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Developing Reasoning Ability and Curiosity of Students toward Mathematics through Problem Based-Learning

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Abstract— Learning mathematics is implemented in schools one of which aims to make the students have the ability to use reasoning and an attitude of curiosity in learning mathematics. Therefore, to be accustomed to using his reasoning, then students should be trained to be able to: (1) find pattern on a mathematical phenomenon; (2) formulate mathematical conjecture; and (3) draw conclusions based on valid arguments. Meanwhile, to increase the curiosity, the students need to be trained to get used to: (1) enthusiastic to learn; (2) trying to understand concepts; (3) happy and studious; (4) trying to find a solution difficulty in understanding the lessons; and (5) use the concept that has been studied previously in understanding new concepts. The ability and the attitude can be trained and improved through learning mathematics in the classroom. One approach to learning that are considered effective for improving reasoning ability and attitude of curiosity of students is a problem based-learning (PBL), because in the PBL the issues presented at the beginning of learning is a real problem or it could also be ill-structured so that learning step the next requires investigation of activities of individual or group that requires them to train mathematical reasoning abilities and stimulate curiosity in learning mathematics. The phases of the PBL approach include: (1) to orient students on the issue; (2) organize the students to learn; (3) guiding the investigation; (4) develop and present work; and (5) analyze and evaluate the problem-solving process.

Keywords: *curiosity, mathematical reasoning, problem based-learning*

I. INTRODUCTION

Permendiknas No. 22 of 2006 on the Content Standards states that the objective of mathematics courses in Indonesia, one of which is that the students have the ability to use reasoning and have respect for the usefulness of mathematics in the life of one of them an attitude of curiosity in learning mathematics. In addition, the learning characteristics that arise during the process of teaching and learning in schools in line with Permendikbud 68 in 2013 such that the learning patterns let a student-centered, interactive learning, students actively construct knowledge-based group, sera shades of active learning and critical , Thus, the proper learning of mathematics is based on competency so that one type of skills required to refer to the higher order thinking skills (HOTS).

Meanwhile, math teacher attention to HOTS students in Indonesia is still low. It is one of them can be seen from mathematical reasoning skills students are generally still low. The fact is, the data shown from the results of a survey conducted by TIMSS (Trends International Mathematics and Science Study) in 2011. Following the survey data in mathematics in terms of three aspects, namely: knowledge, application and reasoning as in Table 1 below (Mullis, Martin, Foy, and Arora, 2011: 150).

TABLE 1. AVERAGE SCORES INDONESIA IN 2011 BASED ON DATA TIMSS

Ordinal	Category of Capability	The Average Score	The Maximum Score	The Minimum Score
38	*Knowing*	378	616	331
	Applying	384	617	316
	Reasoning	388	612	322

Source: TIMSS 2011 Data

Survey data above show that the mathematical reasoning abilities of students in Indonesia is still low, so that Indonesia was ranked 38 out of 45 countries are included. This is due to the value of the average

scores obtained by students in Indonesia are below average international score which is below a score of 500.

One approach for effective learning to improve reasoning skills and attitudes curiosity of students is a problem-based-learning (PBL). (Fogarty, 1997) stated that the problem based learning curriculum designed a model using real-life contexts problem. Characteristics of learning can be a problem unstructured, open-ended, or issues that are ambiguous. Moreover, PBL is also one of the recommended approach in the learning of mathematics in the curriculum of 2013. Later, in practice PBL needs to be supported by the existence of the learning device. Importance of learning tools is also stated by Posamentier (2007: 47), who said that although many theories suggest about the best way to teach math to students, so it is generally accepted that learning plans are well designed are the main ingredients of successful learning.

Furthermore fact the field regarding the implementation of the curriculum in 2013 found several barriers for teachers, including teachers difficulty arranging time on lesson plans, planning lessons, planning, the assessment, and the sort of knowledge and skill in the preparation of assessment instruments and time constraints in the implementation of learning, the difficulties associated with the device learning, and difficulty activating students (Heri Retnawati, 2015). In addition, there are other findings about the difficulties of teachers in the implementation of teacher assessment is not yet fully understood. difficulties teachers are also found in: developing instruments attitude, implement authentic assessment, formulate indicators, designing rubrics for skills assessment, and collect the scores of several measurement techniques. In addition, teachers can not find a decent application to describe student achievement (Heri Retnawati, 2016: 390) .Therefore, the corresponding mathematical learning device 2013. The demands of the curriculum need to be developed, especially in this study by using the PBL approach.

II. DISCUSSION

A. Mathematics Learning

During the learning process, the thought of giving information and then manage and refine the concept before. Learning does not only include the process of receiving new information, ideas and skills, but the new material is the result of reconstruction or synthesis returned by the mind (Joyce & Weil, 2004: 13). In other words, learning is a process of change of behavior, habits, knowledge, attitude, and the ability of a person towards a better direction. These changes resulted from a series of experiences that involve interaction with the environment and the necessary infrastructure. It shows that the environment and various facilities that support has a very important role in the learning process.

As for the scope of school mathematics, Ebbut and Straker (Marsigit, 2009: 8) defines it as follows: (1) mathematics as search activity patterns and relationships, (2) mathematics as creativity requires imagination, intuition and invention, (3) mathematics as problem solving activities (problem solving), (4) mathematics as a tool to communicate.

B. Problem Based-Learning (PBL)

PBL is an approach to learning that is initiated by the filing of the issues or questions that are expected to be completed by the student. PBL uses the context of real-world problems to identify students in identifying researching concepts and principles as well as knowing how the solution through the issue (Duch, Groch, & Allen, 2001: 6). In addition, sometimes the problem situations that arise in the learning process is complex and confusing students that need to be studied to examine linkages with different disciplines, in other words the issue in early learning are sometimes ill-structured or open-ended (Fogarty, 1997). Further characteristics of PBL delivered Arends & Kilcher (2010: 326) includes: (1) problems or issues (learning begins with the filing of the problems in students); (2) authentic (students seeking a realistic settlement to a real problem); (3) investigation and problem solving (students actively involved through a series of investigative activities and problem-solving groups); (4) view interdisciplinary linkages (students explore the standpoint of several disciplines when analyzing the problems in the investigation); and (5) a small group collaboration (learning occurs in the context of a small, in a group consisting of five or six students); and (6) the results of discussions and presentations (students demonstrate learning outcomes by creating products and flaunt it. In many cases, the students present the group's work to her friends or other groups).

With PBL, the focus of mobile learning content or material to the issues such as the following illustration.

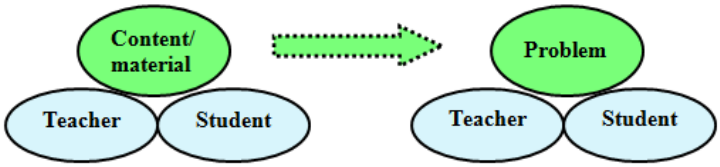

FIGURE 1. FOCUS OF PBL

With the picture above scheme, learning becomes more realistic to create learning that emphasizes real-world, high-level thinking skills, cross-disciplinary learning, independent study, group work skills and communicate through the atmosphere PBL.

TABLE 2. PHASES OF PBL

Phases Of Learnin	Learning Activities
Phase 1: Orient students on issues	The teacher presents real problems through pictures, video and motivate students to perform troubleshooting. Students at this stage make observations on the issues presented.
Phase 2: Organize students to learn	Students in small groups to design steps to resolve problems by collecting information needed by the observations that have been made. Teachers guide students prepare questions and plan for settlement of the issue through the guide in the form of an activity sheet. Students prepare questions to the problems observed.
Phase 3: Guiding investigations of individuals or groups	Students with the group gathered information to conduct an investigation into the problems presented through data or information that has been collected. The data collected is processed to determine the settlement of the problem through investigation. Teachers guide the students carry out the settlement to get a solution to the problem.
Phase 4: Develop and present work	Students communicate the results of the solution to the problems that have been obtained at the front of the classroom or in the other group.
Phase 5: Analyze and evaluate the problem solving process	Students perform evaluation or review of the results that have been obtained. At this stage, teachers guide students in making a final conclusion.

C. Mathematical Reasoning Ability

Reasoning ability is one of the important ability to have. Reasoning can be expressed as the science regarding the procedure of withdrawal conclusion (Leighton in Goldstein, 2008: 435). A more complete definition of the reasoning states that the reasoning could be viewed as a cognitive process in which people start with a number of inter-related information further draw conclusions from the information link (Kurtz et al. In Goldstein, 2008: 435). The two statements in line with the suggestion that reasoning is a thought process or activity that seeks the connection between the facts that are known (premise) leads to a new statement or conclusion (Sadiq, 2009: 9).

The process of reasoning to support understanding in mathematics learning and enables students to understand that they learned. This process involves the phenomenon explore, develop ideas, create duagaan mathematics, and the results justify. During the learning process the teacher to help and provide support to students to find the concepts they are learning through exploration. Thus, students can easily understand the mathematical concepts they are learning.

Thus, the opinion of some of the above it is operationally mathematical reasoning referred to in this research include the ability to create a mathematical conjecture, found a pattern on a mathematical phenomenon, draw conclusions from a statement, and provide an alternative for an argument. In other words, the indicators of the ability of mathematical reasoning in this study, are presented in Table 3 below.

TABLE 3. INDICATORS OF MATHEMATICAL REASONING

No.	Indicators Mathematical Reasoning
1.	Finding patterns on a mathematical phenomenon
2.	Formulate a mathematical conjecture
3.	Drawing conclusions from a statement

D. Curiosity of Students

Definition of curiosity (curiosity) expressed by many psychologists. (Litman & Spielberger, 2005: 75) defines the attitude of curiosity broadly as a desire to acquire new knowledge and new sensory experiences, which motivate action exploration. In line with this, (Renner, 2006: 305) states that the type of curiosity which is among others include information and new knowledge. A similar opinion illustrates curiosity as an impetus internally to mastery / attainment of knowledge and skills, and it will tend to be

reduced in line with the acquisition of knowledge and the results of repetition / exercise (Berlyne, 1954: 180).

Thomas Alva Edison was revealed that the greatest invention in the world one of which is the idea or the ideas of the children and each of the ideas came from a curiosity, so it's important to cultivate curiosity. Moreover, the attitude of curiosity is precisely what has been a lot to contribute in the development of various new discoveries (Stokoe, 2012: 63). Likewise curiosity in learning, critical owned by the students, because with the curiosity would trigger the need for students to learn, investigate or find out. This will lead to an interest to follow up exploration activities or investigation (McElmeel, 2002: 51). In fact, curiosity about something causes a strong desire to understand it.

Curiosity can be increased by connecting the lesson, one of them by hooking sample materials studied to student life (Arends, 2012: 162). By knowing the benefits of use in everyday life, it can bring up to feel the curiosity of students towards learning. Examples workmanship issues contained in problem-based learning (PBL) or in other learning approaches that are realistic. Furthermore, cultivate an attitude of curiosity can be reached in several ways, including: (1) demonstrate things that are unique, new, exciting, shocking or surprising, (2) activities that are challenging students with the knowledge they have (Slavin, 2006: 327).

At a more narrow sense (Kasdhan, at al., 2004: 291) view curiosity as a system of emotional-motivational positively related to exploration activities of the introduction of a thing, the search for the needed information, and setting themselves up for mengekslorasi and get new ideas and opportunity challenges in trying new things. Meanwhile (Ball, 2012: 3) analogize curiosity in science as an impulse that requires understanding of the symptoms that occur in nature.

From the opinions of experts who presented above, it can be concluded that in general curiosity is defined as the desire to obtain more information about the knowledge, skills, or similar natural conditions around new experiences. The desire of curiosity will encourage someone to do a quest for information / knowledge is required. In addition, the finer points of some sense of curiosity outlined above, namely: (1) the desire to obtain some necessary information about an object being studied is the trigger for the attitude of curiosity, (2) the manifestation of the attitude of flavor curious visible from search action / exploration and investigation. The exposure of the aspects and operational indicators curiosity of students that will be used to measure the curiosity of students to mathematics for this study are presented in the table below.

TABLE 4. CURIOSITY ASPECTS AND INDICATORS OF STUDENTS

Aspect	Indicator
Desire to learn	a. Enthusiastic about learning mathematics b. Trying to understand the mathematical concepts c. Happy and diligent study, vigorously, do not get bored with varied tasks.
Investigate	Trying to find a solution difficulty in understanding the math by asking the friends / people who know better, or by reading / studying math book.
Coordinate existing cognitive structure	Using the theory / concept that has been studied previously in understanding new concepts.

E. Development Learning Tool

In planning learning activities, teachers should set up a device that can support the learning process so that it can run properly. The learning tools that will be developed in the study include lesson plan and student activity sheet.

benefits of preparation lesson plan at least serve as a guide to teach or record teachers in the learning process. In addition, the lesson plan will also provide an opportunity for teachers to mentally rehearse prior to the implementation of learning (Posamenteir, at al., 2007: 47). It is very urgent and very beneficial, especially for teachers who are teaching experience is still relatively new to teaching and teachers who try to apply the model / learning approaches that are new.

The use of worksheets students in learning activities greatly help students to cultivate their own ingredients studied or with friends in a form of group discussions. Student worksheet also serves as a learning resource to facilitate learning in groups according to the learning activities developed.

F. Review of Relevan Research

The research is relevant to this study from the aspect of problem based learning to aspects of mathematical reasoning abilities and aspects of the curiosity of students, as follows:

1. Research conducted by Endang Wahyuningsih (2014) in the junior class VIII, entitled "Development of a circle with a learning device problem-based learning approach oriented mathematical reasoning and communication in class VIII SMPN Puring Kebumen". This research resulted in the learning circle with a problem-based approach pemebelajaran oriented mathematical reasoning and communication junior high school students of class VIII. The tests showed that the lesson plan and

worksheets that are developed each valid criteria with very good category. Field trial results showed that the developed lesson plans and worksheets that meet the criteria of a practical and effective. Practicality achieve excellent category based on the evaluation of teachers, both categories based on student responses, and the very good category is based on the observation keterlaksanaan learning. The effectiveness of achieving effective category based mastery learning students. The percentage of the number of students who pass the tests of mathematical reasoning abilities reached 82.82%, the test mathematical communication ability reaches 76.57%, and the learning achievement test reached 79.69%.

2. Research conducted by Mirayanti (2012) on the high school students of class XI in Bima. The study is quasi-experimental research. The population in this study were all high school students in class XI in Bima district in the academic year 2011/2012. Research samples were high school students of class XI each category represent the school well, pretty and less. The study design used is Nonequivalent Control Group Design by using purposive sampling technique. Research results show that there are differences both on the increase in mathematical reasoning ability and the ability of mathematical communication between students who received the study of mathematics by problem-based learning approach and conventional learning at school either category, sufficient and less. In the school category enough, increase the ability of students' mathematical reasoning, either learning using problem-based learning and conventional learning is higher than the category of good schools and less. Improved communication skills students learn mathematical menngunakan problem-based learning in school enough categories, higher than the students in the school category and less good.
3. Research conducted by Tatang Herman at students of SMP Negeri 22 Bandung with a main subject is class VIII B. The title of his research is Problem Based Learning to Enhance Mathematical Reasoning Ability Junior High School Students. This research is the development activities undertaken collaboratively between teachers, students, and faculty by using descriptive qualitative method. The results of these penelitiann visible improvement of mathematical reasoning abilities experienced by students occurs in every cycle. In the first cycle reasoning test results showed the average mean of 7.35 and the second cycle reaches 7.56. Then in the third cycle of learning seem more evolved and is also evidenced by the results of tests of reasoning at the end of the third cycle, which reached an average 7.90.

G. Framework

In the first phase of PBL, students are exposed to the problems that are real that stimulate the curiosity of students. Such problems will raise questions on students, encouraging students reason to hypothesize and speculate. In the process of finding a solution, students need to think logically. Thus, learning by PBL can improve students' mathematical reasoning abilities.

The next phase, students will be guided to plan the inquiry process by forming a group, divide the tasks of investigation, as well as set a specific subtopic-topics to be studied more deeply. So that the investigation can proceed smoothly, the division of tasks for each member of the group must be clear. In this situation, the student will communicate to share role and it is expected to increase their curiosity towards their respective roles in the investigation activities to be undertaken in the next phase.

In the third phase PBL, students are asked to conduct an investigation / discussion groups. At this stage, students can discuss intensively so that they will be asked, answered, criticize, mengevalasi, and to clarify any concepts or mathematical arguments that emerge from the discussions. In this event also allows the development of students' ability to create, refine and explore allegations (conjecture) that solidify their understanding or mathematical concepts being studied, or the mathematical problems are solved. In addition, these activities also allow students to collect and analyze information, conduct investigations, and make conclusions. Thus, the atmosphere of cooperation within the group as described above, can improve communication skills, curiosity and students' mathematical reasoning.

Furthermore, in the fourth phase is the presentation of the work, the students communicate the results of group discussion, either orally or in writing to the teacher and classmates. At this stage, the students rehearsed a lot about how to present their thoughts are kind and courteous to others. Thus, learning by PBL can improve students' mathematical communication skills.

Last phase of the analysis and evaluation of problem-solving process. The core of this activity is to reflect on the thinking of students and the process of investigation or the problem solving process that has been done. Through this phase, various errors will be corrected. Thus, it will improve the ability of mathematical reasoning and mathematics achievement learn some vital lessons.

III. CONCLUSION AND SUGGESTION

PBL is a learning approach that stimulates the power of reason and the attitude of curiosity of students. Moreover, PBL is also a learning approach that is recommended and in accordance with the curriculum of 2013. Each phase in the PBL has a role in enhancing the ability of reasoning and the curiosity of students. Presents problems that will be used in PBL is not easy. The exact problem should include a contextual situation motivate students to complete although not yet know firsthand how that should be done to solve the problem. This does not mean that type of problem to be intractable students, even teachers are expected to predict that siiswa has the potential to solve them. Sometimes PBL can be time consuming long enough if the management class is not managed properly. Therefore, teachers should have a lesson plan carefully, so it is expected to guide and help students exactly how, appropriate and timely.

Teachers as agents of change in the front line of education are expected to implement the PBL approach in teaching mathematics in schools. Thus, it is expected that students have good mathematical reasoning ability and a high curiosity towards mathematics.

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REFERENCES

Arends, R.I. (2012). *Learning to teach (9th ed.).* New York: McGraw Hill

Arends, R.I., & Kilcher, A. (2010). *Teaching for student learning becoming an accomplished teacher*. New York: Routledge

Ball, P. (2012). Curiosity: How Science Became Interested in Everything.USA: The University of Chicago Press

Berlyne, D.E. (1954). A Theory of Human Curiosity. *British Journal of Psychology*, 45,3, 180

Duch, B., J., Groh, S., E., & Allen, D., E. (2001). *The power of problem-based learning a practical "how to" for teaching undergraduate course in any discipline*. Virginia: Stylus Publishing, LLC

Endang Wahyuningsih. (2014). Pengembangan perangkat pembelajaran lingkaran dengan pendekatan pembelajaran berbasis masalah berorientasi kemampuan penalaran dan komunikasi matematis pada siswa kelas VIII di SMPN Puring Kabupaten Kebumen. Tesis Magister, tidak diterbitkan. Yogyakarta: SPS UNY Yogyakarta

Fogarty, R. (1997). *Problem-based learning & curriculum models for the multiple intelligences classroom*. Glenview: Pearson SkyLight.

Goldstein, E.B. (2008). *Cognitive psychology: connecting mind, research, and everyday experience (2th ed.).* Belmont: Wadsworth Cengage Learning.

Heri Retnawati. (2015). Hambatan Guru Matematika Sekolah Menengah Pertama Dalam Menerapkan Kurikulum Baru. *Jurnal Cakrawala Pendidikan*, 390-403

Heri Retnawati. (2016). Vocational High School Teachers' Difficulties in Implementing the Assesment in Curriculum 2013 in Yogyakarta Privince Of Indonesia. *Internaional Journal of Instruction (IJI)*, Vol.9, 1, 1-16.

Kasdhan, T.B., Rose, P., Fincham, F.D. (2004). Curiosity and explosation: facilitating positive subjective experiences and personal growth opportunities. Journal of Personality Asessment, 82(3), 291-305.

Kemdikbud. (2013). *Permendikbud Nomor 68, Tahun 2013 tentang Standar Kerangka Dasar dan Struktur Kurikulum Pendidikan Dasar dan Menengah.* Jakarta: Depdikbud.

Kemdiknas.(2006). *Permendiknas Nomor 22, Tahun 2006 tentang Standar Isi Pendidikan Dasar dan Menengah*. Jakarta: Depdiknas.

Marsigit. (2009). *Matematika 1 SMP Kelas VII*. Jakarta: Yudhistira.

Mc Elmell, S.L., (2002). *Character education: a book guide for teachers, librarians, and parents*. Colorado: Greenwood Publishing Group, Inc.

Mikrayanti. (2012). Meningkatkan Kemampuan Penalaran dan Komunikasi Matematis Siswa Sekolah Menengah Atas Melalui pembelajaran Berbasisi Masalah: Studi Kuasi Eksperimen pada Siswa SMA di Kabupaten Bima, tidak diterbitkan. Bandung: SPS UPI Bandung.

Mullis, et al. (2011). Trends in International mathematics and science study. (2011). *TIMSS 2011 international results in mathematics*. Boston: Iternational Association for the Evaluation of Educational Achievement.

Posamentier, A.s, Jaye, D., & Krulik, S. (2007). *Exemplary practices for secondary math teacher*. Alexandria: ASCD.

Shadiq, F. (2009). *Kemahiran matematika*. Yogyakarta: PPPPTK Matematika.

Slavin, R.E. (2006). *Educational psychology (8th ed)*. New York: Allyn & Bacon.

Stokoe, Robert. (2012). Curiosity, A Conditing Learning. *International School Journal 32.1*, 63-65.

Tatang Herman. (2007). Pembelajaran Berbasis Masalah untuk Meningkatkan Kemampuan Penalaran Matematis Siswa SMP. *Jurnal Cakrawala Pendidikan, 27. 1*, 41-62