The Validity of realistic mathematics education based mathematics learning materials for vocational high school students

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Abstract. The validity of learning materials made by the teachers is untested, so it is not valid yet to use in supporting the improvement of students’ mathematical communication skills. This research is a part of RME based research on Mathematics learning materials development to improve mathematical communication skills for Grade X SMK students on construction and property engineering programme. This research is aimed to assess validities of learning materials through two phases. First, self-evaluation was conducted by involving a peer. The results showed that Mathematics learning materials could be extended to the expert review phase with minor revision. Second, expert review, the researcher asked five experts to assess its validity. Thus, the results show Mathematics learning materials have been valid.

1. Introduction
Indonesia is one of developing countries which has high rate of unemployment. Based on the data from Badan Pusat Statistik (BPS), open unemployment rate in 2018 was 5.34% from 131.01 life rate of labour force [1]. Therefore, unemployment must be noticed particularly by Indonesian government.

Indonesia has strived to solve this unemployment problem by improving education system. One of the efforts conducted by Indonesia government is by enhancing the educational quality for Vocational High School (SMK). It is because education on SMK level is expected to prepare students with abilities, attitudes and skills that are compatible to be used in the workplace. This goal is compatible with provision 15 in Constitution No. 20 in 2003 about national education system which stated that vocational education is intermediate education to prepare the learners specially to work in certain disciplines.

The graduates of SMK, who are ready to work, must have relevant graduation standard to the working world. According to the regulation of Indonesian Minister of Education and Culture No. 29 in 2016, standards competency for SMK graduates must have three dimensions, such are attitude, knowledge and skills dimensions. These three dimensions will set them to be able to face the working life.

The fact in reality is different. It is because SMK stimulates high rate of unemployment [2]. Data from BPS in 2018 showed that the percentage for unemployment rate, come from SMK, is 11.24%. Based on the survey of Asian Development Bank, its could be happened because the graduates did not fulfil expectations of supplier [3]. It was declared by Subandi that a cause for the students to be unemployed was lacks of soft skill [4]. Soft skill, which is demanded by the working world based on NACE (Natioanla Accotation of College and Employers) is communication skills [5].

Communication skills can be enhanced through mathematics learning. It is because mathematics has one of the purposes to improve mathematical skills of the learners. Mathematical communication skill
is a significant skill to be possessed by them. Mathematics is not only a cognitive device to assist learners in order to develop pattern, solving problems and drawing a conclusion, but also a device to communicate thinking, to vary idea clearly, precisely and in a simple way [6]. Thus, Mathematics has an important role in enhancing the communication skills of SMK students.

In the matter of fact, students’ mathematical communication skills are still poor. SMK students’ mathematical communication skills are still poor, compared with SMA students, and their skills are divided into three criteria; 6.25% for Advance, 34.38% for moderate, and 59.37% for poor criteria [7] [8]. This matter shows that students’ mathematical communication skills are still poor.

Lack of mathematical communication skills is caused by lack of students’ interest to their learning. Hence forth, they are not actively participated the learning process. It is compatible with ones found by a research about participation of learners has a correlation with their mathematical communication skills [9]. Thus, in order to enhance these skills, a teacher must design a teaching method which will be able to stimulate their interest to mathematics.

SMK students have diverse skills programme. This condition must be one of considerations for mathematic teacher in designing a lesson. It was mentioned by [10] that Mathemati teaching method, which is compatible with their fields, could attract their interest to study. However, in reality learning materials, designed by the teacher, has not been able to considered students’ field of study in SMK. This matter could be seen from students’ worksheets (LKPD) designed by the teacher. A sample of worksheet, designed by the teacher, can be seen in the figure below:

![Figure 1. Sample of Worksheet used by teacher](image1.jpg)

Figure 1 above shows that LKPD, used by the teacher, does not apply a contextual matter which is correlated with students’ field of study. It is made by referring directly to the mathematical concept by giving example $2^3 = 2 \times 2 \times 2$. Meanwhile, a lesson for exponential number could be initiated with contextual matters which are relevant with their field of study. In construction and property engineering programme, lesson about exponential number apply a problem about measuring volume of a cube building in which students used a function $v = s^3$. To measure the volume, they must find the value of $s^3$ by measuring the value of $s \times s \times s$, through this measuring activity they are guided to draw a conclusion that the exponential number can be measured by multiply the number with the same number multiple times depend on the number at the rank.

Beside that, Design of Learning Implementation (RPP) for mathematics deigned by the teacher has not also been compatible with the worksheet. This matter can be seen at the core activity from the RPP in which the teacher plans an activity by presenting the concept in various problems. In fact, in their worksheets the teacher does not refer to a problem in comprehending the concept. A sample of referred RPP can be seen in the figure below:

![Figure 2. Sample of core activity in RPP designed by teacher](image2.jpg)

Figure 2 above shows that problems applied by the teacher have not been clear and not been describing the application of worksheet. Thus, it might be possible that the problems, applied by the teacher, are the same for all programme or are not compatible with the Worksheet. Furthermore, it also
does not show specifically activities, loaded in worksheet. Hence, \textit{RPP}, designed by the teacher, is not fully helpful in the application of the worksheet.

One of the causes which shapes incompatibility between \textit{RPP} and Worksheet, made by the teacher and non-reflexive matters on the worksheet to the vary \textit{SMK} students’ characteristics, is untested validities for \textit{RPP} and worksheets made by the teacher. It is because validity is one of aspects which must be contained by qualified learning materials. Validity can be assessed by asking it to the experts. Validity of learning materials can be assessed from several aspects, such are: eligibility, language/construct, presentation and graphics [11].

Based on the explanation above, it was said that in this research validation to mathematics learning materials; \textit{RPP} and RME-based worksheets, will be done. RME is used because it is compatible with students’ characteristics in this research. It is relevant with characteristics of RME, declared by Traffers. He stated that RME has five characteristics; (1) to use of context, (2) to use of model in progressive mathematisation, (3) utilization of students’ construction results, (4) interactivity, and (5) correlation. Therefore, RME is able to increase students’ interest in studying mathematics, so their mathematical communication skills can be enhanced [12].

In this research, validity test to \textit{RPP} was assessed based on compatibility between components in \textit{RPP} and curriculum 2013 and it fit with RME characteristics. In addition, validity assessment to worksheet is done by considering the characteristics of RME in which worksheets are arranged by using contextual matters which are compatible with expertise programme on construction and property. Every matter used in it has illustrative figure to ease the students understanding the materials. These materials must be able to facilitate the occurrences of horizontal and vertical Mathematisation.

2. Methods

This research is Research and Development (R&D). The development research is a method used to produce certain products. Development model used in this research is Plomp model which consists of three phases, such are \textit{preliminary research}, \textit{development or prototyping phase}, and \textit{assessment phase}. At the initial phase, we analysed the context and needs in Mathematics learning at \textit{SMK}, especially at expertise programme of construction and property engineering. At the prototyping phase, we developed products obtained from previous study; they are \textit{RPP} and RME-based worksheet for expertise programme on construction and property engineering. Moreover, Plomp’s model has advantages in assessing practicality of the developed learning materials through one-to-one evaluation, small group, and field test phase [13].

Prototype production belongs to designing, developing and formative evaluation activities. Evaluation phase is the phase of assessing the prototype produced by using effectivity and practicality tests. At this phase, semi-summative evaluation was also applied. Formative evaluation consists of self-evaluation, expert review, one to one, small group, and field test. The summary of these phases is provided in the figure below.

![Figure 3. Formative Evaluation [13]](image-url)
In this research, validity of RPP and RME-based worksheet will be discussed. Validation was done in two activities; self-evaluation, and expert review. Self-evaluation was done by involving peers to review errors in RPP and worksheet, such as typing errors. Expert review was done by asking helps from 5 experts to assess the validity for RPP and RME-based worksheet. There were three mathematic experts involved to assess the validity, 1 expert on education, and 1 linguist. Instrument for collecting data used in this research was questionnaire sheets. Technique of data analysis was using the Likert scale. The analysis was conducted in a sequence as follows:

- Data obtained from validation sheet were presented in the table by giving sore to every answer as shown in the table:

  | Answer              | Score |
  |---------------------|-------|
  | Very Valid (SV)     | 5     |
  | Valid (V)           | 4     |
  | Fairly Valid (CV)   | 3     |
  | Less Valid (KV)     | 2     |
  | Not Valid (TV)      | 1     |

  **Table 1. The Procedure of giving score to validity data analysis**

- Measuring score and average of validation results by validators for every item by using formula [14]:

\[
\bar{x}_i = \frac{\sum_{i=1}^{n} x_i}{n}
\]

Information: \( \bar{x}_i = \) Average value of each item
\( x_i = \) Score given by validator \( i \)
\( n = \) Number of Validator

- Determining validity of learning materials by using formula:

\[
R = \frac{\sum_{j=1}^{m} \bar{x}_j}{m}
\]

Information: \( R = \) Validity of learning materials.
\( \bar{x}_j = \) Average score for \( j \)-item assessment
\( m = \) Number of item

The criteria to obtain validity level of learning materials by using a criterion as in the table follows:

  | Average    | Criteria   |
  |------------|------------|
  | R > 4.2    | Very Valid |
  | 3.4 < R ≤ 4.2 | Valid      |
  | 2.6 < R ≤ 3.4 | Fairly Valid|
  | 1.8 < R ≤ 2.60 | Less Valid |
  | R ≤ 1.8    | Not Valid  |

  **Table 2. Validity Criteria [15]**

3. **Results and Discussion**

3.1. **Results of Self Evaluation**

At Self Evaluation phase, the researcher re-checked to prototype I within the helps from peers at the same expertise programme. The researcher with peer’s help checked the errors in prototype I; typing errors, picture clearness, compatibility of learning materials on worksheet, suitability between pictures...
and problems, activity sequence, and conformity of problems as they are stated on worksheet. All the aspect was evaluated on RPP and RME-based worksheet.

There were few revisions applied on RPP. Such are (1) revising errors typing, (2) adding more procedures into the materials, since it is stated in Permendikbud No 22 in 2016 that learning materials must consist of four elements; fact, concept, principle, and procedure. Meanwhile, revisions applied on RME-based worksheet are: (1) significant change to cover of worksheet. It was done due the cover was fulfilled by figures so the writings on it could not be seen clearly. Moreover, the design of it was less attractive and required to be revised. (2) revising errors typing. (3) accomplishing incomplete questions on worksheet.

3.2. Expert Review

3.2.1. RPP Validation

RME-based RPP validation was done by 5 experts; 3 Mathematicians, 1 Expert on education technology, 1 Indonesian linguist. The results of this validation can be seen in the table below:

| No | Assessed Aspect | Validator | Average | Criteria |
|----|-----------------|-----------|---------|----------|
| 1  | RPP components  | 5 4.29    | 4.05    | 4.47     | 4.47     | 4.45     | SV       |
| 2  | Learning Activities | 5 4.57    | 4.00    | 4.21     | 4.21     | 4.40     | SV       |
| 3  | Language        | 5 4.4     | 4.4     | 4.4      | 4.4      | 4.20     | V        |

Overall Average: 4.35 SV

Information: SV = Very valid  
V = Valid  
1, 2, dan 3 = Mathematicians  
4 = Linguist  
5 = Education technology expert

In the table 3 above, it can be seen that the results of RME-based RPP validation test for RPP components and learning activities are at very valid criteria with score per each 4.45 and 4.40. Meanwhile, linguistic aspect is at valid category with value 4.20. Overall, developed RPP has been at very valid criteria with 4.35 average score. Thus, it can be concluded that RME-based RPP has been very valid based on experts’ assessments.

Developed RPP based on curriculum 2013 revised 2017 edition on Mathematics basic competency has fulfilled many aspects. For instance, RPP components have been suitable with curriculum 2013. Besides, validity of RPP is also assessed based on RME characteristics. They are contextual usage, model usage for progressive mathematizing (horizontal and vertical mathematizing), utilization of learners’ construction results, interactivities and correlation.

Developed RPP has fulfilled those five characteristics. This matter can be seen on preliminary activity which has contained correlative characteristics or intertwining with other learning materials. Core activity contains contextual problem usage as a starting point of learning, instructions to guide learning doing horizontal and vertical mathematizing, giving opportunities to the learners to explain their construction results to their friends, and availability of opportunity for them to do interactivity in discussing the results.

Based on RME components and characteristics, RME-based RPP validation value is found to be valid. Therefore, this RPP can be used as a teacher’s guidance in practising mathematics teaching and learning, and it is also expected to be used by mathematic teachers on expertise programme at construction and property engineering students and be able to enhance their mathematical communication skills.
3.2.2. Worksheet Validity

Worksheet validity assessment was done based on RME characteristics in which the worksheet should be arranged by using contextual problems and they are relevant with construction and property engineering programme. Every problem, used in it, has illustrative figure to ease the learners understanding the problem. It must be able to facilitate the occurrence of horizontal and vertical mathematizing.

RME-based worksheet validation was done by 5 experts; 3 Mathematic lecturers, 1 linguistic lecturer, and 1 education technology lecturer. Observed aspect was presentation aspect, content, language and graphics. The results for these aspects can be seen in the table 4 below:

| No | Assessed Aspect | Validator 1 | Validator 2 | Validator 3 | Validator 4 | Validator 5 | Average | Criteria |
|----|-----------------|-------------|-------------|-------------|-------------|-------------|---------|----------|
| 1  | Presentation    | 4.70        | 4.20        | 4.50        | -           | -           | 4.47    | SV       |
| 2  | Content         | 4.90        | 4.00        | 4.50        | -           | -           | 4.47    | SV       |
| 3  | Linguistic      | -           | -           | 4.20        | -           | -           | 4.20    | V        |
| 4  | Graphical       | -           | -           | -           | 4.14        | -           | 4.14    | V        |
|    | Overall Average |             |             |             |             |             | 4.32    | SV       |

Information: 
- SV = Very Valid
- V = valid
- 1, 2, dan 3 = Mathematicians
- 4 = Linguist
- 5 = Education technology expert

In the table 4 above, it is shown that average value for presentation and content aspects have very valid criteria with same value 4.47. Average value for linguistic and graphical aspects are at valid criteria with value per each 4.20 and 4.14. Meanwhile, overall average value for worksheet validity is 4.32 stated as very valid criteria. Hence, it can be concluded that RME-based worksheet has been valid.

Based on the results of validation above, it can be declared that RME-based worksheet has been designed sequentially whether it is from didactic, content, language and graphics. Other than that, it also has contained RME characteristics, which are (1) worksheet has been designed to use contextual problems relevant with construction technology and property expertise programme, (2) there are instructions which direct learners to do horizontal and vertical mathematizing, (3) there are correlation between learners’ activity and their expertise programme, such as drawing, and using measuring devices in solving problems. This matter is supported by the assessment of experts who stated the validity of the worksheet. Therefore, it is expected to be used in Mathematics learning and be able to enhance learners’ mathematical communication skills at Grade X SMK construction and property engineering expertise programme.

4. Conclusion

RME-based RPP and worksheet have achieved valid criteria. Based on expert review, RME-based RPP obtains average value 4.35 entitled as valid category. Meanwhile, RME-based worksheet obtains average value at 4.32 entitled as very valid criteria. Hence, RPP is compatible with RPP components and curriculum 2013 and contains RME characteristics. Besides, RME-based worksheet has also accomplished RME characteristics. It is because RME-based worksheet has been designed to use contextual problems which are relevant with learners’ expertise programme and it is able to facilitate the occurrences of horizontal and vertical mathematizing. Every problem uses illustrative figure to ease the learners understanding of the problem.

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