MATHE*dunesa*
Jurnal Ilmiah Pendidikan Matematika *Volume 1 No. 7 Tahun 2018*
ISSN :2301-9085

DEVELOPMENT OF MATHEMATICS PROBLEMS USING SPUR (SKILLS, PROPERTIES, USES, AND REPRESENTATIONS) MULTIDIMENSIONAL APPROACH FOR STUDENTS IN THE 8TH GRADE

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Abstract

This study described how to develop mathematics problems that were valid and reliable by using SPUR (Skills, Properties, Uses, and Representations) multidimensional approach. In mathematics learning, majority of teachers designed problems for assessing students without validity and reliability test. Therefore development research could be one way for that situation. This study used Tessmer development model that consisted of two stages: 1) Preliminary stage, researcher found literatures and establish subjets in one-to-one, small group, and field test stages, and 2) Formative evaluation stage, researcher designed mathematics problems and it was reviewed by three experts in expert review stage, two 9th grade students in one-to-one stage, six 9th grade students in small group stage, and 37 students in 8th grade for field test stage. The last stage of this study produced 25 multiple choice problems (5 skills dimensional problems, 5 properties dimensional problems, 9 uses dimensional problems, and 6 representations dimensional problems). There were 10 valid and reliable problems and the product had an adequate reliability as 0,60.

Keywords: problems development, SPUR multidimensional approach, formative evaluation

PRELIMINARY

One of the most important components in learning activity was an assessment. In Permendikbud RI (2016: 4), it aimed to observe and evaluate processes, learning progresses, and improvements of learning outcomes sustainably. Seeing an Article 14, Permendikbud RI Number 23 (2016: 11) was about assessment standard of education that had some forms for teachers to achieve it. They were tests, observations, individual or group tasks, and the others according to the students' characteristic. Yusuf (2015: 94) stated that a test was the one of assessment instrument could be differentiated by realization form that were paper and pencil test, oral test, and performance test.

Paper and pencil test was often used by teachers and the common one in Indonesia is Ujian Nasional (UN). It was an activity of measuring the achievement of graduate competency in certain subjects nationally with reference to Standar Kompetensi Lulusan (BSNP, 2017). For Junior High School, mathematics was one of subjects that is examined in UN. The number standard of problems is 40. Majority of problems prepared for UN was still on knowledge, understanding, and application cognitive level. **Figure 3** showed that framework in year 2015/2016 of UN contained knowledge, understanding, application, and reasoning cognitive level.

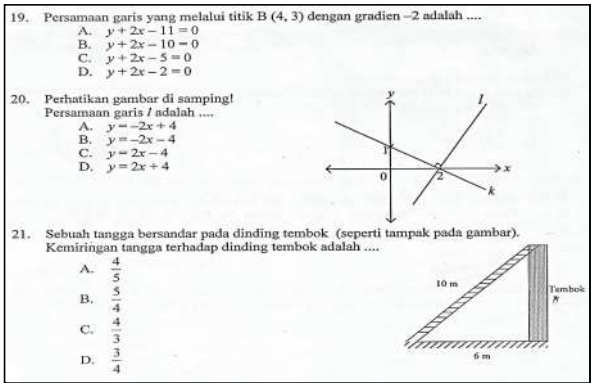
A problem for function prepared in the framework was on knowledge, understanding, application, and reasoning cognitive level but problem for aplication and reasoning was not found. It can be shown by UN document in year 2015/2016 as follows.

16. Fungsi f dinyatakan dengan $f(x) = 3x + 5$. Hasil dari $f(2b - 3)$ adalah ....
    A. $5b + 8$
    B. $5b + 2$
    C. $6b - 4$
    D. $6b - 15$

Figure 1 Function Problem

Students were asked to find the value of the function for problem 16 in **Figure 1**. It examined students in knowledge and understanding cognitive level.

Apart from that, there were three problems for straight line equation in knowledge and understanding cognitive level as follows.


19. Persamaan garis yang melalui titik B (4, 3) dengan gradien –2 adalah ....
A. $y + 2x - 11 = 0$
B. $y + 2x - 10 = 0$
C. $y + 2x - 5 = 0$
D. $y + 2x - 2 = 0$

20. Perhatikan gambar di samping!
Persamaan garis *l* adalah ....
A. $y = -2x + 4$
B. $y = -2x - 4$
C. $y = 2x - 4$
D. $y = 2x + 4$

21. Sebuah tangga bersandar pada dinding tembok (seperti tampak pada gambar). Kemiringan tangga terhadap dinding tembok adalah ....
A. $\frac{4}{5}$
B. $\frac{5}{4}$
C. $\frac{4}{3}$
D. $\frac{3}{4}$

Figure 2 Straight Line Equation Problems

Level Kognitif	Bilangan	Aljabar	Geometri dan Pengukuran	Statistika dan Peluang
Pengetahuan dan Pemahaman • Mendeskripsikan • Membuat tabulasi • Menghitung • Menginterpretasi • Memprediksi • Menentukan	Siswa dapat memahami pengetahuan tentang: - operasi bilangan bulat dan sifat-sifatnya - operasi bilangan pecahan dan sifat-sifatnya - operasi bilangan berpangkat dan sifat-sifatnya - operasi bilangan bentuk akar dan sifat-sifatnya - pola barisan bilangan - barisan dan deret - aritmetika sosial - perbandingan	Siswa dapat memahami pengetahuan tentang: - bentuk aljabar - persamaan dan pertidaksamaan linier satu variabel - sistem persamaan linier dua variabel - himpunan dan diagram venn - relasi atau fungsi - persamaan garis lurus	Siswa dapat memahami pengetahuan tentang: - hubungan garis dan sudut serta ukurannya - konsep segiempat dan segitiga serta ukurannya - teorema pythagoras - unsur/bagian lingkaran serta ukurannya - unsur bangun ruang sisi datar maupun lengkung - luas permukaan dan volume bangun ruang sisi datar maupun lengkung - kesebangunan dan kongruen bangun datar	Siswa dapat memahami pengetahuan tentang: - menyajikan dan mendeskripsikan data dalam bentuk diagram batang, garis atau lingkaran - rata-rata, median, modus - titik sampel, ruang sampel dan peluang
Aplikasi • Mengklasifikasi • Mengeskperimen data • Mengonstruk • Menyelesaikan masalah	Siswa dapat mengaplikasikan pengetahuan tentang: - operasi bilangan bulat dan sifat-sifatnya - operasi bilangan pecahan dan sifat-sifatnya - operasi bilangan berpangkat dan sifat-sifatnya - operasi bilangan bentuk akar dan sifat-sifatnya - pola barisan bilangan - perbandingan - aritmetika sosial	Siswa dapat mengaplikasikan pengetahuan tentang: - persamaan dan pertidaksamaan linier satu variabel - operasi dua himpunan - relasi atau fungsi - persamaan garis lurus - sistem persamaan linier dua variabel	Siswa dapat mengaplikasikan pengetahuan tentang: - teorema Pythagoras - unsur-unsur/bagian lingkaran - unsur-unsur bangun ruang - kesebangunan dan kekongruenan segitiga - luas permukaan dan volume bangun ruang sisi datar maupun lengkung	Siswa dapat mengaplikasikan pengetahuan tentang: - rata-rata, median, modus - penyajian data dalam bentuk diagram batang, garis atau lingkaran - ruang sampel dan peluang sederhana

Level Kognitif	Bilangan	Aljabar	Geometri dan Pengukuran	Statistika dan Peluang
Penalaran • Menjelaskan • Membedakan • Menafsirkan • Menyimpulkan	Siswa mampu menggunakan nalar yang berkaitan dengan: - bilangan bulat - pecahan - barisan dan deret - aritmetika sosial - perbandingan	Siswa mampu menggunakan nalar yang berkaitan dengan: - persamaan linier dua variabel - penggunaan konsep himpunan - penggunaan konsep fungsi	Siswa mampu menggunakan nalar yang berkaitan dengan: - kesebangunan segitiga	Siswa mampu menggunakan nalar yang berkaitan dengan: - rata-rata, median, modus - penyajian data dalam bentuk diagram batang, garis atau lingkaran

Figure 3 Framework 2015/2016

Seing **Figure 2**, problems for straight line equation was designed in knowledge, understanding, and application cognitive level. Therefore suitability between framework and problems was needed in designing problems.

Relating to the designing math problems to assess the process and learning outcomes of students, an interview with mathematics teacher of SMP Negeri 22 Surabaya could show that mostly teachers adapt problems from various sources such as: books, students' worksheet, internet, and the other without testing their validity and reliability. Teachers assume that problems were valid and reliable. This was also supported by Yusuf's opinion (2015: 95). He stated that teacher-made tests were specially designed to assess the learning process and outcomes of students was not yet known the validity and reliability.

Considering the benefits of math problems to train the readiness of the exam, assess the learning, and as exercise questions for learners as well as the facts that had been presented then the development of math problems was necessary to be done especially for problems in the applications and reasoning cognitive level.

Therefore, developing mathematics problems could be used SPUR (Skills, Properties, Uses, dan Representations) multidimensional approach. **Skills dimension** was the procedures, such as carrying out one step or multiple step algorithms, inventing new algorithms, and using technology to perform mathematical calculations. **Properties dimension** was the underlying theories and principles of mathematics, often requiring students to identify or apply mathematical properties or provide mathematical justifications. **Uses dimension** was real world applications, which often means expecting students to develop models to describe the mathematics. **Representations dimension** was visual depictions of mathematical concepts, such as graphs, pictures of geometric figures, or statistical plots. This approach could give teachers useful information about the depth of their students' understanding of a mathematical topic. A research also had shown that if students have a rich network of connected ideas about a mathematical concept, their capacity to problem solve and succeed in novel mathematical situations was enhanced (Bleiler & Thompson, 2013: 294)

SPUR multidimensional approach could be used for developing mathematics problems by adapting Tessmer (1993) development model that consisted of two stages, preliminary and formative evaluation stages. Spesifically, this study described how to develop mathematics problems that were valid and reliable by using SPUR for 8th grade in the first semester and how the development product.

METHOD

This study adapted Tessmer development model that consisted of two stages, preliminary and formative evaluation stages. Formative evaluation consisted of self evaluation, prototyping (expert review, one-to-one, and small group), and field test.

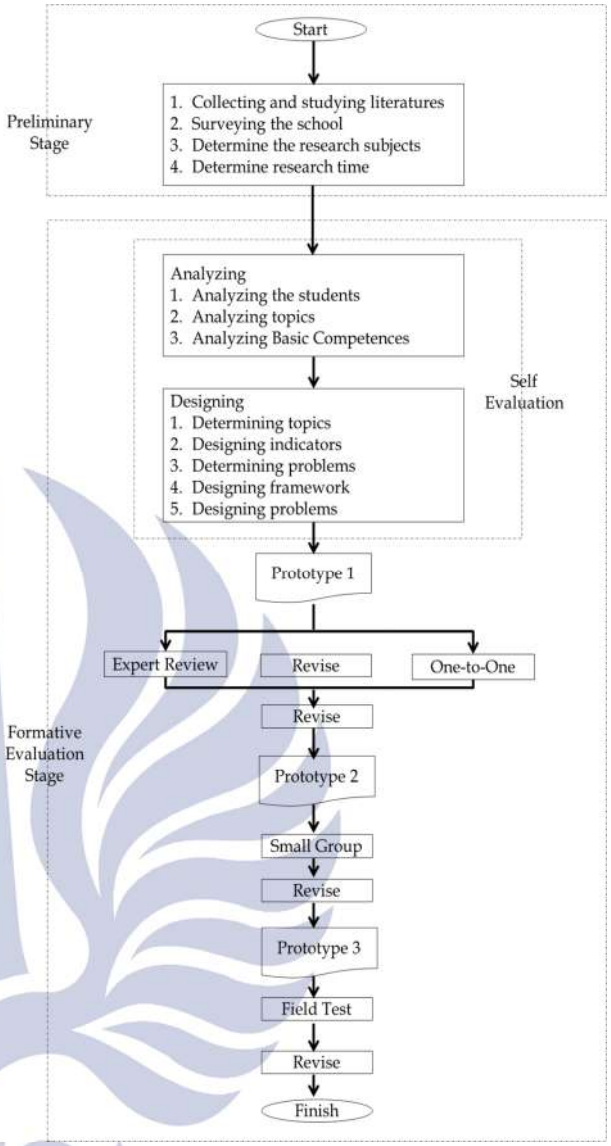


Figure 4 A plot of Research Design

Information:

Preliminary stage

A researcher found and studies some relevant literatures, surveys SMPN 22 Surabaya for preparing the research, and discusses with teacher there for the research time.

Formative Evaluation Stage

1. Self Evaluation

In this stage, the researcher did analyzing and desigining before trying out of students. For

analyzing, the researcher analyzed the students who would be selected as research subjects, books for choosing math topics in junior high school, and basic competency in syllabus of Curriculum 2016. Furthermore math topics and basic competency would be used in designing problems which are called Prototype 1.

2. Expert Review and One-to-One

   In this stage, three experts who experted in pure mathematics and education in State University of Surabaya, would review and evaluate Prototype 1 based on the topics, constructions, and language or cultures in the expert review sheet descriptively. The researcher found the validity. In the same time, two students class IX-A SMPN 22 Surabaya also reviewed it through trying out the problems. They reviewed the clarity and legibility of problems. Furthermore, the research asked them for knowing depth information that could be recorded and noted in the students review sheet. The data obtained would be used for revising Prototype 1 which turned into Prototype 2.

3. Small Group

   Six students class IX-A SMPN 22 Surabaya tried to solve the problems in Prototype 2 and reviewed it in this stage. It was almost the same as the previous stage but researcher or teachers could not help them when they got difficulties. They were just observing and asking the clarity and legibility of problems. The data obtained would be used for revising Prototype 2 which turned into Prototype 3.

4. Field Test

   In the last stage, Prototype 3 would be used in the real test. All of students in the class VIII-C SMPN 22 Surabaya tried to solve the problems. Researcher would revise if it was needed. Data obtained would be used to find the validity and reliability.

RESULT AND DISCUSSION

Development Process and Result

This study started by designing problems, called Prototype 1 that were prepared in the self evaluation stage and pre-study in the preliminary stage. The supporting literatures was needed in this study.

In the expert review stage, three experts reviewed and evaluated Prototype 1 based on the content, language, and culture descriptively. Prototype 1 had a mean of validity 3,41 (V**a**P) for very valid interpretation. The following table showed the result of (V**a**P).

Tabel 1 The Expert Assessment Result

Criteria-i	Expert			K_i	A_i	VaP
	1	2	3			
Topics						3,41
1	3	3	2	2,67		
2	4	4	4	4	3,56	
3	4	4	4	4		
Construction						
4	4	3	4	3,67		
5	4	4	3	3,67		
6	4	4	4	4		
7	4	4	3	3,67		
8	3	4	3	3,33	3,56	
9	3	2	2	2,33		
10	4	4	3	3,67		
11	4	4	3	3,67		
12	4	4	4	4		
Language and Cultures						
13	3	4	2	3		
14	3	4	2	3	3,11	
15	3	4	3	3,33		

In the same time, NSA and KNA (14 years old), the students class IX-A SMPN 22 Surabaya, reviewed Prototype 1 (30 problems) in one-to-one stage. They reviewed the clarity and legibility of problems. Furthermore, the research asked them for knowing depth information that could be recorded and noted in the students review sheet. Data obtained from these two stages would be used to revise it. For the result, four problems (problem 1, 2, 11, and 13) had to be eliminated for revising Prototype 1 which turned into Prototype 2.

Six students class IX-A SMPN 22 Surabaya tried to solve the problems in Prototype 2 and reviewed it in small group stage. It was almost the same as the previous stage but researcher or teachers could not help them when they got difficulties. They were just observing and asking the clarity and legibility of problems. The data obtained would be used for revising Prototype 2 which turned into Prototype 3. The result showed that problem 14 had to be eliminated because this problem was suitable to assess students in 6th grade, elementary school.

In the field stage, Prototype 3 consisted of 25 problems that would be used in the real test. All of students in the class VIII-C SMPN 22 Surabaya had to solve it. Researcher would revise if it was needed. Data obtained would be used to find the validity and reliability. The following table showed valid and unvalid problems.

Tabel 2 The Validity of Prototype 3

Problem Number	r_{pbi}	Interpretation
1	−0,04	Invalid
2	0,09	Invalid

Problem Number	r_{pbi}	Interpretation
3	0,17	Invalid
4	0,10	Invalid
5	0,22	Invalid
6	0,24	Invalid
7	0,42	Valid
8	0,42	Valid
9	0,22	Invalid
10	0,17	Invalid
11	0,00	Invalid
12	0,33	Valid
13	0,10	Invalid
14	0,62	Valid
15	0,37	Valid
16	0,48	Valid
17	0,49	Valid
18	0,32	Invalid
19	0,40	Valid
20	0,23	Invalid
21	0,31	Invalid
22	0,39	Valid
23	−0,01	Invalid
24	0,55	Valid
25	0,28	Invalid

There were 10 valid problems and they had an adequate reliability as 0,60. The following table showed the result of problems that were developed by SPUR multidimensional approach.

Tabel 3 Development Product

Topics	Problems Number	Dimensions			
		S	P	U	R
Algebra	7			√	
Relations and Functions	8		√		
Straight Line Equation	12				√
	14				√
Linear Equation of Two Variables	15			√	
	16	√			
	17			√	
	19			√	
Pythagorean Theorem	22		√		
	24			√	
Total		**1**	**2**	**5**	**2**

Discussion

1. Choosing Subjects

   The subjects at one-to-one and small group stages used the students class IX-A SMPN 22 Surabaya. The 9th grade was the best grade level for junior high school. Selection of research subjects at both stages was done randomly. Theoretically, the selection of the subjects in these stages was actually determined by the mathematical ability of the students.

   Two subjects at the one-to-one stage could use both students in medium math skills or by using learners in high and low math skills. The chosen subjects also had a good level of confidence and talkative. It aimed to obtain more information about the design under development.

   Furthermore, for the selection of subjects at the small group stage was similar to the selection in the one-to-one stage by looking at the mathematical ability of students. If the subject was determined as many as six people then the researcher could choose two students for each ability (high, medium and low ability).

2. Results

   This development research resulted 25 questions (5 problems of skills dimension, 5 problems of properties dimension, 9 problems of uses dimension, and 6 problems of representations dimension) that was tested to 37 students of class VIII-C SMPNe 22 Surabaya in field test stage. This was not suitable with the expected product specification of 40 multiple choice of mathematics problems and each dimension contains 10 problems.

   In the process of developing a mathematical problem with the SPUR multidimensional approach, the researcher eliminated problems with some considerations obtained through results at each development stage. Therefore, the design of the problem was reduced in each stage so there was a discrepancy between expectations and the results obtained.

Conclusion

This study produced 25 multiple choice problems (5 skills dimensional problems, 5 properties dimensional problems, 9 uses dimensional problems, and 6 representations dimensional problems). There were 10 valid and reliable problems and the product had an adequate reliability as 0,60.

Suggestion

The following were suggestions that can be given based on the result and discussion of this study.

1. Researcher suggested to develop mathematics problems that are valid and reliable especially on the skills, properties, and representations dimensions.
2. For designing stage, researcher suggested to design the problem beyond the expected product

specification. It aimed to minimize the mismatch of plans and results obtained.

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