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Developing Realistic Problem-Based Learning Model For Teaching Mathematics in Vocational Education

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Abstract: The mathematics teaching approach in a vocational school (SMK) in Padang needs to develop students' capacity to solve contextual problems. This study was designed using the Realistic Mathematics Education (RME) theory and Problem-Based Learning (PBL) approach. The research aims to investigate the characteristics of the instructional model based on 1) its validity using expert validation, (2) its practicality using users' feedback. The study was carried out in three phases: 1) preliminary phase, 2) prototyping phase, 3) assessment phase. The product of this research is an instructional model which is accompanied by a guide book to explain the rationale of Realistic PBL model, mathematics instruction book for teachers and students. The findings showed that the instructional model met the two criteria: validity and practicality.

Keywords: Instructional Model, PBL, RME Approach, Mathematics at SMK (vocational school).

1. Introduction

The math subject is listed in the compulsory subject group as it must be mastered by vocational students other than Indonesian, English, and others. Mathematics must be mastered because it is a tool/means to master other fields of science including the field of expertise selected by students who study in SMK. In addition, mathematics has a large contribution in the achievement of life skills that includes problem solving, reasoning and proof ability, connecting ability, communication skill and the ability to represent (representation). NCTM (2000) states that the above abilities are needed by students in this century because it can help students adapt to living, working and community [2]. This is in accordance with the opinion of Benson (1997) that SMK graduates also have to master mathematics in addition to the area of expertise is favored, so it is not surprising one of the goals of vocational education in developed countries like in the United States (US) is to produce graduates with good math skills [3].

In a study conducted in one of the vocational schools in the city of Padang during November 2015 was found; a) communication skills and mathematical disposition of vocational high school students, thus impacting on the results of learning mathematics is less satisfactory. b) lack of respect for the utility of mathematics by vocational students in everyday life. c) the learning of mathematics in SMK is still done by using the classical patterns, teacher centered and is not contextual. d) the unfairness distribution on the education/training and socialization related to contextual learning models that may lead the difficulties in implementing the *Permendiknas* (The Regulation of National Education Minister)) number 22, 2006 [4], and *Permendikbud* (The cultural and educational Ministry regulation) number 22,2016 [5] where the problem solving and start learning mathematics with the situation that appropriate (contextual problem) when it is not usually done by teachers in SMK.

Based on the explanation above problem, it is needed serious effort to handle various problems that exist in SMK. One of them is by applying Problem Based Learning Model (PBL) with Realistic Mathematics Education (RME) Approach.

RME approach is an approach devoted exclusively to math learning which according to the author can be one of the learning problems in SMK. The approach developed by Freudhental in 1970 emphasizes on the students mathematical process skills, starting with the use of realistic problems or problems that can be imagined by students to deliver students to the process of mathematization [11]. But RME does not yet have a requirement as a learning model. In Practice, The author believes that RME approach will be better if implemented with Problem Based Learning Model (PBL).

The PBL model is a model of learning that begins with students doing authentic problems with the intention to develop their own students 'knowledge, develop inquiry and develop students' self-

reliance and self-confidence [7]. Problem-solving and contextual problems are the uniqueness of the PBL Model, and this model emphasizes collaboration in groups that strongly support students to improve their communication skills [8-9].

The combination of PBL Model with RME Approach is expected to improve the quality of mathematics learning in SMK. Based on the above explanation and the evidence of the success of the PBL Model and the advantages of the RME approach become the motivation of this research.

2. Related Works

The Problem-Based Learning model (PBL) is a student-centered learning model that requires an active role of students in solving problems, emphasizing learning by doing, and building student metacognition [8]. PBL can improve the ability of mathematical communication and problem solving skills of students [9] and recommended to be used as a strategy for meaningful learning that can improve student learning achievement and improve students' beliefs about mathematics [10].

Realistic Mathematics Education (RME) is a learning approach specifically developed for learning mathematics. The RME approach is defined as contextual learning that requires student participation in solving real problems with meaningful contexts [11][23][24]. RME theories relate to constructivist studies and contextual learning [11][6][25]. RME seeks to change students' views of mathematics and how teachers teach mathematics [13]. The RME approach in various studies has proved effective in making students more active in learning mathematics [12][13], improving students' mathematical concepts [11], improving students' high-order thinking skills [14] and improving students' mathematics learning achievement [12][13].

Based on the success of several PBL and RME studies, a study was conducted that incorporated the PBL model with RME approach. Some of the relevant studies; 1) experimental research on the use of PBL with RME Approach with E-Learning Edmodo assistance. The results showed that PBL with RME assisted approach E-Learning Edmodo can improve students' mathematical literacy ability [15]. 2) experimental research on the development of students' mathematical connection ability through Problem Based Learning and Course Horay Review Method. The study was conducted in junior high school with the result of mathematical connection in experiment group better than control group [16]. 3) Development of Problem Based Learning Model with scientific approach on triangle material in junior high school. This research produces a valid and practical triangle material learning tool based on a strong rational theory, and possesses an internal consistency in the learning process [9].

Based on some of the above research, this paper focuses on the development of Problem Based Learning Model with Realistic Mathematics Education (RME) approach which is practical and valid in Vocational High School. The development of the learning model uses the steps of Ploomp (2013) [1] and produces three products: a rational book of learning models, teacher mathematics books and mathematics books for students. By designing a student-centered learning model in solving problems then the student can use the existing concept in himself to find a new concept. Thus, the development of learning models will be able to improve and develop the ability of learners.

3. Material & Methodology

3.1 Data

As the result of this research is to develop PBL Model with valid and practical RME Approach for SMK students in Padang. This research is included in educational design research with development study type [1]. The product produced in this research is in the form of the development of PBL Model with a valid and practical RME approach.

Data was obtained from several vocational school: SMKN 1 Padang, SMKN West Sumatra, SMKN 5 Padang, SMKN 4 Padang, and SMKN 8 Padang. The study took place from May 2017 to October 2017. Interviews for preliminary data were conducted with 11 students and 5 teachers at SMK above, followed by collecting various information needed on the desired learning model. The next step was to develop the necessary instruments and products based on data at the introduction stage.

3.2 Development Procedure

The research stages are tightly controlled by using formative evaluations established by Tessmer (1993)[17]. The stages of the research development and formative evaluation was carried out as follows:

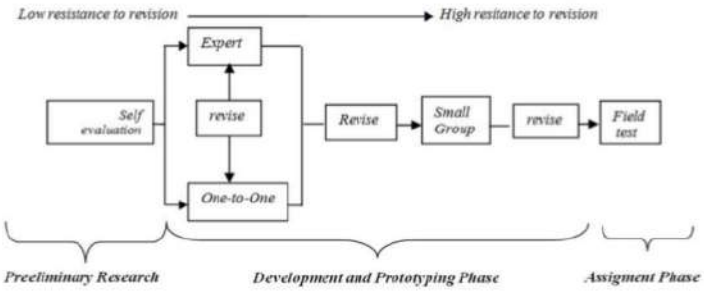

Figure 1. The Stages of the Research and Formative Evaluation

3.3 Prevalence Data Analysis and Practical Model Learning

The steps of the validity analysis were performed by using tabulation for all assessments from six experts (four material experts, one instructional technology and one linguist) to the research instrument and the three products (rational model book, teacher book and student book) then calculated on average, and censored for each aspect, after which it is compared against the criterion of the validity in Table 1.

To assess the practicality of the learning model being developed, the observation sheet analysis of the learning was used by the observer, the questionnaire analysis of each student's response to the mathematics book with the PBL realistic model and the questionnaire analysis of the teacher book's practicality of each meeting with the *PBL realistic model.* After the average of each aspect of practicality that had been obtained, then it was continued by determining the percentage for each aspect and comparing them with the criteria of the table of practicality in the Table 1.

Table 1. The Criteria of Validity and Practicality of Research Products

Criteria of Validity				Criteria of practicality		
Score	Percentage	criteria		Percentage	Criteria	
5	90%–100%	Very Valid	Sources: [18]	81%–100%	Very practical	Sources: [19]
4	75%-89%	Valid		61%–80%	Practical	
3	65%-74%	Valid		41%–60%	Practical	
2	40%-64%	Less Valid		21%–40%	Less practical	
1	0%-39%	Not valid		0%–20%	Very less practical	

This research is related with the validity and practicality of the products being developed. Based on the above table all instruments to measure validity and practicality indicate criteria, very valid/valid, very practical/practical, then the product were regarded worthy to use.

4. Result and Discussion

4.1. Result

4.1.1. Introduction Phase (Preliminary Research)

Based on the research framework, at this preliminary stage self evaluation was conducted on things to be obtained to develop the research product; a) collecting various information including: student conditions, curriculum and learning tools currently in use, b) analyze the information collected, c) formulating the rational development of PBL with the RME Approach, d) formulating the product design framework. Based on the activities undertaken at this preliminary stage it is important to decide in selecting matrix material in SMK to be developed.

4.1.2. Development Phase (Development and Prototyping Phase)

The designing process of the developed product was done by prototyping. The development of PBL realistic model products is as follows:

a. First Prototype

1) Description

The product should accommodate the things required at the introduction stage. In addition, since the model was developed, the requirements/definitions of the learning model must be met. In this prototype, three product development were produced: a) a realistic PBL model rational book, b) The teacher mathematics book for matrix material and, c) student mathematics book matrix material.

2) Expert Review

Expert suggestions for the first prototype was aimed at the cover of each product (still in simple). In the rational book the model was suggested that the steps on the syntax of learning were more detailed and the layout of each made more orderly. In the teachers' book, it is truly recommended to package the learning by building a solid foundation of knowledge first, making it easier to build on it until it reaches the formal mathematical stage (Iceberg-Formal Mathematics). On the other side, the the students' book were more recommended operational as well as some of the context of the problem made more simple.

3) One to One

One to One was done with a student from SMKN 3 Padang, and a teacher from SMKN 1 West Sumatra. The results of one to one evaluation of student books and teacher books are commented positively by teachers and students, and students suggest that researchers give examples of problems in students' books to make it easier for students to complete the exercises.

4) Revisions

All suggestions and improvements from experts, teachers and students were accepted by the authors to revise the product except to add examples of problem solving at the beginning of the lesson as it contradicts the principle of developing the learning model the PBL's own realistic model (Table 2).

Table 2. The syntax of Realistic PBL Models

Before revision	**After revision**
Phase 1: Realistic Problem Presentation (presenting, reviewing and understanding the contextual problem).	**Phase 1:** Realistic Problem Presentation (Reviewing, Presenting a realistic problem)
Phase 2: Preparation (Organizing students to develop problem solving strategies for individuals or groups)	**Phase 2:** Understanding and Problem Solving (Teacher gives students an opportunity to understand the problem well, individuals and groups)
Phase 3: Application of Strategy (Organizing Students Implementing Problem Solving Strategies).	**Phase 3:** Assistance (Provide help it is needed)
Phase 4: Presentation of Works (Communicating troubleshooting results)	**Phase 4:** Presentation of Work and Reflection (Communicating the results of problem solving and reflection)
Phase 5: Follow-up (Master gives back some Realistic problems)	**Phase 5:** Discovery of Knowledge and Concepts Teachers and students discover knowledge and concept
Phase 6: Evaluation (Evaluating Process and Learning Outcomes)	**Phase 6:** Giving Follow Up (Master gives back some realistic problems
	Phase 7: Closing Evaluation (discussing, evaluating processes and outcomes as well as summing up learning)

One example of iceberg invented the matrix concept in a teacher's book, beginning with building a firm foundation through the provision of a contextual problem to the point of formal mathematics (Figure 2).

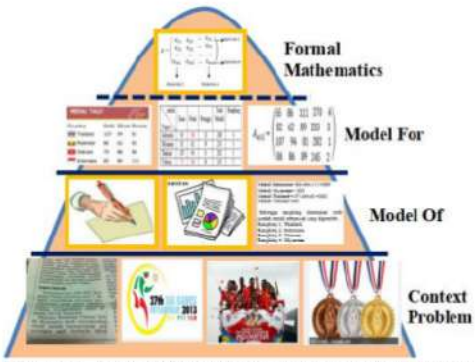

Figure 2. Iceberg for Finding the Concept of Matrix

b. Second Prototype

1) Description

The first prototype that has been revised produced a second prototype. The second prototype of all product books has changed with the new book cover. In the rational book the syntax model of learning was also made in more detail with a strong theoretical rationale, the layout of the rational model book has also been made regularly. The description of activities in the teacher's book has been made more detailed with the purpose of more operational learning. Some of the problems in the context in teachers' book and students' book have also been simplified.

2) Expert Review

In this second prototype the correction of the experts is only done to a few types, the error in the selection of raw word/standard word to be corrected. At this stage, the experts provide an assessment of the validity of the product. Presentation of data summary validation results on each product can be seen in the Table 3.

Table 3. Product Validity of Realistic PBL Model Research

No.	Product Development	Aspect of the Assesment	Average Score	%	Criteria
1.	Rational Book on Realistic Model PBL	Rational Development of Supporting Models and Theories, Synopsis of Learning, social system, reaction principle, support system, impact of learning and impact accompaniment	4.25	84.99	Valid
2.	Student Math Book With Realistic Model PBL	Feasibility of content, aspects of presentation, aspects of graft, and language aspects	4.23	84.54	Valid
3.	The Teachers'Mathematics Book With Realistic Model PBL	Learning Objectives, teaching materials, learning models, learning process activities, assessment techniques, RPP components, language, learning support, appearance and benefits.	4.22	84.44	Valid
	Total average		**4.23**	**84.66**	**Valid**

3) Small Group

After the second prototype was declared to be valid by the experts, the prototype was conducted a Small Group trial consisting of 5 students of SMKN 4, grouped into two heterogeneous groups. Some general comments derived from small group trials are "this student's math book is interesting", challenging to think critically because it is rather difficult, some of the problems are written in an elusive language inside. Students who follow Small Group were also asked for an example of problem solving.

4) Revisions
Revisions in accordance with suggestions and inputs when conducting evaluation activities with Small Group except for sample problem solving requests on students' books. To solve this problem, the description of preliminary activities in the book was given by the teacher assertion that the typical characteristic of the Realistic Model PBL does not contain a sample problem.

4.1.3. Assignment Phase
a. Description The third prototype (the last part)
The third prototype is a revised product based on evaluation activities on the previous Small Group. This prototype is then tested in a limited (field test) to see the practicality of the three products.
b. Field Test
Field trials were conducted to see the practicality of the three research products. Practicality is seen from the implementation of learning, student responses to the book used and the assessment of practicality to the teacher book. The presentation of the product's practicality is in Table 4.

Tabel 4. Product's Practicality

No.	Aspect of Assessment	Description	Meeting I (%)	Meeting II (%)	Meeting II (%)	Average (%)	Category
1	Learning Implementation	Principal of reaction, System social, Instructional Sintax	84.61	83.97	84.32	84.30	Very practical
2	The Student Response on the text book of Realistic PBL Model	Hints. Objectives, materials, practice questions, Language, Display of Materials, benefits	79.10	75.34	78.63	77.69	Very Practical
3	The Practicality of Teacher's Books	Hints. Objectives, materials, Steps on learning exercise questions, Language, Display of Materials, benefits	82.96	87.41	85.15	85.27	Very Practical
	Total Average Score					**82.42**	**Very Practical**

4.2. Discussion

The validity of the product being developed can be identified from strong theoretical rationale and internal consistency [20]. While the practicality considerations can be seen in the following aspects: ease of use, including: a) easy to use, stored and can be used at any time, b) the time required in the implementation should be short, fast and accurate, c) the attractiveness of the device to student interests, d) easy to be interpreted by teachers and students, e) have the same equivalent, so it can be used as a substitute or variation [21]. In other side, the practicality of research product can be seen from a) Students and teachers can carry out activities in accordance with the activities listed on learning syntax b) Teachers can manage learning and perform its role well [22].

5. Conclusion

Based on the results of expert validation reviewing the resulting product (Realistic Model Rational Book, Master Book and Student Book with Realistic Model PBL) as a whole then Realistic PBL model is said to be valid. It is based on an assessment of a logical theoretical rationale, a strong foundation of tokens and components in a consistently related product of research. Designed products (rational realistic PBL model books, teacher books and student books with realistic PBL models especially matrix materials) have been referred to the principles of the RME approach and the PBL Model.

From the results of the observation sheet of the process of implementation of learning can be seen that in terms of the implementation of learning models is very practical, students' responses to the book of mathematics is practical and the book of mathematics for teachers is also in the category very practical. This shows teachers and students can implement learning activities in accordance with the principles of the PBL Realistic Model.

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