Development of mathematics learning device based on guided discovery of program of international student assessment model orientation (preliminary research)

C Afrilia¹, Yerizon², D Permana², and Armia²

¹ Post Graduate Students of Mathematics Education Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, Sumatra Barat, Indonesia
² Post Graduate Teaching Staff Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, Sumatra Barat, Indonesia

yerizon@yahoo.com

Abstract. Student’s mathematical problem solving ability has optimal yet, this is due to school learning fail to get students used to work on problem solving PISA questions model. The purpose of this research is to produce mathematics learning device based on guided discovery of PISA model orientation in order to improve student’s problem solving ability. This is a development research. Development model of this research is Plomp model which consists of three phases, namely, preliminary research, development or prototyping phase, and assessment phase. The results of data analysis on preliminary research are: 1) Teacher has yet to be able to develop the learning device to improve students’ mathematical ability. 2) Learning resources used by the students are optimal yet to be able to draw student’s interest to learn. 3) Students are expecting for the attractive worksheet display and small number of the questions. 4) Students are expecting worksheet to discuss more on the use of mathematics in the society real life and problems related with their personal activities. 5) Students who are living in the remote area tend to be less motivated and less willing the learning process. 6) Students prefer group learning to individual learning.

1. Introduction

Mathematics education is a life aspect that plays important role in improving student’s quality. It is expected that, through mathematics learning, students can learn to solve the problem and learn to improve their mindset to discover noble ideas related with the learning process.

According to Regulation of National Education Minister of Republic of Indonesia No.58 year 2014, amongst the purposes of mathematics learning is for the students to perform tenacious attitude and self confident in solving the problem [1]. This is in line with the general purpose on mathematics learning as stated in National Council of Teacher of Mathematics [2] that students are required to possess concept understanding, problem solving, communicating, reasoning, and mathematics connection abilities. Based on the above statement, it is obvious that mathematical ability is of vital importance in improving student’s learning quality one of them is a problem solving ability.

Problem solving ability is the basic one to possess by students to enable them to identify and to solve problem they encounter during learning process. One of the importance of problem solving is it serves as general purpose in teaching mathematics. The indicators of problem solving are the identification of
data adequacy to solve problem. The making of mathematics model, selecting and implementing the strategy, interpreting result based on original case, and finally checking on the correctness of the answer or result.

Student’s problem solving ability is still low, hinges on [3] [4] [5] [6] [7] [8] [9] [10]. This is supported by the survey result conducted by Programmed of International student Assessment (PISA) in 2009 which reveals that Indonesia has failed to perform high achievement on reading, science, and mathematics disciplines. PISA survey result on mathematics shows that Indonesia is in 61 position out of 65 nations with a score of 371 out of average score of 496 [11]. This is a very apprehensive position to the Indonesian development and education quality in the international level.

The low student’s achievement in Indonesia in this program is related closely to the school learning. School learning has failed to get the students used to work on PISA model questions. Most of PISA questions present mathematics ability in which one of them is a problem solving ability.

PISA question is developed based on content, context, and competency [11]. Meanwhile, the contexts of PISA questions are four and relate with situation/context, personal, occupational, societal, and scientific. Next, PISA competence is classified into three clusters, namely, reproduction, connection, and reflection [11].

The low ability of student’s mathematical problem solving will also influence learning achievement and may lead to the low learning result. The result of Final Examination (UN) revealed that student’s mathematics achievement is still low. As stated by Anna, amongst 16,616 students who are failed to pass the Final Examination, 1330 of them are failed on Mathematics subject. This is the highest test failure number compared with other learning subject test results (Kompas, on June 25th in 2013). Student’s low achievement can also be seen in the result of middle term test of odd semester on mathematics learning of class VII students in Public Junior High School (SMP N) 1 Lembang Jaya and Public Junior High School (SMP N) 6 Lembang Jaya. The results yielded that the achievement is below the minimum completeness criteria (KKM) that has been established, ≥ 75 for SMP N 1 and ≥ 70 for SMP N 6 Lembang Jaya.

To overcome those above problems, it is of importance to improve the learning process; one of them is by employing learning device which allows students to be active, creative, and well motivated to solve mathematics problem learning. And so mathematics learning can then be fun. The availability of learning device is a supporting learning factor to enable appropriate learning process to take place. [12].

In doing so, to support student’s learning process is by employing their mindset which can be found on lesson plan. Teacher may as well use worksheet as one of the learning media. The purpose of using worksheet is to help students to comprehend the material and to help teacher to assure students are active in the learning process, hence the students can be more motivated to try to find problem on worksheet and discuss it with their peer.

In fact, learning device used in the field has optimal yet in motivating students to solve problem during learning process. This is supported by interviewing result conducted by the researcher with Ms. Ernawati in December, 17th 2018. She is mathematics teacher of class VII in SMP N 1 Lembang Jaya. She revealed that worksheet employed has yet be able to facilitate students in developing their ability in problem solving which can obviously seen on their low learning result.

Worksheet employed shows no question or statement that requires students to solve the problem. As the effect, students less developed their mathematics problem solving ability. Worksheet employed only containing learning material, question sample, and exercise in both essay and multiple choices. Those are failing to fulfill the student’s need. Worksheet employed started directly with mathematics concept, question sample, and exercises.

In its real practice, numerous teachers have yet using a variety of learning material in their learning process. Teacher tends to focus only on textbook. They deliver the learning material in sequence exactly as the textbook arrangement. In fact, they are actually allow to create their very own learning material, one of them is worksheet they made by themselves. However, mostly they purchase worksheet from the market since some teacher has no capability in designing their own worksheet.
Mathematics learning also require appropriate model to improve problem solving ability, which is in line with the characteristics of the material delivered to the students. One of the learning models to enable students to improve their mathematics problem solving ability is guided discovery learning model [13]. The learning steps of guided discovery learning model [14] are as follow:

- **Stimulation** (left question or encourage students to observe picture and to read a book about the material).
- **Problem Statement** (provide opportunity for the students to identify numerous relevant problems with learning material).
- **Data collection** (provide opportunity for the students to collect information).
- **Data processing** (to process data obtained from the students).
- **Verification** (thorough checking to verified hypothesis validity).
- **Generalization** (drawing conclusion).

The advantages of guided learning discovery are to lead the students to be an independent learner by employing their logic in thinking and reasoning, and to solve the problem to finally find the result. This kind of achievement will be more meaningful and last longer. This opinion is strengthened by research result conducted by Sherly [15], it is proved that mathematics learning with guided discovery can help improve Junior High School student’s mathematical problem solving ability.

Learning device based on guided discovery often found in the field. Therefore, the researchers are intending to develop learning device based on guided discovery of PISA model orientation where the questions in the worksheet are PISA model questions in order to train the student’s ability in problem solving.

2. **Research method**

This is a development research aimed to produce certain product and to test its validity, practicality and effectiveness [16]. The development model employed is Ploomp model which consists of three phases: preliminary research, prototyping stage, and assessment stage [17]. Preliminary research consists of need analysis, student analysis, curriculum analysis, and concept analysis.

Need analysis is to observe, to interview, and to distribute the questionnaire to obtain any needed related information in educational field. The purpose of this phase is to obtain information and perhaps revision and innovation are of vital importance to collect the temporary characteristics of the developed product.

Curriculum analysis is implemented toward curriculum 13 for mathematics learning subject of class VII Junior High School. Curriculum analysis is to analyze the basic competence that can be seen on content standard and learning purpose. Curriculum analysis is implemented by analyzing core and basic competencies, material scope, learning purpose, and achievement indicator that have to be fulfilled. The result of the curriculum will be analyzed to allow the resulted mathematics learning device is in line with the purpose of the competence that has to be achieved by the students.

Students need analysis is conducted by interviewing one of the mathematics teachers in SMPN 1 Lembang Jaya. The purpose of this analysis is to discover the student’s characteristics including: academic ability, the environment around the students, students learning style preference, and students learning motivation particularly on mathematics subject. Hence, the resulted learning device is in line with students characteristics. In this research, the research subjects are students of class VII of Public Junior High School (SMP N) 1 Lembang Jaya.

Concept analysis aimed to determine both learning content and learning material required in the development of learning device. Material is of vital importance to achieve competence achievement indicator. Once all the learning material delivered on first semester in class VII, it is important to conduct concept analysis aimed to identify main concepts that will be taught and to arrange them systematically based on the presentation order [15].

3. **Result and discussion**

On preliminary research, the core steps are as follow:
3.1 Need Analysis
Based on the result of interview and observation conducted on December 17th, 2018, it is known that some students are still thinking that mathematics learning is hard to comprehend; therefore they need innovation in mathematics learning process in the form of new learning model other than conventional learning which can optimize student’s ability in mathematics problem solving.

The other need in conducting learning is learning device so that learning process can run systematically to achieve the learning purpose. The required learning, devices are lesson plan and worksheet to allow the improvement of student’s ability in solving mathematics problem of class VII Junior High School. The results obtained from need analysis are learning material employed by the teacher has optimal yet; teacher has no capability to develop his/her own learning device to enable the improvement of student’s mathematical problem solving, teacher relies heavily on the worksheet available in the market. The interview results with a teacher also indicate that the developed lesson plan is not as expected. In some cases, teacher are actually has prepared the lesson plan, however the implementation is different. In addition, worksheet employed also has yet help the implementation of lesson plan.

Instead of conducting interview and observation, questionnaire also distribute to 28 students. The questionnaire is about the characteristics of the worksheet expected by the students. The result of the questionnaire reveals that students are expecting mostly blue color worksheet on A4 size paper. They think that this A4 size is easy to carry anywhere they go. They also ask for a more attractive worksheet display and the numbers of the questions are less. The problem expected by the students to be discussed on the worksheet is a problem related with the use of mathematics in the real society life and problems related with student’s individual activity as well as problems in the surrounding environment.

3.2 Curriculum Analysis
After conducting curriculum analysis, analyzing core, basic competencies, indicator, and the learning purpose are not described in detail yet. This can be seen from the syllabus of mathematics subject for class VII of first semester distributed by teacher. Therefore, learning device is needed.

Learning device employed has to be able to facilitate students to be able to comprehend the material guided through different kinds of learning activities. Based on these descriptions of competencies core, basic competencies, and indicator. Hence, the learning will be started by giving problem or questions to students in order to motivate them in finding a learning concept, so that material that will be learned will stay longer in their memory. Problem or questions given to the students are PISA model questions. The purpose is to train student’s automatic ability of mathematics problem solving.

3.3 Students analysis
After conducting interview and observation toward class VII of SMP N 1 Lembang Jaya, it revealed that students have different academic abilities, some are high, some are moderate, and others are low. Students are also immature yet considering their age; hence learning device which can help them be motivated is of vital importance. Students of class VII of SMP N 1 Lembang Jaya are used to live in the rural mountainous area, which is far away from a city, so they tend to be passive during learning. Therefore, students need learning device that can make them active during learning process.

Instead of interview with a teacher, students also given questionnaire in the form of questions related with themselves. The result of the questionnaire revealed that students still think that mathematics learning is hard to comprehend. In the learning process, students prefer group works to individual work since they can discuss the problem with their peer.

3.4 Concept Analysis
After analyzing the concept based on curriculum 13 of class VII in the odd semester, the learning material consists of 4 chapters: Number, set, algebraic forms and its operation, equations and one variable linear inequality. Based on the result of concept analysis, it is decided that material of Number will be used as mathematics learning material that will developed. The material given has to follow the
logic sequence; hence all indicators can be achieved. Finally, material which is in line with indicator will be explained in a more detail to facilitate the students for easier comprehension.

4. Conclusion
This is a development research which produces learning device based on guided discovery of PISA model orientation. The devices are lesson plan and worksheet of class VII on Number learning material. Problem or questions presented on worksheet are PISA model questions. The purpose is to train student’s ability in mathematical problem solving.

The development model used is PLomp model which consists of three phases: preliminary research, development or prototyping phase, and assessment phase. This research hinges only on preliminary research. Preliminary research consists of need analysis, student analysis, curriculum analysis, and concept analysis. The results of data analysis on preliminary research are:

- Teacher has yet to be able to develop their own learning device to allow the improvement of student’s mathematics ability.
- Teacher relies heavily on the worksheet available in the market.
- Some students still think that mathematics is a difficult learning subject to comprehend.
- Learning resources employed by the students has optimal yet in drawing students’ attention.
- Students are expecting for a more attractive worksheet display and the questions on the worksheet are in small number.
- Problems expected by the students to be found in the worksheet are related with the use of mathematics knowledge in real society life and problems related with their personal activity as well as problem they encounter in their surrounding environment.
- Students who live in the mountainous area which is far away from the city tend to be less motivated and less willing in the learning process; hence most of them are less active during learning process.
- Students prefer to work on group rather than work individually.

Acknowledgements
The authors are grateful to the ministry of Research, Technology, and grateful to the ministry of Research, Technology, and Higher Education Of Republic of Indonesia a the sponsor of this research (Contrac No.: 374/UN35.13/LT/2019, date 25 March 2019).

References
[1] Peraturan Menteri Pendidikan Nasional Nomor Nomor 58 tahun 2014. Kurikulum 2013 Sekolah Menengah Pertama/Madrasah Tsanawiyah. Jakarta: Departemen Pendidikan dan Kebudayaan.
[2] NCTM. (2000). Priciples and Standards for School Mathematics. RestonVA: NCTM.
[3] Amir M F. (2015). Pengaruh pembelajaran kontekstual terhadap kemampuan pemecahan masalah matematika siswa sekolah dasar. Prosiding Seminar Nasional Pendidikan : Tema “Peningkatan Kualitas Peserta didik melalui implementasi Pembelajaran Abad 21” Fakultas Keguruan dan Ilmu Pendidikan Universitas Muhammadiyah Sidoarjo.
[4] Hunter R. 2015. Pengembangan perangkat pembelajaran untuk meningkatkan kemampuan pemecahan masalah matematis dan self efficacy siswa. Jurnal Pendidikan Matematika dan Terapan FKIP–Univ. HKBP Nommensen,Vol. 1, Hal. 1-14.
[5] Kim K. 2014. The relationship between problem solving ability, Professional self concept, and critical thinking disposition of nursing students. Namseoul University. Interenational Journal of Bio-Science and BoîTechnology. 6, Hal. 131-142.
[6] Lein, A.E.L. 2016. Assessing the relation between seventh-grade students engagement and mathematical problem solving performance. Journal Preventing School Failure, Vol. 60, Hal. 117-123.

[7] Nasution D H dan Yerizon. 2019. Development Of Student Worksheets Based On Discovery Learning To Improve Student Mathematical Problem Solving Ability In Class X Senior High School. International Journal Of Scientific & Technology Research Volume 8, Issue 06, June 2019.

[8] Suastika K. 2017. Mathematics Learning Model of Open Problem Solving to Develop Students’ Creativity. International Electronic Journal Of Mathematics Education E-Issn : 1306-3030, Vol. 12, No. 3, 569-577.

[9] Widodo S A. 2017. Development of teaching materials algebraic Equation to improve problem solving. Infinity Journal of Mathematics Education 6 (1) : 59-68.

[10] Yurniwati dan latipa. 2017. Improving mathematics achievement of Indonesian 5th grade students through guided discovery learning. Journal on Mathematics Education Volume 8, No. 1, Hal 77-84

[11] OECD (2010), PISA 2009 Results: Executive Summary

[12] Kurniawati W Y. 2013. Pengembangan alat peraga dan lembar kerja siswa berorientasi konstruktivisme dalam pembelajaran kimia SMA.Prosiding Semirata FMIPA Universitas Lampung.

[13] Khasanah, dkk. 2017. Guided Discovery Learning in Geometry Learning. International Conference on Mathematics, Science and Education 2017 (ICMSE2017).

[14] Yerizon, dkk. 2018. Student Responses Toward Student Worksheets Based on Discovery Learning for Student with Intrapersonal and Interpersonal Intelligence. IOP Conf. Series Materials Science and Engineering 335 (2018) 012113 doi:10.1088/1757-899X/335/1/012113

[15] Sherly. 2014. Pengembangan Perangkat Pembelajaran Matematika Berbasis Metode Penemuan Terbimbing Untuk Meningkatkan Kemampuan Pemecahan Masalah Matematika Peserta Didik Kelas VII SMP. Padang: FMIPA UNP

[16] Sugiyono, 2008. Metode Penelitian Pendidikan. Bandung: CV. Alfabeta.

[17] Plomp T. 2013. An Introduction to Educational Design Research :SLO – Netherlands Institute for Curriculum Development.