The Development of Mathematics Learning Devices Based On Problem Based Learning and Geogebra-Assisted for Junior High School Students

N Priyatno1, I M Arnawa1,2 and N N Bakar2

1Department of Mathematics Educations, Universitas Negeri Padang, Indonesia
2Department of Mathematics, Universitas Andalas, Padang, Indonesia

Email: nandapriyatno2@gmail.com

Abstract. Based on observations, interviews, and preliminary analysis conducted, it showed that students' mathematical problem-solving skills were still not satisfying. This was caused by the teaching materials used by teachers in teaching have not helped students a lot in understanding mathematical concepts and properties. Based on these problems, the main objective of this research is to produce a practical mathematics learning devices in the form of RPP and LKPD for junior high school students based on problem based learning (PBL) and geogebra-assisted. This study was research and development (R&D) conducted with the Plomp development model. The subjects of this study were the student's grade viii SMP Negeri 25 Padang. Based on the R & D that has been carried out, it obtained that the learning devices (RPP and LKPD) were valid and practical.

1. Introduction

The mathematical abilities of Indonesian students at all levels of education have not met expectations ([1-10]). The low mathematical ability of elementary and junior high school students can be seen from the results of studies conducted by the Trend in International Mathematics and Science Study (TIMSS) in 1995, 1999, 2003, 2007, 2011, and 2015. Table 1 show the TIMMS score and achievement position Indonesian students internationally.

| Year | Score | Rank | Number of Countries Participated | International Mean Scores |
|------|-------|------|----------------------------------|---------------------------|
| 2003 | 411   | 35   | 46                               | 467                       |
| 2007 | 397   | 36   | 49                               | 500                       |
| 2011 | 386   | 38   | 42                               | 500                       |
| 2015 | 397   | 44   | 49                               | 500                       |

Source: https://timssandpirls.bc.ed

The analysis of the TIMMS study results showed that Indonesian students are weak in solving mathematical problems related to reasoning, problem-solving abilities, and mathematical communication.
Besides the TIMMS assessment results, the low mathematical ability of junior and senior high school students can also be seen from the results of the Program for International Student Assessment (PISA) study which is an international program organized by The Organization for Economic Cooperation and Development (OECD). The results of the PISA study from 2000 to 2018 show that the average mathematical ability of Indonesian students is always below the international average, as stated in Table 2.

West Sumatra as part of Indonesia, especially in Padang, SMPN 25 Padang showed that the results of the mathematical problem-solving abilities of the students were still not satisfying. This can be seen from the percentage of the students who completed the problem solving given as presented in Table 3.

Table 2. Indonesian student performance in mathematics literacy

| Year | Score | Rank | Number of participant countries | International mean score |
|------|-------|------|---------------------------------|--------------------------|
| 2000 | 367   | 39   | 41                              | 500                      |
| 2003 | 360   | 38   | 40                              | 500                      |
| 2006 | 391   | 50   | 57                              | 498                      |
| 2009 | 371   | 61   | 65                              | 496                      |
| 2012 | 375   | 64   | 65                              | 494                      |
| 2015 | 386   | 63   | 70                              | 490                      |
| 2018 | 379   | 73   | 79                              | 489                      |

Source: https://www.oecd.org/indonesia/

Table 3. Percentage of students success per indicators of mathematical problem solving ability

| School          | Indicators of mathematical problem solving | Question Number |
|-----------------|------------------------------------------|-----------------|
| SMPN 25 Padang  | Ability                                   |                 |
|                 | 1  | 2  | 3  | 4  |     |
| SMPN 25 Padang  | 55%| 50%| 55%| 60%| 1   |
| SMPN 25 Padang  | 45%| 55%| 40%| 50%| 2   |
| SMPN 25 Padang  | 40%| 45%| 35%| 40%| 3   |

Source: Mathematics teachers at SMP 25 Padang

Based on the observations conducted in Class viii 1 on January 13th, 2020 until January 24th, 2020, and the results of the interviews with the mathematics teachers held on January 15th, 2020 obtained information that: (1) the learning resources and learning media were still of a general and have not been linked to the students’ daily lives; (2) the teaching materials that were used by the teachers have not helped the students in understanding the mathematical concepts and properties; (3) the students lacked ability in solving the problems.

Based on these problems, it is very important to develop mathematical learning devices based on problem-based learning. According to Eggen [11] and Wena [12], the stages in implementing problem-based learning are as follows: (1) identifying questions, (2) formulating hypotheses, (3) collecting and analyzing data, (4) assessing hypotheses and making generalizations. From the results of this study, it is hoped that the learning devices will be obtained that can facilitate the students to be actively involved in the learning process. Some studies on the development of the teaching materials based on problem-based learning showed that the students are greatly helped in understanding the mathematical concepts and properties [8].

This study aims to produce valid, practical, and effective mathematics learning devices. There were many studies and the development models that can be used, for example, the 4-D model, ADDIE model, and Plomp model. In this study, the Plomp model was used. Compared to other models, the Plomp model guarantees more practical products because the practicality testing stage is carried out in three stages namely one-to-one evaluation, small group, and field test [13]. Plomp model has been widely used to
develop mathematics teaching materials, ranging from teaching materials for elementary schools to teaching materials for universities [13-18].

2. Materials and Methods
This study was a R&D to develop and produce a product as a solution to problems related to education. The products being developed were the learning devices in the form of lesson plan (RPP) and student worksheet (LKPD) based on problem-based learning assisted by geoGebra to improve the students’ mathematical problem-solving ability at grade viii SMPN 25 Padang.

In this study, the development model used was Plomp model. The Plomp model consists of three phases, namely the preliminary research phase, the development or prototype phase (development or prototyping phase), and the assessment phase [13-18].

3. Result and Discussion
To produce a practical learning mathematics for junior high school students based on problem based learning (PBL) and geoGebra-assisted The steps being passed are one to one evaluation and small group evaluation. The result of one to one evaluation and small group evaluation each were presented in Table 4 and Table 5.

| LKPD Number | Observation Results |
|-------------|---------------------|
| LKPD 1      | Students have not fully understood the instructions and instructions given and the students are using the geogebra application for the first time. Students with high ability could do well and were not reluctant to ask questions if difficulties. Students with middle ability did the activities in a hurry and did not read well the instructions that are there. Students with the low ability still needed guidance in doing activities. The problem-solving ability of the students was still low, and they had difficulty in defining the problem and collecting and analyzing data. |
| LKPD 2      | Students with high ability could complete the activity well even though there are some mistakes. Students with middle and low ability had difficulty understanding the given problem. The problem-solving ability of the students has begun to emerge and has begun to use the geogebra application according to the instructions in LKPD. |
| LKPD 3      | Students with high ability were able to understand the problem well, although occasionally in the solution they still asked the researcher. Students with low ability began to understand a little but still need guidance in solving problems and using the geogebra application. Students could already understand the problems given, only moderate and low ability students still need guidance occasionally. The mathematical problem-solving abilities of the students which were high, medium, and low have been improved. This can be seen in the students' problem solving that has been able to take pictures and graphics using the geoGebra application quite well. |
| LKPD 4      | Low-ability students had little difficulty in solving problems or problems so they still need guidance. However, overall, the ability of the students to solve problems was better. |
| LKPD 5      | In completing the activities and exercises questions, the students have tried to solve it themselves. Students looked happy and enthusiastic about learning LKPD 6 |
The results of the interviews with each student were conducted after the completion of the one to one evaluation activity. The results of the interviews conducted with the students concluded that (1) the students like the cover and appearance of LKPD, (2) PBL-based LKPD is clear, (3) PBL-based LKPD based on *geogebra* helps the students to learn. Based on the results of observations and interviews with students, revision of the LKPD was done, as presented in Figure 1a and 1b.

**Before Revision**

| Langkah-langkah menggunakan Geogebra: |
|---------------------------------------|
| 1. Buka aplikasi Geogebra             |
| 2. Pilih menu view, kemudian klik 3D graphics |
| 3. Untuk membuat alas kita pilih menu tool bar Polygon |
| 4. Kemudian pilih tool bar Pyramid, kemudian klik Extrude to prims |
| 5. Lalu masukkan ukuran sisi kubus     |
| 6. Kemudian pilih icon Pyramid, kemudian klik Net |
| 7. Kemudian kita klik gambar kubus, maka teduhar jaring-jaring kubus |

The Steps in Operating *Geogebra* Application

1. Open the *Geogebra* application
2. Select the View menu, then click 3D graphics. To make the base we choose the Polygon toolbar menu. Then select the Pyramid toolbar, then click Extrude to prims
3. Then enter the side size of the cube
4. Then select the Pyramid icon, then click Net. Then click the grave image, then you will see the cube net

**After Revision**

| Langkah-langkah menggunakan Geogebra: |
|---------------------------------------|
| 1. Buka aplikasi Geogebra             |
| 2. Pilih menu "View", kemudian klik "3D graphics" |
| 3. Untuk membuat alas kita pilih menu tool bar "Polygon" |
| 4. Pilih menu tool bar "Pyramid", kemudian klik "Extrude to prims" |
| 5. Lalu masukkan ukuran sisi kubus     |
| 6. Pilih menu tool bar "Pyramid, kemudian klik "Net" |
| 7. Kemudian kita klik gambar kubus, maka akan muncul jaring-jaring kubus |

After you know the elements of the cube, now create a cube using the *Geogebra* application.
1. Open the *Geogebra* application
2. Select the "View" menu, then click "3D graphics". To make the base of the cube we select the toolbar menu "Polygon".
3. Select the toolbar menu "Pyramid", then click "Extrude to prims"
4. Then enter the size of the side of the cube
5. Select the toolbar menu "Pyramid, then click" Net ".
6. Then we click the grave image, then the cube net will appear.

**Figure 1a.** Sample LKPD revision results

In Figure 1b, there is a revision where previously the place for students 'answers was too small so that after a revision the place for students' answers was enlarged and given instructions.
Table 5. The observation results on LKPD in small group Evaluation

| Meeting | Observation Results |
|---------|---------------------|
| Meeting I | Students did not understand in operating the *geogebra* application so that it required full direction and guidance from the researcher and the students were not accustomed to solving story problems. Students have started to get used to completing activities by following the steps available, they are no longer awkward to ask questions, and if they don’t understand they go back to reading the steps. They have been more active, and group cooperation has also increased with an appropriate allocation of time. |
| Meeting II | Students began to get used to doing activities with their groups. The confusion about filling LKPD 3 has diminished, and the students have been quicker to understand and answer questions on LKPD 3. Students have begun to see an improvement in problem-solving abilities, namely in working on the problems in practice and analyzing the story problems. |
| Meeting III | Students were enthusiastic about using the *geogebra* application, and they were able to make drawings and graphs using *geogebra*. The time allocation was appropriate and the problem could be solved even with the help of the researcher. The cooperation of the students in solving the problems, helping each other friends in understanding the problems already look very good, they were very happy and enthusiastic. The problem-solving ability of the students has begun to be trained by completing the questions given, although the students with the low ability still made some mistakes. |
| Meeting IV | Students were familiar with learning activities so far, namely discussing in groups about the activities that exist in LKPD 6, formulating hypotheses, (3) collecting and analyzing data, (4) assessing hypotheses and making generalizations. |

The results of the questionnaire responses of the students towards LKPD can be seen in Table 6.
Table 6. The results of questionnaire responses to LKPD in small group evaluation

| Rated aspect    | Mean scores of each aspect | Percentage of Practicality (%) | Category     |
|-----------------|----------------------------|-------------------------------|--------------|
| Presentation    | 3.40                       | 85.12                         | very practical |
| Ease of use     | 3.42                       | 85.42                         | very practical |
| Legibility      | 3.33                       | 83.33                         | Practical     |
| Time allocation | 3.33                       | 83.33                         | Practical     |
| Mean            | 3.37                       | 84.30                         | Practical     |

Based on Table 6, it can be seen that the PBL-based LKPD using geogebra for each aspect of the assessment was in the very practical and practical category. It was obtained that the percentage of PBL-based learning devices based on geogebra was 84.30%. Based on the results of the interviews conducted on the students, it was found that the participants were greatly helped by the presentation of LKPD that related to things that were close to them. The existing LKPD was not too difficult to understand and helps them understand the learning materials. The students were also very happy and enthusiastic about learning to use LKPD. Because LKPD is easy for students to read, so the students understand the subject matter easily.

4.1 Conclusion

Based on the results of the development process that has been carried out, the results are obtained in the form of learning mathematics for junior high school students based on problem based learning and geogebra assisted that have been practical. Based on this study, the researcher suggests developing RPP and LKPD based on PBL using geogebra applications on other Mathematics materials.

References

[1] Arnawa I M, Yerizon, Nita S 2019 Errors and misconceptions in learning elementary linear algebra J. Phys. Conf. Ser. 1321 022095
[2] Safitri Y and Arnawa I M Mathematics Learning Device Development Based on Constructivism Approach to Improve Mathematical Reasoning Skill of Class X Students in Vocational High School (SMK) Int. J. Sci. Technol. Res. 8(5) pp 131-135
[3] Arnawa I M, Yerizon, and Nita S 2020 Improvement students’ achievement in elementary linear algebra through APOS theory approach J. Phys. Conf. Ser. 1567 022080
[4] Harahap S D, Fauzan A, Elizar, and Arnawa I M 2019 Preliminary Research Development MetaInquiry Learning Model in the Numbers Theory Course J. Phys. Conf. Ser. 1387 012134
[5] Yuwandra R and Arnawa I M 2020 Development of learning tools based on contextual teaching and learning in the fifth grade of primary schools J. Phys. Conf. Ser. 1554 012077
[6] Syafriafdi N, Fauzan A, Arnawa I M, Anwar S, and Widada W 2019 The Tools of Mathematics Learning Based on Realistic Mathematics Education Approach in Elementary School to Improve Math Abilities Univers. J. Educ. Res. 7(7) pp 1532–1536
[7] Ismail R N, Arnawa I M, and Yerizon Y 2020 Student worksheet usage effectiveness based on realistic mathematics educations toward mathematical communication ability of junior high school student J. Phys. Conf. Ser. 1554 012044
[8] Rahmi N, Arnawa I M, and Yerizon Y 2019 Preparation development of learning device problem-based learning model with the scientific approach to improve mathematical problem-solving ability Int. J. Sci. Technol. Res. 8(8) pp 522–529
[9] Roza N, Arnawa I M, and Yerizon 2018 Practicality of mathematics learning tools based on discovery learning for topic sequence and series Int. J. Sci. Technol. Res. 7(5) pp 236–241
[10] Arnawa I M, Yerizon, and Nita S 2019 Improvement Students’ Level of Proof Ability in Abstract Algebra Through APOS Theory Approach Int. J. Sci. Technol. Res. 8(7) pp 128131

[11] Eggen P D K 2012 Strategi dan Model Pembelajaran (Jakarta: PT Indeks)

[12] Wena M 2009 Strategi Pembelajaran Inovatif Kontemporer: Suatu Tinjauan Konseptual Operasional (Jakarta: Bumi Aksara)

[13] Arnawa I M, Yerizon, Nita S, and Putra R T 2019 Development of students’ worksheet based on APOS theory approach to improve student achievement in learning system of linear equations Int. J. Sci. Technol. Res. 8(4) pp 287-292

[14] Rusdi, Fauzan A, Arnawa I M, and Lufri 2020 Designing mathematics learning models based on realistic mathematics education and literacy J. Phys. Conf. Ser. 1471 012055

[15] Ulfah A S, Yerizon Y, and Arnawa I M 2020 Preliminary research of mathematics learning device development based on realistic mathematics education (RME) J. Phys. Conf. Ser. 1554 012027

[16] Permatasari C P, Yerizon, Arnawa I M, and Musdi E 2019 The development of learning instruction based on problem-based learning to improve the problem-solving ability of students in grade vii (preliminary research) Int. J. Sci. Technol. Res. 8(8) pp 600–604

[17] Arnellis A, Fauzan A, Arnawa, I M, and Yerizon Y 2020 The effect of realistic mathematics education approach oriented higher-order thinking skills to achievements’ calculus J. Phys. Conf. Ser. 1554 012033

[18] Fitriani N and Arnawa I M 2020 An initial observation of learning devices and mathematical problem-solving ability of senior high school students J. Phys. Conf. Ser. 1554 012067