication, ideas become objects of reflection, refinement, discussion, and amendment. The communication process also helps build meaning and permanence for ideas and makes them public. When students are challenged to think a reason about mathematics and to communicate the result of their thinking to the other orally or in writing, they learn to be clear and convincing.

Mathematical communication that is considered to be demonstrated by students during the learning contained in NCTM [8] which stated that the standard used for mathematical communication is as follows.
1. Describe and reflect ideas or ideas related to mathematics.
2. Generalize and formulate mathematical definitions in an investigation.
3. Expressing mathematical ideas in written and oral.
4. Present a written mathematical concept with understanding.
5. Clarify and explore mathematical revelations that have been read or heard.
6. Understand the usefulness, and the effectiveness of mathematical notation in the development of mathematical ideas.

In Principles and Standards for School Mathematics [8] it is also mentioned that the standard of ability that should be mastered by students at the secondary school level is 9-12 is the ability to:
1. Compile and link mathematical thinking and communicate to other students.
2. Expressing mathematical ideas logically and clearly to other students, teachers, and others.
3. Analyze and assess students' mathematical thinking and strategies used by others (friends and teachers).
4. Using mathematical language appropriately in various mathematical expressions.

Based on discussion, it can be concluded that mathematical communication skills are the ability to use mathematical language to express mathematical ideas correctly, it is the ability to make data representations in the form of symbols, images, graphs, tables, or diagrams, also the ability to interpret data in various forms, evaluate the mathematical ideas presented, and strategies that are used and convey mathematical ideas logically and clearly.

C. Problem Based Learning

The process of mathematics learning where the teacher does not provide the experience of reasoning to the students resulted in the students unable to express opinions and provide explanations [14]. The role of mathematics learning in improving reasoning and communication skills is very important. Haylock [15] stated that there are three skills that will be developed in teaching students to use and apply math are: (a) problem-solving strategies; (b) mathematical reasoning; and (c) mathematical communication. So it is very important for a teacher to design and implement learning that can facilitate students' reasoning and mathematical communication skills. In developing students' reasoning and mathematical communication skills, teachers are required to plan and manage effective learning in teaching students in logical thinking, attitudes, and skills. An effective teacher is a teacher who has the preparation and implementation of systematic learning [16].

One alternative that can be used is to apply problem based learning model (PBL). PBL is as a curriculum model designed using real-life problems. The problem is unstructured, open-ended or ambiguous issues [17]. Problem-based learning is selected for the following reasons: (1) providing real-life, real-life problems, (2) encouraging students to engage in learning activities, (3) encouraging the use of different approaches, (4) giving students opportunities making choices about how and what to learn, (5) encouraging collaborative learning, and (6) helping to achieve quality education [18]. The problem-based learning stages consist of: (1) problem presentation, (2) problem solving planning, (3) problem investigation, (4) presentation of results, and (5) analyzing and evaluating. PBL has characteristics, namely: (1) the real problem the starting point of learning, (2) the existence of questions in learning, (3) encouraging students in problem solving or finding solution (4) in learning to gain information and knowledge, (5) utilizing various sources of knowledge and information resources in learning, (7) small group learning, (8) teachers as facilitators in learning, (9) presenting results [17]. In addition, in problem-based learning, students have a better role in transferring knowledge and using it in a variety of situations [19].

SMK is a vocational school that gives students who graduate to become professional workers in their field. Mathematics learning in SMK is different from mathematics learning in SMA or MA, because the learning of mathematics emphasizes on the use or application of mathematics lesson material that can be applied in the work world. Mathematics learning in school, in this case SMK, There are some characteristics of mathematics, among others: (1) the object is studied abstract, (2) the truth is based on logic, (3) the learning is gradually and continuously, (4) there is a link between the material one with others, (5) using symbol language, and (6) applied in other fields of science.

Furthermore, the objectives of the mathematics course in SMK [20] are as follows: using reasoning on the nature, performing mathematical manipulations both in simplification, and analyzing the existing components in problem solving in the context of mathematics as well as outside mathematics (real life, science, and technology), communicating ideas, reasoning and able to construct mathematical evidence using full sentences, symbols, tables, diagrams, or other media to clarify circumstances or problems, and have an attitude of appreciating the usefulness of mathematics in life.

Through problem-based learning, students are expected to be more motivated and enthusiastic in learning mathematics because learning is no longer monotonous, consequently the achievement of learning mathematics learners will also increase. The problems presented in the PBL are a real problem in everyday life or contextual.

ME-259
The mathematical contextual problem is a mathematical problem that uses multiple contexts to present situations that have been experienced in real for students [21]. The problem must also be in accordance with the mathematical concepts being studied. Context itself can be interpreted by the situation or phenomenon or natural events associated with the concept of mathematics being studied. There are four kinds of context or situation problems [22], as follows: (a) personal students, ie situations relating to the daily life of students both at home and with family, with their playmates, classmates and pleasures; (b) academic schools, for example situations related to academic life in schools, in classrooms, and activities related to the learning process; (c) the public or the public, the situations relating to the life and activities of the community in which the student is living; and (d) scientific or mathematical, ie situations relating to phenomena and substances scientifically or related to mathematics itself.

Delisle [18] added that PBL provides a discovery structure that helps students learn more in depth and leads students to a broader understanding. Students not only remember the concepts they are learning, but students are also given the opportunity to understand how to use them. In line with the opinion of Delisle, Tan [23] also argues that in the problem-based learning approach: understanding is derived from interaction with the problem scenario and the learning environment, engagement with the problem and the problem inquiry process creates cognitive dissonance that stimulates learning. Knowledge evolves through collaborative process of social negotiation and evaluation of the viability of one’s point view. Arends [24] reveals that the essence of problem-based learning is to expose students to an authentic and meaningful problem for students and to encourage students to conduct investigative and discovery activities. Problem-based learning has been recognized as an expansion of active learning and a student-centered learning approach, using unstructured problems (real-world problems or complex simulation problems) as a starting point and anchor for the learning process [23]. Furthermore, Roh [25] says that problem-based learning is a classroom learning strategy that organizes and manages mathematical learning around problem-solving activities and gives students the opportunity to think critically, propose their own creative ideas, and communicate with their friends mathematically.

Characteristics of problem-based learning [26] are as follows: 1) lessons focus on solving problems, 2) responsibility for solving problems rests on students, and 3) teachers support the process as students work on problems. Then, problem-based learning process [18] is as follows.

1. Determine the problem: At this stage, the problem scenario applies as a stimulus to help and provide the realistic context that students may encounter.
2. Problem analysis and learning issues: At this stage, the student's initial knowledge is activated and extends the ideas to determine further learning.
3. Meetings and reports: Students report their findings to each group. Students share information or new knowledge that they have discovered individually.
4. Presentation of solutions and reflections: At this stage students present the solution of the problem. The student paraphrases and demonstrates the new knowledge gained.
5. Conclusion, integration, and evaluation: At this stage students reflect on the new knowledge they have gained on learning as a result of the problem. Teachers help students make conclusions and integrate key principles and concepts.

Furthermore, [18] in the PBL approach, students are not only given problems but given the opportunity to construct knowledge through collaborative interaction and discovery. In PBL students are given the opportunity to find knowledge for themselves and interact with other students. Then students construct a new structure of knowledge about knowledge possessed on the basis of prior knowledge. Problem-based learning strategy is more concerned with the process and not just looking at learning outcomes. If the learning process can be done optimally then the results obtained will be optimal learning as well. The assignment of problems to be solved in the mathematics learning process is closely related to the core competencies and basic competencies to be studied in mathematics subjects after elaborated into indicators of achievement.

Learning mathematics in Vocational High School (SMK) need to optimize the ability of mathematical reasoning and communication of students. Mathematical reasoning and communication are expected to be the basic competencies that students need to have in learning mathematics. There was a significant relationship between mathematical communication and mathematical reasoning abilities of students with the basic competence achievement of mathematics. If the mathematical reasoning and mathematical communication ability are low, consequently achieving basic competencies of students will be low and vice versa. This shows that both these capabilities should receive special attention in the study of mathematics, without ignoring other mathematical abilities of the students. So that teachers should be able to design learning that can lead students to improve the ability of mathematical reasoning and communication, one of them is using problem-based learning. As a result, mathematics is seen not to be taught by teachers, but to be learned by students.
CONCLUSION

It is important for a teacher to design and implement learning that can facilitate students' mathematical reasoning and communication skills. In developing students' reasoning and mathematical communication skills, teachers are required to plan and manage effective learning in teaching students in logical thinking, attitude, and skills. In this paper, problem based learning is one of the alternative learning models that effectively improve the ability of mathematical reasoning and communication student of Vocational High school. It also using PBL, student can find the material learned and relate it to real life situations that encourage students to apply it in their lives.

Based on the results of research by Habsah (2017) concluded that mathematics teaching materials with realistic mathematics approach oriented communication and mathematical reasoning abilities of students who have developed is valid, practical, and effective in terms of mathematical reasoning and communication skills. A minimum percentage of the number of students who are in the good category reached 83.33% for reasoning and reached 86.67% for mathematical communication skills. These percentages indicate that learning using teaching materials with realistic mathematics approach effective in terms of reasoning and communication student for a minimal percentage of students who are in the good category is 75%. This research is relevant because the realistic mathematics approach is one of the development of problem-based learning approach and contextual approach.

REFERENCES


