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Mathematics Learning Devices Development based on Realistic Mathematics Education on Probability

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Abstract: The purpose of this research is to develop mathematics learning devices in the form of Lesson Plan (RPP) and Student Assignment (LKPD) based Realistic Mathematics Education (RME) on probability materials in line with curriculum 2013. In addition, this research aims to describe the quality of developed learning devices in both validity and practicality aspects. This is a development research with 4D model including define, design, develop and disseminate. The researcher modified the development model by simplified the model through limit the research up to develop stage by considering the time and the cost. The define stage consists of: a) curriculum analysis; b) student analysis; and c) concept analysis. The design stage consists of: a) Lesson Plan design; b) Student Assignment design; c) instrument design and validation on assessment instrument of learning devices. Meanwhile, the develop stage consists of: a) the validation of learning devices by the expert and mathematics teacher; b) testing; and c) the questionnaire of both teacher and students responses. This research produces mathematics learning devices in the form of Lesson Plan and Student Assignment based Realistic Mathematics Education (RME) on Probability materials class X. The research findings shows that according to expert and mathematics teacher assessment, the developed learning devices are valid with 3.25 on average for lesson plan and 3.48 on average for student assignment. The result of the teacher response on the questionnaire shows that student response and interview display that mathematics learning devices in the form of lesson plan and student assignment are practical to be used on mathematics learning particularly on probability materials with 3.50 on average for Lesson Plan and 3.30 on average for Student Assignment.

Keywords: Realistic Mathematics Education (RME), mathematics learning devices, probability

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INTRODUCTION

Mathematics is one of the compulsory subjects to be learned in every level of education in Indonesia. However, today mathematics is not merely viewed as a

compulsory subject at school but it is a subject which acts as a basic towards varied disciplines and that is absolutely important in facing today world (Council & Committee, 2001; Mathematics, 2000).

One of the topics studied in Mathematics high school is the Probability. The ability of students to solve the problem of probability is a matter that needs to be mastered by high school students as the preliminary condition of statistical material that is very much used in designing research and processing research data from various branches of science. According to the High School Mathematics teachers that the most difficult material for their students is the enumeration rule which is the subject matter. Difficulties about the material of enumeration rules are not only felt in Indonesia but also in developed countries. This can be seen in Pratt's (2000) study entitled "Making Sense of The Total of Two Dice", and Abrahamson & Cendak (2006) study entitled The Odds of Understanding The Law of Large Number. Pratt's research tells the student's dexterity of determining the many ways a number emerges from the number of eyes the two dice are thrown, while Abrahamson's study tells students' difficulties understanding the concept of combination.

Curriculum 2013 requires teacher to be able to use learning resources provided, to be able to develop the media or other learning resources that may support the learning activity, and to be able to develop learning process to facilitate students in the learning process in line with the future important competence needed by the students (Dewey, 2013; Gonwa & Wadei, 2013; Goodson, 2013; Pinar, 2013; Tyler, 2013). The Necessary relevance between mathematical concepts that have been studied children with the reality of their daily lives or in the other fields. To that end, the relevance of mathematics learning should take advantage of the child when learning mathematics (Ball & Bass, 2000; Boaler, 2002; Cucker & Smale, 2002; Duval, 2006; Freeman et al., 2014).

Rusman (2012), stated that one of the competence that a teacher must possess is to master the foundation of the education which discusses about teacher's ability to select, to develop and to use the learning resources. In addition, Regulation of national education

minister (*Permendiknas*) number 71 in 2013 requires a teacher at education unit to be able to develop learning devices which contains Lesson Plan where one of the elements is learning resources. Student Assignment (LKPD) is one of the learning resources that can be developed by the teacher. Learning devices based Realistic Mathematics Education (RME) which consists of Lesson Plan (RPP) and Student Assignment (LKPD) considered as able to motivate students to understand the meaning of learning material by relating it with their daily life context.

The purpose is to enrich the students with knowledge and skill to be implemented in solving different problems. Realistic Mathematics Education (RME) is a learning theory developed in Holland by Haans Freudenthal since 1971, learning devices based realistic mathematics is a device which refers to assumption that mathematics has to be related with reality and mathematics is a human activity (Korthagen, Kessels, Koster, Lagerwerf, & Wubbels, 2001; Kwon, 2002; Van den Heuvel-Panhuizen & Drijvers, 2014).

Realistic mathematics education is to use the problem that can be imagine or understood by the students to build their knowledge such as the use of daily life problems or to relate them with the learned and comprehended concepts previously by the students. Probability learning materials is a material that is really close to the daily life of the student, particularly toward the graduate of high schools. The probability theory is used to determine the probability of the graduates to be accepted at the public higher education through comparing data in the previous years between the number of the accepted students and the total number of the registrant. The knowledge of probability is really useful for the students to develop their knowledge prior to enter the higher education level based on their interest. It is due to the probability theory is not merely to be implemented in mathematics, but this theory may as well to be implemented in the other

disciplines such as geography, economics, physics, techniques, and the like.

RME approach is based on Freudenthal's interpretation of mathematics as a human activity (Streefland, 1991; Van Den Heuvel-Panhuizen, 2003; Widjaja & Heck, 2003). From this perspective, students should learn mathematics by mathematizing subject matter from realistic situations and by mathematizing their own mathematical activity (Rasmussen & King, 2000). RME approach is contrary to conventional approach that mostly used by the teachers in Indonesia to teach mathematics.

We employed RME approach in this research because in line with the idea of how mathematics has to be taught in RME. Process of learning mathematics in RME can be described as a phenomenon of an iceberg below (Barnes, 2004, 2005; Fauzan, Slettenhaar, & Plomp, 2002b; Kaiser & Sriraman, 2006).

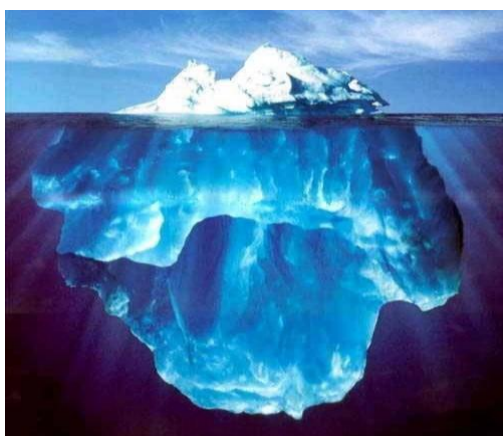


Photo: Frans Moerlands

Figure 1. RME as a phenomenon of an iceberg

A very strong foundation is needed to support the top of the iceberg to appear on sea surface. In relation to this phenomenon, formal and abstract mathematical concepts are situated on the top of the iceberg. Mathematics educators or researchers need to provide a strong foundation and 'a best trajectory' for students to reach the top of the iceberg. To do so, at the beginning of the lesson, students are provided with contextual problems that can be solved using their informal knowledge. The contextual problems will also facilitate students to use their own

symbols or their own strategy. This process is called *horizontal mathematization*. After experiencing similar processes and empowering by *simplification* and *formalization*, students will use more formal language or strategies in solving contextual problems. The journey, that will bring students to re-invent a formal mathematical, is called *vertical mathematization* (Michelsen, 2005).

Conventional approach refers to the way of teaching in which teacher mostly starts a mathematics lesson by explaining an algorithm or a formula. Then, teacher gives example(s) to show how the algorithm or formula works, followed by students' activity of solving mathematical problems that are similar to the example(s) given by the teacher (Fauzan, 2002; Fauzan et al., 2002b; Fauzan, Slettenhaar, & Plomp, 2002a). By using conventional approach, the teachers teach *ready made* mathematics, that is the mathematics of mathematicians (Cobb, Stephan, McClain, & Gravemeijer, 2010; Drijvers, Doorman, Boon, Reed, & Gravemeijer, 2010; Drijvers et al., 2010; Sembiring, 2010). Students tend to perform unexpected behaviours during teaching and learning process. The students are obstructing their peers, lots out of class permission, drawing or just doing nothing on their desk. Thus, the low attention display by the students during mathematics and learning process along with the difficulty they face in comprehending the learning material are obstacles experienced by the teacher to achieve the learning goal.

Meanwhile, RME approach facilitates students to build conceptual understanding using their informal knowledge. If the conventional approach tends to put an algorithm as a starting point, then RME approach puts it as an end of the instruction (Hadi, 2013; Hough & Gough, 2007). To understand an algorithm, students will work on contextual problems that gradually will give them experiences to find the algorithm by themselves under the guidance of the teacher (Barnes, 2005; Clements & Sarama,

2004; Cobb et al., 2010; Kaiser & Sriraman, 2006; Leder, Pehkonen, & Törner, 2006; Webb, Van der Kooij, & Geist, 2011; Widjaja & Heck, 2003) at Figure 2.

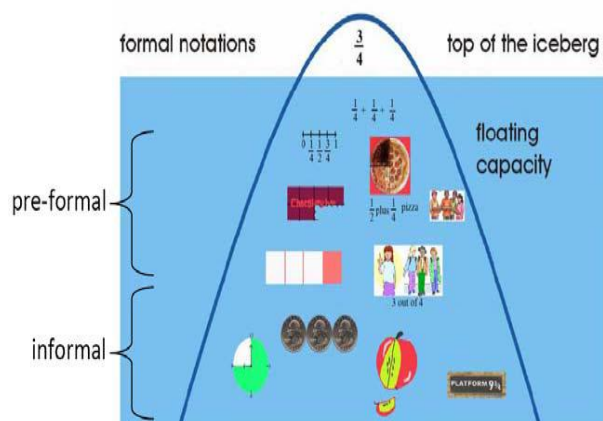


Figure 2. Building conceptual understanding by solving contextual problems using informal knowledge

In learning mathematics using RME approach, students will experience how to solve a contextual problem using their informal knowledge. This process is called horizontal mathematization. At the beginning, students will solve the problems informally using their own ways, their own words, or their own symbols. After experiencing a similar process (through simplification and formalization), they will use more formal ways or symbols that will lead them to reinvent an algorithm or a formal mathematical concept. This kind of process is called vertical mathematization (Devrim & Uyangor, 2006). In experiencing horizontal and vertical mathematization, the students will use multiple representations in form of real world object, model, pictures, graph, tables, or symbols.

In comparing the effect of RME and conventional approach on students' mathematical representation ability, we also involved gender and learning styles (auditory, visual, and kinesthetic) of the students as variables. There were some reasons behind this idea. Firstly, most teachers in Indonesia rarely consider gender and learning styles in choosing an approach in teaching mathematics. Secondly, male or female students or students with a certain learning style might have different preferences in

using mathematical representations (Caligaris, Rodríguez, & Laugero, 2015; Hickendorff, 2013). Thirdly, RME approach accommodates gender and learning styles differences when students get involve in doing mathematics activities (Fauzan et al., 2002a). The differences are also accommodated by characteristics of RME such as students' free productions, students' contributions, and interactivity.

METHOD

This research is a research and development. The 4-D model consists of four development stages, namely define, design, develop and disseminate. This research development was only in 3 steps. Define is to determine and define the requirements need to develop learning devices. This stage is also to analyze the goal and limitation of the developed learning material. Next, design step is to pay attention on three product characteristics, namely: content, interface and support. At the develop step, formative evaluation is take place. It consists of prototyping stage (self evaluation, expert reviews, one-to-one evaluation and small group).

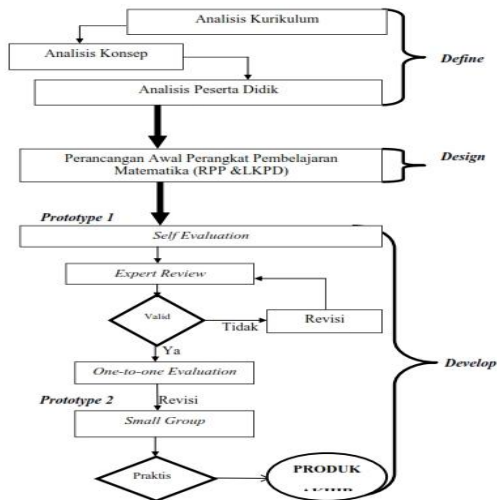
Ardhana (2002) mentioned that "Research and Development (R&D) is a development and validation processes of education product". On this research, the resulting product is mathematics learning devices based on Realistic Mathematics Education (RME). The resulted learning devices are in the form of Lesson Plan (RPP) and Student Assignment (LKPD.) The testing subject in this research is students of class X MAN Koto Baru Solok and mathematics teachers of MAN Koto Baru Solok. The instrument used in this research is Validation Sheet of Mathematics Learning Devices and Practicality Test Sheet.

This study included a type of literature study. With literature study is a way used to collect data and sources related to the topics raised in a study. The data sources containing: a mathematical problem solving ability,

approach *Realistic Mathematic Education (RME)*. The sources are obtained from journals, books, articles, research reports and internet sites.

In general, this developed model can be seen in the following chart I:

The mathematics learning devices chart based on Realistic Mathematics Education (RME).



RESULT AND DISCUSSION

The result of this research is about activity in developing mathematics learning devices in the form of Lesson Plan (RPP) and Student Assignment (LKPD) which involves the result of define, design and develop.

On the define stage, curriculum analysis which is in line with curriculum 2013 is take place, next the analysis of the students' characteristics, and the last one is the define stage to analyze the concept in the form of concepts identification in teaching which arranged in detail and systematic.

The design stage is to design the mathematics learning devices in the form of Lesson Plan (RPP) and Student Assignment (LKPD) that will be developed and assessment instrument that will be implemented. The final result of this design stage is initial design of Lesson Plan (RPP) and Student Assignment (LKPD) that will be developed and the assessment instrument of learning devices quality. Below is the

specification of research product on the design stage:

1. Lesson Plan (RPP) Initial Design

Lesson plan (RPP) is design based on writing steps of the Lesson Plan that has been explained on the previous chapter. Below is the initial stage of the Lesson Plan (RPP) in the form of writing order which consists of:

- a. The identity of the Lesson Plan (RPP)
- b. Basic Competence
- c. Basic Competence and Competence Achievement Indicator
- d. The purpose of the Learning
- e. Learning Material
- f. Learning Method
- g. Media/ Devices/ Resources of Learning
- h. Learning activity
- i. Learning Result Assessment

Moreover, the developed Lesson Plan (RPP) also design based on the appropriateness of the aspect in relation with the characteristics of mathematics learning based on Realistic Mathematics Education (RME), so that the designed learning activity may facilitate students in relating the materials that they learned with the daily life problems in order to have a more meaningful learning activity.

2. The initial design of Student Assignment (LKPD)

- a. The performance of initial cover of LKPD



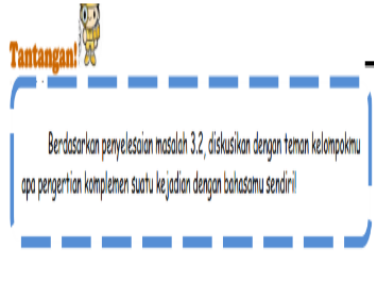
Gambar 4.1 Tampilan Halaman Sampul

b. The performance of opening page of each activity on LKPD



Jumlah	DADU I	DADU II	Jumlah Kombinasi Total Kombinasi Kejadian
0			
1			
2			
3			$\frac{2}{36}$
4			$\frac{3}{36}$

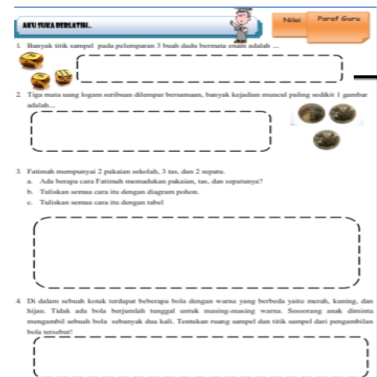
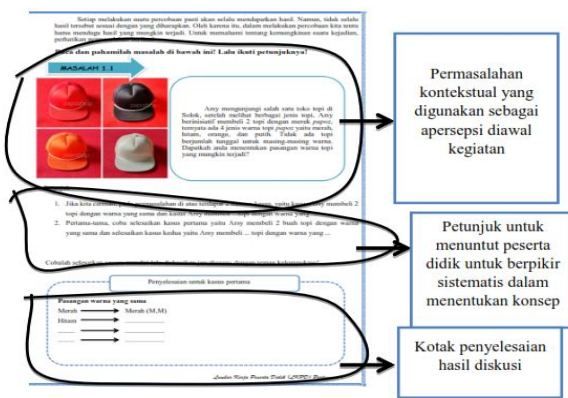
Memberikan kesempatan kepada peserta didik untuk menyelesaikan masalah kontekstual yang diberikan dengan cara diskusi dalam kelompok kecil.
(interactivity student contribution and use of models)



Mengarahkan peserta didik untuk menyimpulkan *(Interactivity)*

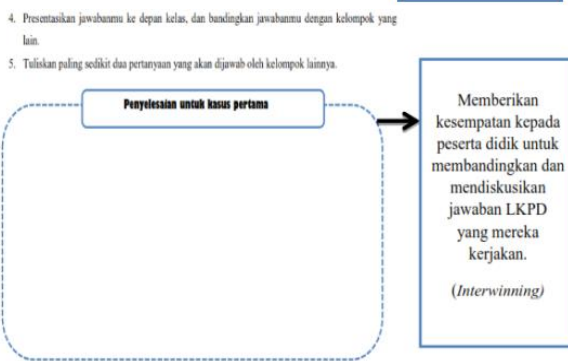
Gambar 4.6 Tampilan Halaman Pembuka untuk Setiap kegiatan

c. The performance of learning activity on LKPD based on RME



Latihan soal yang digunakan untuk mengukur tingkat pemahaman peserta didik terhadap kegiatan yang telah dilakukan.

Gambar 4.8 Tampilan bagian penutup LKPD



Kolom kesimpulan, yaitu kesimpulan yang didapatkan setelah hasil diskusi dan presentasi kelompok.



Memberikan kesempatan kepada peserta didik untuk memahami masalah kontekstual dan memberikan kesempatan untuk bertanya tentang apa yang belum mereka pahami.
(Use of Context)

The designed mathematics learning devices is validated and practiced by the expert of mathematics education which consists of five validators.

The result of mathematics learning devices validation can be seen on the following table 1:

Table 1. Assessment Detail on Lesson Plan (RPP)

Aspect of Assessment	Average	Criteria
The Identity of Lesson Plan (RPP)	3.73	Very Valid
Time Allocation	3.2	Valid
The Formulation of Material Achievement Indicator and the Purpose of the Learning	3.45	Valid
Learning Material	3.16	Valid
Learning Method and Approach based on RME	3.24	Valid
Media/Learning Resources	3	Valid
Learning activity based on Curriculum 2013	3	Valid
The Assessment of Learning Result	3.23	Valid

Table 2. The Assessment Detail of Student Assignment (LKPD)

Aspect of the Assessment	Average Score	Criteria
Content feasibility	3.34	Valid
Presentation feasibility	3.56	Very Valid
Language feasibility	3.28	Valid
Graphics feasibility	3.75	Very Valid

The practicality is obtained through the questionnaire data of both teacher and student and supported by the result of observation, the implementation of learning and interview toward teacher and students. Below is the description of research result of testing held at MAN Koto Baru Solok.

Table 3. The Practicality Assessment on Lesson Plan (RPP) by Teacher

Aspect of the Assessment	Practicality Score	Criteria
The component completeness and the presentation or performance of Student Assignment LKPD	3.1	Practical
The ease in using LKPD	3.3	Practical
The appropriateness between the devices and the time	3	Practical

Table 4. Practicality Assessment on LKPD by students

Aspect of the Assessment	Practicality Score	Criteria
The appropriateness of material based on RME	3.34	Practical
Language feasibility	3.30	Practical
Presentation feasibility	3.56	Very Practical
Graphics feasibility	3.54	Very Practical

The table above shows that the developed Lesson Plan (RPP) and Student Assignment (LKPD) are valid and practical including the comments from both validator and teacher.

The development is to do the formative evaluation which includes self evaluation and prototype stage (expert review, one-to-one evaluation, and small group).

CONCLUSION AND RECOMMENDATION

Based on the research result and the discussion, it can be concluded that: The development of mathematics learning device based on Realistic Mathematics Education (RME) on Probability learning materials for Senior High School (SMA/MA) class X is valid in criteria of Lesson Plan with average 3.25 and is valid in criteria of Student Assignment (LKPD) with average 3.48.

Learning devices based on the developed Realistic Mathematics Education (RME) is practical in criteria. This practicality can be seen from the result of the questionnaire distributed toward the students and the teacher with the average score 3.50 for Lesson Plan (RPP) and 3.30 for Student Assignment (LKPD) and the interview result with both teacher and students.

Based on this research and development, below is some recommendations by the researcher: The testing on the learning devices based on Realistic Mathematics Education (RME) is just implemented toward one class and the

testing material is on one material only. It is suggested that the future researcher would test it to the other class by using broader number of testing materials, so that it may minimized the disadvantage of Student Assignment (LKPD).

The testing of this learning devices based on Realistic Mathematics Education (RME) is held for three meetings only. It is suggested that future prospect researcher may test in a larger amount of meetings so that the data and conclusion obtained can be more accurate.

This research is limit up to develop stage. In order to get a better result, it is suggested that this research should also be tested on other school so that the research result can be developed forward to the disseminate stage.

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