Development of student worksheets based on Realistic Mathematics Education (RME) oriented to mathematical reasoning

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Abstract. Student worksheets in schools have not been fully developed based on contextual problems that are close with student environment. Therefore, students thinking skills have not facilitated. Based on these problems, the purpose of this study is develop student worksheets based on RME that can facilitate students to improve mathematical reasoning. This research is development research that uses Plomp development model. The subject trial of this study are 31 students class VIII of Junior high school in Wonosobo. Validity assessment instrument is a validation sheet. Practical assessment instruments are teacher and student assessment sheets, also learning implementation observation sheets. The effectiveness assessment instrument is mathematical reasoning test. Data analysis was carried out by converting quantitative data into qualitative data. The results showed that student worksheet validity score was 95. Practicality based on the teacher's assessment with a score of 37, the results based on students assessment have an average score of 62.35. Average of learning achievement is 95.37% and the results of mathematical reasoning test which shows that 96.55% of students complete the minimal mastery criteria. Therefore, student worksheet who developed is suitable for mathematics learning activities and can be used to improve students mathematical reasoning.

1. Introduction
Learning in junior high schools contains activities with various characteristics. In mathematics learning based on Minister of Education and Culture Regulation Number 22 of 2016, states that learning with interactive and inspirational characteristics makes learning fun and can motivate students to actively participate in learning. It aims to develop learning that makes students feel that mathematics learning is meaningful and enjoyable learning.

Student participation in learning makes students easier to understand the concept of knowledge. Active involvement of students can help them to discover their understanding[1]. Students who have understood themselves can evaluate their understanding and will be able to put themselves in learning related to the knowledge they get. Students with mathematical abilities also have other critical abilities such as reasoning, abstraction, patterns and recognition of relationships and conceptual thinking[2]. In mathematics learning, one of the thinking skills related to understanding is reasoning ability. Mathematical reasoning is a element key of mathematics and becomes a center for learning mathematics[3].
Mathematical reasoning as a basis for learning practice is useful to make a conclusion. In mathematics learning, arguments are also have an important part in making a conclusion. Reasoning ability allows students to give reasons and actions to make conclusions[4]. Student can practice making conclusions through problem solving. Problem solving can improve mathematical reasoning that used to make a conclusion[5]. The relationship between mathematical ideas is very influential in mathematical reasoning.

Mathematical reasoning is very important in forming patterns from mathematical event. Pattern identification is a mathematical reasoning process by looking for similarities and differences, concluding the narrative about recursive relations between objects[6]. Mathematical reasoning will be very effective if it is well understood by students and can be applied in mathematics learning. However, in reality, mathematical reasoning in Indonesia is not good, it is seen based on the results of TIMSS 2011 on the cognitive domain for 8th grade students that the lowest ability of Indonesian students in the domain of cognitive processes was found in reasoning aspect (17%), and at the international level just 30% [7].

When ongoing observation, it have been seen that students are only given mathematical problems that focus on problem solving without being associated with contextual problems. In the learning process, an appropriate approach is needed so that it can make students easy to understand mathematical concepts that are appropriate to their surroundings. Approach through contextual problems is needed to built students mathematical knowledge. In relation to contextual problems, RME is one approach that based on the context of daily life. Theory of RME that proposed by Hans Freudenthal in 1970s, shows that RME involves students in learning mathematics by starting with meaningful context. Context is seen as a starting point and as a source for learning mathematics[8].

Based on interviews, the use of student worksheets has not maximal. This happens because the content of the student worksheets emphasizes more on the collection of questions and instructions that are less directing students, so that mathematical reasoning skills can’t develop. While, the student worksheet preferably contains a clear procedure, about what students should do, interesting as well as the age of the student and provides continuity of directed training rather than continuation of learning[1]. Teacher also said that she has never compiled a student worksheet before.

In connection with previous research, there are several studies that have been conducted in developing student worksheets based on RME to improve mathematical reasoning. Student worksheets who developed based on RME can improve mathematical reasoning in the marine context[9]. The difference between this research and that research is that research based on the marine context while this research based on the mountain context. In addition, the development of student worksheets on Algebra material with RME approach can improve mathematical reasoning[10]. The difference is that research on algebra material while this research on probability material.

Based on the description above, it is necessary to make improvements in mathematics learning, considering mathematical reasoning is element key in mathematics learning. Developing student worksheets that are practical, valid, and effective using a realistic mathematics education approach are needed to improve their reasoning and application of mathematical concepts about probability can be mastered well.

The purpose of this study is to produce and describe the characteristics of probability students worksheets with RME approach. Students worksheets was developed expected can be improve students mathematical reasoning.

2. Methods
This research is research development. The development model used in this study was the Plomp development model which consisted of three stages, namely preliminary research phase, development or proto typing, and assessment phase[11].

Subjects trial in this study were students of class VIII Junior high school in Wonosobo consisted of 31 female students with an average age of 13-14 years old.
Preliminary research phase was preparation phase to develop the product. In this phase, identification and study about students condition in mathematics learning that took place in schools. It was viewed from the mathematical reasoning and the probability material.

Second phase was the development or prototyping. In this phase, the activity of designing and compiling student worksheet based on RME approach which was containing problems that could improve mathematical reasoning. In compiling student worksheet, the researcher made map of the needs of the student worksheet, made framework of student worksheet, and made student worksheet.

The assessment phase toward student worksheet was developed, would be rate by two expert judgments of the UNY Postgraduate Mathematics Education program lecturers, to find out the Validation. Furthermore, the practicality of student worksheet was developed was assessed based on teacher assessment sheet, students assessment, and observation sheet of the implementation learning process. Meanwhile, to measure the effectiveness of student worksheet which was developed could be seen from the results of the students mathematical reasoning test.

Data collection techniques in this study consisted of (1) giving of validation sheet consisting of 26 statements to measure the validity of the student worksheet which was developed, (2) teacher assessment sheet consisted of 14 statements, (3) student assessment sheet consisted of 16 statements, (4) Observation sheet implementation of learning used to measure the practicality of the student worksheet developed, and the test of mathematical reasoning consisted of 5 questions in essay form.

The data analysis technique was used in this study was to make the conversion table into the standard value of five criteria and converted the assessment score data into the standard value of five criteria. The basis that was used as reference was adapted from Widoyoko[12].

Validity of student worksheet was developed belong in valid criteria if the worksheets assessment results were in the minimum category "high". The student worksheets was developed said to be practical if the teacher and students assessment results in a "practical" minimum category and average percentage of learning implementation was more than 80%. Validity and practical categories were shown in Table 1 below.

| Validity Category | Practical Category |
|-------------------|--------------------|
| Interval Score    | Teacher assessment | Student assessment |
| X > 109,2         | Very High          | X > 33,6           | X > 67,2 |
| 88,4 < X ≤ 109,2  | High               | 27,2 < X ≤ 33,6   | 54,4 < X ≤ 67,2 |
| 67,6 < X ≤ 88,4   | Moderate           | 20,8 < X ≤ 27,2   | 41,6 < X ≤ 54,4 |
| 46,8 < X ≤ 67,6   | Low                | 14,4 < X ≤ 20,8   | 28,8 < X ≤ 41,6 |
| X ≤ 46,8          | Very Low           | X ≤ 14,4           | X ≤ 28,8 |

Effectiveness analysis was carried out to determine the extent to which student worksheets that have been made meet the effective criteria determined based on the results of a mathematical reasoning test. The criteria for the effectiveness of student worksheets were developed based on mathematical reasoning tests if the percentage of student learning completeness more than equal to 75%.

3. Result and discussion

The results of the initial research phase shown that students still depend on teacher, so that students not accustomed to built their own understanding, students feel difficult to generate mathematical ideas, students have not been very good in abstract thinking in solving problem, student worksheet has not facilitated students to construct their knowledge. Teacher have never compiled worksheets in mathematics learning and students participation in the process of mathematics learning still low.
In the development phase, development of student worksheet refers to the basic competition and indicators. It was suitable for probability topic and based on mathematical reasoning indicator. Student worksheets were developed with the RME approach which adopted the characteristics of the RME approach with a context that was close to the student environment, namely those related to mountain area because Wonosobo is the mountain area. Distribution of probability material on student worksheets in each meeting can be seen in Table 2.

Table 2. Distribution of probability material on student worksheets in each meeting

| Probability material                                      |
|----------------------------------------------------------|
| Student worksheet 1: Empirical probability                |
| Student worksheet 2: Sample space and sample point        |
| Student worksheet 3: Theoretical probability              |
| Student worksheet 4: Differences between empirical probability and theoretical probability |

In the field of mathematics, when students do mathematical activities, many aspects of reasoning are involved in it. A lot of reasoning is involved in doing mathematics even though it is hidden from view[13]. Some aspect that relate to mathematical reasoning such as make a conclusion. Reasoning ability is defined as the ability to justify choices and conclusions[14]. Other than that, argument used to make conclusion. Mathematical reasoning is defined as an argument produced to convince oneself or another about the truth of a statement[15]. So that, we must have an idea or can generate a connection between them. Mathematical reasoning is the ability to see connections/relations between mathematical ideas and apply these understandings as solutions to new problems[16]. If students can use their mathematical reasoning exactly, they can solve every problem. So that we must facilitate student to develop their mathematical reasoning in order to make they understood about mathematics concept. Problem solving is important for training students reasoning which can be used to measure mathematical concepts they have understood[17]. After student understood about mathematics concept, and they accustomed to solving problems, so that they know the pattern of a problem they solve. Mathematical pattern used in a problem supports students arguments in convincing each other that the solution of the pattern used is valid[18]. The indicators of mathematical reasoning are shown in Table 3.

Table 3. Indicators of mathematical reasoning

| Aspects   | Indicator                                          |
|-----------|----------------------------------------------------|
| Pattern   | Determines the pattern of mathematical events      |
| Conjecture| Make conjecture                                    |
| Conclusion| Make conclusion based on logical arguments         |

In order to developed student worksheet that can facilitate mathematical reasoning, need an approach who suitable. RME aimed to create mathematics learning more interesting and meaningful for students who are taught through contextual problems where the problem is close to the experience and knowledge of students[19]. RME uses contextual problems that can be imagined as a way into mathematics to support students as they develop mathematical abilities[20]. Providing contextual problems facilitates students to use their own models in solving mathematical problems[21]. Context are not added at the end of learning, but serve as realistic starting point to support student engagement and elicit student thinking[22]. The main purpose of the RME is to describe mathematics education to students by increasing the rediscovery of their mathematics[23].

Student worksheets were developed with the RME approach which adopted the characteristics of the RME approach with a context that was close to the student environment, namely those related to mountainous regions because Wonosobo is the mountain area. Design of student worksheets based on characteristics of RME can be shown in Table 4.
Table 4. Design of student worksheets based on characteristics of RME

| Characteristics of RME       | Features of student worksheets          | Design                                                                 |
|------------------------------|----------------------------------------|------------------------------------------------------------------------|
| Use of Context               | Use of contextual problems             | Understand the problem contains context in accordance with the material to be studied in "Come to Understand" |
| Use of a model for progressive mathematizing | Using a mathematical model | Activity contains the process of developing a mathematical model. Students are directed to develop informal models in their own way or understand models that have been developed |
| Utilization of students construction results | Learning activities facilitate students to write formal results from the discussions conducted | In the conclusions and exercises section, students are given the opportunity to write down the formal results that have been done during the discussion. |
| Interactivity                | Learning is designed in groups/discussions | In the student activities, students work in groups to determine the problem solving of a given problem so that it is expected that there will be an exchange of ideas in each child in each group or even between groups. |
| Linkages                     | Learning activities facilitate students to use interrelations between concepts or knowledge | The relationship between learning activities facilitates students to use the interrelationship between concepts or knowledge In the part of student activities, student activities use the connection of concepts / knowledge possessed to solve problems |

However, student worksheet is a tool for organizing learning activities[24]. So that suggestion or comment to better worksheet are needed. The expert assessment aims to explore comments and suggestions, both in writing and verbally as material for improvement of the student worksheets developed. Expert judgment is carried out by the validator. An assessment of the student worksheets developed was also carried out by the teacher and students to see the practicality of the product being developed. Effectiveness of the student worksheet developed by looking at the results of the test of mathematical reasoning ability. The results of the trial of student worksheets on validity, practicality, and effectiveness of student worksheets developed after analysis are described in Table 5.

Based on Table 5, the average score for validator assessment is 95 (88.4 < X ≤ 109.2) which is in the valid category. This shown that the student worksheet was developed has reached a valid category.

Practicality assessment of student worksheets that was developed in terms of teacher assessment sheets, student assessment sheets, and observation sheets for learning implementation. The results of the teacher's assessment of the student worksheet that was developed received a total score of 37 (X > 33.6). While, the results of the students assessment for student worksheet that was developed have an
average score 62.35 that belong in practical category. This shown that the student worksheets was developed meet the practical criteria according to the teacher's assessment. The learning implementation observation sheet was filled by observers to find out the percentage of learning implementation have an average 95.37% of compliance.

**Table 5.** The results of the validator's assessment of student worksheets

| Assessment Indicator | Validator assessment score |
|----------------------|----------------------------|
| Content              | 50                         |
| Construction         | 28                         |
| Language             | 16                         |
| Sums                 | 94                         |
| **Average**          | **95**                     |
| **Category**         | Valid                      |

Furthermore, analysis of the implementation of learning based on RME steps will be presented in Table 6 below.

**Table 6.** Observations of learning outcomes based on RME steps

| Steps in RME                                | Percentage of implementation (%) |
|---------------------------------------------|----------------------------------|
| Understanding contextual problems           | 100                              |
| Developing informal models                  | 100                              |
| Using linkages between concepts             | 100                              |
| Interactivity and formalization             | 100                              |
| Applying formal models to other problems    | 100                              |

Based on these results it can be concluded that the student worksheet was developed meets the practical criteria, it has seen from the results of the analysis of teacher assessment, student assessment, and observation of learning achievement.

Criteria for effectiveness, if the result of mathematical reasoning test more than equal with 75%. The result of mathematical reasoning test analysis are presented in Table 7.

**Table 7.** The results of mathematical reasoning test in the probability material

| Information                                      | Class VIII F |
|--------------------------------------------------|--------------|
| Top Rated                                        | 100          |
| Lowest Score                                     | 29.17        |
| Average                                          | 89.66        |
| The number of student complete minimal mastery criteria | 28           |
| The number of student not compete minimal mastery criteria | 1            |
| Passage percentage                               | 96.55%       |

Based on Table 7 it is known that as many as 28 students were completed with a percentage of 96.55% completeness. This shows that the student worksheet that was developed fulfills the criteria effectively, it seen from the results of the mathematical reasoning ability test because it has fulfilled the completeness criteria that more than equal with 75%.

The student worksheets was developed studied based on validity, practicality and effectiveness of student worksheets that had been developed. Quality development products meet the criteria for validity, practicality and effectiveness of Nieveen[25].

Product validity based on an assessment conducted by experts, it shown that the average score on the assessment of student worksheets was 95 from the score range 26-130. Validation results have been shown to be valid. The student worksheets that has been developed has fulfilled the valid category. In addition, the student worksheets were developed are valid because the assessment results
according to the aspects of assessment which include aspects of content, construction, and language have also been included in the valid category. Thus, it can be concluded that student worksheet based on RME oriented towards mathematical reasoning ability has fulfilled the validity aspect and is suitable for use.

The practicality of student worksheets were developed in this study is based on the teacher's assessment in the very practical category with the acquisition of scores 37 as much as the score range 8-40. Furthermore, in the field trial also obtained student assessment results after participating in learning using student worksheets that have been developed into the practical category with an average score 62,35 on the range 16-80. Next, based on the results of observations of the implementation of learning that was carried out as many as six meetings using the developed student worksheets, the average learning achievement exceeded the specified target is 95,37% which indicated that the student worksheets could be implemented well and easy to use. Based on the results of the teacher's assessment, student assessment and observations of learning feasibility shown that the student worksheets based on RME oriented towards mathematical reasoning abilities had fulfilled the practical aspects and were worthy of use.

The effectiveness of the product were developed after the implementation of the field trial is based on the results of a mathematical reasoning ability test. Based on the results of field trials, obtained the results of mathematical reasoning ability tests which show that as many students complete the minimum completeness criteria, so that it has fulfilled the aspect of effectiveness and is suitable for use. Furthermore, effectiveness based on each indicators of mathematical reasoning ability is presented in Table 8 below.

| Table 8. Test results of mathematical reasoning seen from each indicators |
|---------------------------------------------------------------|
| Mathematical reasoning                                      |
| Pattern | Conjecture | Conclusion |  |
|----------|------------|------------|  |
| Top Rated | 100        | 100        | 100 |
| Lowest Score | 66,67       | 50         | 18,18 |
| Average   | 96,55      | 86,21      | 89,59 |
| The number of student complete minimal mastery criteria | 26          | 25        | 28   |
| The number of student not compete minimal mastery criteria | 3           | 4         | 1    |
| Passage percentage | 89,66   | 86,21      | 96,55 |

Based on Table 8, the lowest aspect of student mathematical reasoning is on find a mathematics conjecture, so that from the results the teacher can pay more attention to this aspect when wanting to develop a student worksheet based on RME oriented to mathematical reasoning. The percentage of students completeness can be seen from each aspect that has exceeded the effectiveness criteria that are more than 75%.

Student worksheets were developed, contributing to the teaching and learning of mathematics in relation to mathematical reasoning because at the beginning of each material the contextual problem is given as a starting point in learning which is characteristic of the RME approach. Furthermore, students are directed to develop an informal model facilitated to solve problems that exist in contextual problems using their own methods. So students can imagine the contextual problems given according to what they see in everyday life to be modeled into mathematics, this can grind the way students reason.

In the use of student worksheets, students work in groups to determine problem solving of the given problems so that it is expected that there will be an exchange of ideas for each other in each group or even between groups. This includes the characteristics of RME, interactivity. So that in the process students are guided to discuss well.
In group discussions, when the exchange of ideas has been carried out students will find agreement on ideas that they think are the most correct. In the process of exchanging ideas, to solve problems, this activity also aims to improve students mathematical reasoning. The context presented encourages students to find a mathematics conjecture, find patterns and represent their mathematical ideas. It also contains the characteristics of RME, namely the relationship, after students are guided to discuss properly students will use the knowledge or concepts that have been possessed to be linked to problem solving from the context presented in order to reach an agreement of ideas to be made. Furthermore, in writing the conclusions, students are given the opportunity to write down the formal results that have been done during the joint discussion. Then from the conclusions made by students, they will practice doing the questions in the exercises to explore their understanding and deepen the knowledge they already have from the results of the construction on student activities. So that it is expected that when students do the exercises the construction of students understanding that has been possessed can be stated in this section. This section which contains the characteristics of the RME (student construction utilization).

Student worksheets were developed based on the contextual issues that came from the context of mountain area, because Wonosobo was a mountain area. So that contained of context problems is close to the students environment, such as agricultural products and vegetables. Those things will make easier for students to develop models when contextual problems are given, therefore students can improve their mathematical reasoning.

4. Conclusion
Based on the study description above, it can be concluded that student worksheets based on RME oriented to mathematical reasoning have fulfilled the aspects of validity, practicality, and effectiveness. Therefore, student worksheet who developed is suitable for mathematics learning activities and can be used to improve students mathematical reasoning.

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