The development of mathematics learning tools based on number heads together model to improve mathematical problem-solving skills of grade vii junior high school students

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Abstract. This study aims to produce a valid and effective learning tool that is impactful towards students’ mathematical problem solving ability by using number heads together type cooperative learning model. The study developed both lesson plan (known as RPP) and students' worksheets (known as LKPD) by using the Plomp development model. The research focuses on testing the effectiveness of the learning tool. The instruments used in this study are validation sheets and problem-solving skills tests. The result of the survey shows that RPP and LKPD were valid and effective.

1. Introduction

One of the mathematical competencies that students must study is the ability to solve mathematical problems; this is stated in the Regulation of the Ministry of Education and Culture no.58/2014 about the objectives of learning mathematics. Problem-solving is a process of implementing the obtained knowledge to a new and different situation [1]. Though problem-solving is inseparable from mathematical problems, many students still find it challenging to solve mathematical problems [2-12].

The result of study conducted by Programme International student Assessment (PISA); international study literacy, mathematics, and science of 15-year-old students held by the Organization For Economic Cooperation And Development (OECD) started from 2000 to 2018, position Indonesia in rank 39 (out of 41 countries) in 2000; in rank 38 – out of 40 countries – in 2003; in rank 50 (out of 57 countries) in 2006; in rank 61 out of 65 in 2009; in rank 64 out of 65 countries in 2012; in rank 69 out of 76 countries in 2015 and the last survey in 2018 showed that Indonesia ranked 75th out of 80 countries.

Apart from the results of PISA assessment, students’ low mathematical ability in the primary and secondary schools can be seen from the result of studies conducted by Trend In International Mathematics and Science Study (TIMSS) in 1995, 1999, 2003 2007, 2011 and 2015. Table 1 illustrates the TIMMS score and Indonesian students' achievement at an international level.

Table 1. Indonesian students performance in mathematics and science

| Year | Score | Rank | Number of Participant Countries | International Average Score |
|------|-------|------|---------------------------------|-----------------------------|
| 2003 | 411   | 35   | 46                              | 467                         |
| 2007 | 397   | 36   | 49                              | 500                         |
The TIMSS and PISA survey results show that the mathematical ability of students in Indonesia is still far behind those of students in other countries. It is also proven by the result of a literature analysis done by Fauzani and Tasman in West Sumatera, which states that students’ mathematical ability in junior high school (known as SMP/MTs) still tends to be low [13]. One of the mathematical skills discussed is the capability to solve mathematical problems.

From the objectives of learning mathematics and the literature review above, it can be perceived that one of the mathematical abilities that students should possess is the ability to solve problems. The ability to solve mathematical problems is crucial because (i) it is a general goal of mathematics education, (ii) it includes methods, procedures, and strategies that are the primary and core process in the mathematics curriculum, and (iii) problem solving is an essential ability to learn mathematics [14].

There are four steps taken to solve the problem; they are (a) understanding the problem, (b) planning the solution, (c) executing the plan, and (d) reviewing [15]. Despite those steps, students are having difficulty understanding existing problems; thus, it is still challenging for them to choose the right method to solve a mathematical problem. Consequently, the students have low achievement in schools.

Students’ less-developed problem-solving ability is also revealed in several studies, stating that the problem-solving ability has not yet been optimal or is still very low [5],[11]. Not only does it occur in Indonesia but other countries as well. The development of Chinese students’ ability to solve problems—as a goal in mathematics education—still becomes a fundamental issue [16]. It also happens in Indonesia.

Based on the initial observation done on 24 April to 8 May 2019 towards students grade VII in Junior High School 1 X Koto Diatas, Padang has indicated that teachers still dominated the learning process to have a slight chance to express their ideas or thoughts. Most teachers started the teaching and learning process by discussing tasks and then directly discussing the subject to be learned, working on the textbook as the exercise materials for students, drawing conclusions, and giving homework; this is the typical teaching and learning process. An interview done with math teachers has shown that students were less interested in studying math; this was caused by the lack of variety of learning models or teachers’ tools. Teachers were limited by their responsibility to complete certain materials in a semester; hence, the expository method is frequently used. Meanwhile, interviews accomplished with some students designate that students find it challenging to understand the problem-solving questions and have struggled to link various concepts that have been studied. Therefore, the students were unmotivated because they did not understand and were unaware of mathematical concepts in daily life.

Students’ low capability in solving mathematical problems could be seen in the initial test given in class VII.4 SMPN 1 X Koto Diatas. No one scored 0. Meanwhile, 76.92 % obtained score 1, 23.08 % obtained score 2, 0 % obtained score 3 and 4. From all scores obtained, the achievement score was 30.77 %. It implies that students’ ability to solve mathematical problems was still low and needs to be improved.

One of the causes of students’ low ability in solving mathematical problems is the learning model used by teachers. The model implemented by teachers has not yet capable to activate students’ interest to study or motivate them to articulate their ideas and thoughts. In other words, the teaching and learning process has not yet strive for the development of problem-solving ability in each student. One of the goals of mathematics education is to enhance problem-solving skills. One way to foster students’ active involvement in the teaching and learning process is to use a cooperative model. Cooperative learning can elicit students’ attentiveness to study either by themselves or in groups from academic ability, ethnicity, and gender to discuss the learning process [17].
Number Heads Together (NHT) type of cooperative learning model is a learning model where every student in a heterogeneous group has a different number. Due to its numbering system, NHT is believed to be apposite for students to be more responsible for the subject studied because they have an equal opportunity to explain the result of their group discussion. This type of learning model requires learning tools based on the characteristics and steps of the NHT type of cooperative learning model, one of which is the Lesson Plan (known as RPP). RPP is a guideline or a learning process that largely determines students' and teachers' actions to reach the pre-established learning goals.

Concerning LKPD used in SMPN 1 X Koto Diatas, it is known that students merely use LKPD issued by publishers. The LKPD is quite helpful in assisting students in understanding learning materials due to a lot of exercises and homework presented. However, the movements are mostly created not in the form of problem-solving activities or exercises. Consequently, when students are given questions that need problem-solving ability, they have difficulty in accomplishing them. For instance, the sets that contain many items that require problem-solving skills and related to daily life. To solve those problems, students do not know about choosing the right strategy. This material is crucial to be mastered as it is the prerequisite material before studying algebra at a higher level. That is to say, LKPD used has not yet capable of optimizing students' active involvement to do an investigation and problem solving, not to mention students' needs and characters.

Based on the problems discussed above, LKPD should have been developed in accordance with students' needs and characteristics, especially the need to solve mathematical problems. One way to accomplish it by developing LKPD based on NHT type cooperative learning model. This type of LKPD stresses students’ activeness in doing investigations and problem-solving utilizing searching the solution through its root or sources, either from books or other media, either done individually or in a group. Students are presented with authentic problems so that they could easily understand the issues and solve them systematically.

Based on the description above, the researchers are interested in designing a mathematical learning tool using the NHT model. Therefore, the researchers conducted a study on "developing mathematics learning tools by using number heads together type cooperative model to improve mathematical problem solving ability of grade vii junior high school students."

2. Materials and Methods
The main objective of this study is to develop valid, practical, and useful mathematical learning tools. The tools developed are lesson plan (known as RPP) and students’ worksheet (known as LKPD) for junior high school, seventh grade Semester 2 students with NHT model to improve students' ability to solve mathematical problems. Developmental research is a process or steps to develop new products or to enhance existing ones that can be accounted for. Research and development (R&D) is a research method employed to produce and test the effectiveness of a product. To achieve the objective, there are various research and development models that can be used. For example 4-D model [18], ADDIE, and Plomp model. This research uses Plomp due to (1) its quality and attributes to produce practical products, and (2) its practicality testing steps that are divided into three stages: one-to-one evaluation, small group, and a field test [19]. Plomp model has been widely used to develop mathematics teaching material in many educational levels, started from primary schools to tertiary education [20-23].

3. Result and Discussion

3.1 Initial Investigation
The initial investigation phase aims to determine the basic problems that occur while learning mathematics in the classroom. This is necessary to develop mathematics learning tools that will be made. This initial investigation phase is started with a need and concept analysis as well as a literature review. The investigation results are described below.
3.1.1 Analysis of Needs and Concepts
An analysis of needs and concepts in this study is based on the rationale of developing open-ended learning tools, analyzing core and basic competence, and analyzing students' characteristics (including cognitive level and age) so that the learning tools produced are in line with students' characteristics.

Based on the results of an observation done towards seven grade students in SMPN 1 X Koto Diatas, it can be identified that the learning process was still dominated by teachers (teacher-centered). In addition, students were less active during the teaching and learning process. Students' low scores fortify this in the mid-exam in the odd semester. Many students failed the exam.

Based on interviews with mathematics teachers, it is understood that teachers have not completely used the learning tools (RPP & LKPD) optimally. The teachers only use textbooks as a learning resource. The students work on the exercises in the textbooks based on what is taught by the teacher. If the exercises given by teachers are different, students usually get confused and could not work on the problem or exercise.

3.1.2 Literature Review
In this literature review, an analysis of theories and concepts related to the development of learning tools based on the NHT model includes the characteristics of RPP and LKPD. Based on the Regulation of Ministry of Education and Culture No. 22/2016, the components of RPP (i.e., lesson plan) include (1) School identity, (2) Class/semester, (3) Primary materials, (4) Time allocation, (5) Learning objectives, (6) Basic competence and its achievement indicators, (8) Learning materials, (9) Learning methods, (10) Learning resources, (11) Teaching and learning stages: pre-teaching, whilst-teaching and closing, (12) Assessment of learning outcomes. Simultaneously, the components of LKPD involve a title on the cover page, sub-title, core competence, basic competence, indicators, learning objectives, instructions, problems, and exercises.

Based on the analysis of the literature review above, theories, concepts, and materials needed in the teaching and learning process are arranged. There are several aspects used as a reference to reconstruct the NHT based learning tool: (1) Numbered Heads Together (NHT) model, (2) Plomp model, (3) RPP and LKPD, and (4) Mathematics learning materials for junior high school students in the 2nd semester.

3.2 Development Phase or Prototype Making
Before expert validation, the learning tools' self-evaluation was carried out using a self-evaluation instrument, as described below in Table 2.

| Types of tool | Self-evaluation results |
|---------------|-------------------------|
| RPP           | Aspects evaluated are aspects of RPP (lesson plan), NHT principles, and learning components. After the evaluation was completed, it was found that the designed RPP has met the determined criteria and corrected not well-developed sentences. |
| LKPD          | Aspects evaluated are the stages of NHT model, the language use, the presentation of images, and the suitability of questions used to train problem-solving ability. LKPD was revised after the evaluation was done. The revision was made by (1) adding questions in accordance with indicators of mathematical problem-solving ability and (2) improving the writing and picture layout. The results of the revision were then consulted and discussed with experts. |

After the RPP and LKPD were revised based on the findings of the self-evaluation, the learning tools were then validated by 5 validators, consisting of math lecturers, Indonesian language lecturers, and education technology lecturers. The validation results are presented in Table 2.
Table 3. RPP and LKPD validation results

| Types of tool | Validation result (%) | Category |
|---------------|-----------------------|----------|
| RPP           | 83.8                  | Valid    |
| LKPD          | 78.5                  | Valid    |

When the revision process of LKPD–based on a suggestion from validators–was finished, a one-to-one evaluation was carried out. LKPD was given to 3 students in grade VII in SMPN Kec. X Koto Diatas with different abilities: high, moderate, and low. The three students were asked to read and comprehend LKPD; the interviews were conducted to find out the practicality of LKPD. The results of the interview analysis depict that the presentation of LKPD is already stimulating and easily understood by students.

Once the revision carried out based on the one-to-one evaluation is finished, a small group evaluation was conducted. LKPD was tried out to 6 students that were divided into two groups. This small group evaluation was carried out 8 times. At the end of the meeting, students were given a questionnaire in response to the mathematics learning tools and a final test to solve their mathematical problem-solving ability.

The effectiveness of the learning tools is seen from the percentage of students who successfully completed the problem-solving ability test. The problem-solving ability test consists of 4 questions in accordance with the problem-solving ability indicators and learning materials taught (i.e., rectangles and triangles). Before the test was conducted, it is first validated by two mathematics lecturers to check the suitability of the questions given and the indicators of mathematical problem-solving ability. The final test results can be seen in Table 4 below.

Table 4. Mathematical problem-solving ability test results

| Total number of student | Students who successfully passed the test | Students that failed |
|-------------------------|------------------------------------------|---------------------|
| 6                       | 5                                        | 1                   |

Minimum pass score: 75

The test was given to 6 students in VII.1 in SMPN 15 Padang. Based on the test results, five students successfully passed the test, and one student failed. This indicates that more than 75% of students obtain a score more than the minimum pass score. In addition to that, the test of learning tools based on the NHT type cooperative learning model has been found to affect students positively. Students have been able to offer many solutions to the problems given in the test. Based on the result, the mathematics learning tools based on the NHT type cooperative learning model is found effective.

4. Conclusion
Based on the data, it can be concluded that RPP and LKPD based on the number head together model was valid and effective. This means that RPP and LKPD based on the number head together model positively impact students' ability to solve mathematical problems. It is expected that this NHT learning tool can be continuously used as a reference or guide for teachers to carry out the teaching and learning process.

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