Developing Ill-defined problem-solving for the context of “South Sumatera”

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Abstract. This study aims to produce a valid and practical ill-defined problem-solving for context South Sumatera. The subject of the research is three students of the first semester of undergraduate students in the mathematics department of Raden Fatah State Islamic University. This study use development studies that consist of preliminary and prototyping. In preliminary stage have been analysis content curricula, indicator, and strategies of problem-solving. Meanwhile, in prototyping stage only consist of self-evaluation, expert review, and one-to-one. The data were collected through a walkthrough, interview, and test. The data were validated using expert review, but in practice, the data were obtained from test and interview to subject of the research. This studies produced two valid and practical problem-solving. The first problem is about “Benteng Kuto Besak”, and the second problem is about “Monpera”. From the expert review, the conclusion can be drawn that two problems which are developing are ill-defined problem-solving, and valid from content, construct, and its language. Besides that, the problems are practical because all students know and understand what the problems goal, but not the solutions.

1. Introduction

There are five abilities students will have through mathematics learning. These capabilities include communication skills, reasoning, connection, representation, and problem-solving [1]. One of the most important skills is the ability of problem-solving because it is the heart of mathematics and can not be separated from the learning of mathematics. Problem-solving ability is the ability to find and apply ideas that students have in other fields of study in everyday life [2].

Problem-solving is the process of identifying a problem, developing possible solution paths, and taking the appropriate course of action [3]. Problem-solving is very important because good problem-solving skills empower someone not only in their personal life but also in their professional life. In the current fast-changing global economy, everyone often identifies everyday problem-solving as crucial to the success of their organizations, and problem-solving can be used to develop practical and creative solutions and to show independence and initiative to employers.

In Indonesia, students problem-solving ability is still low [4, 5]. Many teachers and students experience difficulties, not only in teaching but also on developing and enhancing problem-solving skills [2]. There are a lot of factors that cause the above problems, for example, still, at least problem-solving in school books. This has an impact on teachers and students. Teachers rarely give problem-solving and students rarely do problem-solving.

Patnani [6] adds that the lack of problem-solving skills not only faced by students but also by undergraduate students. The number of complaints occurs in the world of work because undergraduates...
seem unprepared facing the world of work and they are still confused to face the problem. Meanwhile, they are expected to be able to solve problems. This is due to the quality of college graduates who are considered still inadequate in divergent thinking. Although there is the problem that teachers or lecturer once gave to their students a matter in the form of mathematical symbols.

The formal mathematics problem makes the excuse that mathematics is dry, difficult, and unattractive, and some students assume that mathematics is not related to human activity. Therefore, it is necessary to find and add context to the math problem [7]. Also, the use of local context can assist students in understanding the mathematical phenomena of their own life experience perspective [8]. This means that context can not only be used in learning, but also in judgments. One context that can be used is the context of South Sumatera.

South Sumatera is one of the provinces in Indonesia. The local context in the province of South Sumatera is very much and diverse, for example from the aspect of tourism. There are several aspects of this context in South Sumatera that belong to the tourism aspect of culinary, historical place, and natural beauty. Previous research has developed many problem-solving problems [8], but no one has developed it in the context of South Sumatera. This study aims to produce a valid and practical ill-defined problem-solving for the context of South Sumatera.

A Problem is a situation which there is no obvious solution [9, 10]. A problem exists when there is a situation you want to resolve, but no solutions are readily apparent. Problem-solving is a complex task [11]. Problem-solving is the process by which the unfamiliar situation. A situation that is considered as a problem to one person may not be a problem to someone else. Problem-solving also can define as the ability to understand what the goal of the problem and what rules could be applied represent the key to solving the problem. Problem solving is also one of the competency in PISA mathematics [12].

Problem-solving is consist of two types: the ill-defined problem and the well-defined problem [13]. The ill-defined problems are those that do not have clear goals, solution paths, or expected solution. The well-defined problems have specific goals, clearly defined solution paths, and clear expected solutions. Problem-solving is the subject of a major portion of research and publishing in mathematics education. A lot of studies are founded on the problem-solving writing of George Polya. In the case of problem-solving, it may be speculated that a solvers’ idea about the nature of mathematics may affect the way in which a solution is sought [14].

Capraro and Cifarelli [15] give an example, each student will have opportunities to obtain their unique solutions. They can respond to the problem in some significant way with many different solutions. Students also will have more opportunities to make comprehensive use of their mathematical knowledge and skills to solve the problem. They also will choose their favorite strategies to obtain answers and create their unique solutions.

The well-defined problem is contradictive to the ill-defined problem. The well-defined problem sometimes calls as the formal problem. The formal problem has some characteristics. They are as follows: (1) have a defined given initial situation; (2) have a defined goal; (3) have a defined set of resources; and (4) have some ownership [16]. The term problem-solving sometimes includes posing and solving problems, posing and accomplishing tasks, posing and answering questions, and posing and making decisions. Problem-solving is an integral component of every academic discipline [17]. Polya [16] mentions that there are many reasonable ways to solve problems. The skill at choosing an appropriate strategy is best learned by solving many problems. Students will find choosing a strategy increasingly easy. A partial list of strategies includes: (1) guess and check; (2) make an orderly list; (3) eliminated possibilities; (4) use symmetry; (5) consider special cases; (6) use direct reasoning; (7) solve an equation; (8) look for a pattern; (9) draw a picture; (10) solve a simpler problem; (11) use a model; (12) work backwards; (13) use a formula; and (14) be ingenious.

2. Method
This research uses part of Design Research type development study [18] so that every development stage of questions consist of the preliminary stage and formative evaluation stage [19]. The formative
evaluation stage consists of self-evaluation and prototyping, but at prototyping stage, it only occurs at the expert review and one-to-one [20].

The preliminary stage begins by doing curriculum content analysis, determining indicators of problem achievement, and the strategies students use in problem-solving. Next, the results of this preliminary are designed grid, draft questions, and rubric assessment that refers to the strategy used in problem-solving. The developed problem contains the context of South Sumatera, especially the historic place in South Sumatera. Furthermore, self-evaluation stage, the problem device has been developed in its own evaluation by the researcher. This is done with a purpose to know the shortcomings of the draft questions that have been developed so that the resulting draft is feasible to be validated by experts. The next stage is prototyping. The prototyping stage begins with expert validation. Expert validation is defined as testing the quality of the questioning device by the experts viewed from three aspects namely content, constructs, and language.

Along with validation by experts, a one-to-one stage is performed. This is done in order to know the quality and practicality of problem-solving. This stage involves three students of mathematics education of UIN Raden Fatah Palembang. They have various skills (high, medium, low). At the one-to-one stage, students are asked to read and examine the matter, and then ask students to solve the problem. There are several instruments used in this study. They are walkthrough, interview, and test. The walkthrough is used to collect data during expert validation. At the time of one-to-one, there are two instruments are used: interview and test. Interviews are used to collect data of students' understanding of the given problem. While the test is used to see student strategies in solving the problem.

3. Result and discussion

3.1. Preliminary stage

This stage begins with curriculum analysis and collects theories related to the concept of problem-solving. The results of this stage are generated grids, draft questions, and alternative strategies used in solving the problem. All the questions developed contain the context of South Sumatera. At this stage result six problem-solving with the context of South Sumatera.

| Number | Indicator | Context  | Content       | Strategy                      |
|--------|-----------|----------|---------------|------------------------------|
| 1      | Use nonstandard unit sizes to resolve issues related to shape | Gate of Benteng Kuto Besak (BKB) | Space and shape | Consider special cases        |
| 2      | Use a mathematical model to determine the maximum number of visitors | monument of struggle (Monpera) | Change and relationship | Eliminated possibilities     |
| 3      | 1. Using the concept of scale to determine the distance of two points | Dempo Mountain | Quantity | Use a formula                |
|        | 2. Using the concept of speed to determine the location of a place | | | |
| 4      | 1. Predict the wide area of Gelora Sriwijaya using satellite imagery scale | Sports Area (Gelora Sriwijaya) | Space and shape | Consider special cases        |
|        | 2. Predict the capacity if there is a standard size | | | Use a formula                |
| 5      | Determine the broad ratio of the two pensions | monument of struggle (Monpera) | Space and shape | Draw a picture               |
| 6      | Determine the percentage increase in the number of visitors | Temam Waterfall | Uncertainty and Data | Use a formula                |
3.2. Expert review
The main validator of this research is three lecturers in Mathematics Education Department. Stage occurs in two cycles, because of the first walkthrough result of many things to be updated, especially indicators, the language on the problem, and strategy of completion.

Table 2. Result of Expert Review

| Aspect       | Comment from Validator                                      |
|--------------|------------------------------------------------------------|
| Content      | - There are some issues that are categorized not about problem-solving  
|              | - Situation and context offered still tend to be camouflaged  
|              | - The description of the problem does not help much in solving the problem  |
| Construct    | - There is a problem with too many pictures  
|              | - No pictures that do not support problem-solving  
|              | - The information on the picture is less clear  |
| Language     | - There is still an elusive term  
|              | - Use good and correct Indonesian (EYD)  |

3.3. One-to-one
In line with the implementation of expert validation, a one-to-one stage is performed. At this stage, there are three students of Mathematics Education UIN Raden Fatah who became the subject of research. These three students have different abilities. Here are the initials and categories of students' abilities.

Table 3. The Initials and Categories of Students' Abilities

| Initial Name | Ability |
|--------------|---------|
| SrW          | High    |
| SiW          | Medium  |
| MI           | Low     |

The three students are asked to read and examine the problem on the matter. Furthermore, researchers asked some questions to see the responses, constraints, and understanding of students to solving the problem. Here are some questions asked (Table 4)

Table 4. Questions in Interview

| Number | Question                                                                 |
|--------|--------------------------------------------------------------------------|
| 1      | Do you know the meaning of the words in the questions?                   |
| 2      | Can you mention the problem in your own sentences?                       |
| 3      | Is the information sufficient to solve the problem?                      |
| 4      | What do you need to get it done?                                        |
| 5      | Is there anything you do not know from the problem?                      |
| 6      | Is the condition of the questions sufficient for you to determine the things you do not know? |
| 7      | Have you ever encounter a problem like this?                             |
| 8      | Do you know the concepts or theorems that can be used to solve the problem? |
| 9      | What strategies do you use in solving the problem?                       |

From the interview result, it can be concluded that MI students with low ability level tend to be confused when interpreting the problem. This happens to almost all of the question numbers. MI not only cannot solve it but also feel confused when reading and declaring problems in his own language. The problem-solving and some excerpts of the interview with MI on problem number 1 can be seen in Figure 1.
**Figure 1.** MI’s Answer on Problem Number 1

Researcher: "Can you express the problem in your own words?"
MI: "not yet, Sir. I'm confused how to say it"
Researcher: "What is needed to solve the problem?"
MI: "gate size Sir"
Researcher: "Do you know what concepts or theorems can be used to solve the problem"
MI: "I do not know, sir"

The same findings were obtained from highly skilled students (SrW). SrW is not only able to interpret and express problems with its own words when most of the required information does not exist, but SrW has also been able to plan what will be used to solve the problem. SrW has also seen problems like this though in different forms. The problem-solving and some excerpts of the interview with SrW on problem number 5 can be seen in figure 2.

**Figure 2.** SrW’s Answer on Problem Number 5
Researcher: "Have you ever seen a problem like this?
SrW: "Never Sir, but the problem is different. Usually because of the comparison of triangle or square.
Researcher: "Do you know the concepts or theorems that can be used to solve the problem?"
SrW: "know enough, the concept used is the concept of comparison”.

The same findings were obtained from medium-ability students (SiW). SiW is capable of interpreting and raising problems with its own words when most of the required information already exists in the description of the problem, but SiW encounters problems if the required information is unclear, for example on the interior of Monpera, as only the images presented on the problem and there is no explanation of the pentagonal measures. The problem-solving and some excerpts of the interview with SiW on problem number 1 can be seen in Figure 3.

Figure 3. SiW’s Answer on Problem Number 1

Researcher: "What is needed to solve the problem?"
SiW: "Specifically for Problems 1 and 5, I need additional information about the size of the gate and the size of a pentagon with a pink yellow”. Because if not known, then the problem cannot be solved.

Based on the results of expert validation and one-to-one, it can be concluded that only 2 of the 6 questions that have been designed are categorized as a valid problem-solving problem. This is not only reflected in the responses provided by expert validation, but also from the responses, constraints, and understanding of the students.

Although almost all of the problems given can be solved by the students, regarding of responses, obstacles, and understanding and settlement strategies, it can be recommended that all of these problems are categorized as practical. Based on the results of this research, there are only two of six problems that are categorized as valid and practical problems, namely the number 1 problem with the context of "Benteng Kuto Besak" and problem number 5 with the context of "Monpera". The question numbers 1 and 5 have been declared valid and practical can be seen in Figure 4 and Figure 5.
The construction of Benteng Kuto Besak was initiated by The first Sultan Mahmud Badaruddin who reigned in 1724-1758 and the construction was completed by his successor, Sultan Mahmud Badaruddin II who reigned in 1776-1803. To maintain its sustainability, the government of Palembang plans to create a wooden gate. If the size of wood is 20 cm x 300 cm. Determine how much wood is needed for the gate?

**Figure 4. Problem Number 1**

Monpera is a struggle monument made to commemorate the hero's service in South Sumatera. Monpera resembles a five-pointed jasmine. The height of the Monpera building reaches 17 meters, has eight floors, and 45 fields/lane. The numbers represent the date of the proclamation of independence of the Republic of Indonesia August 17, 1945. If you are in the Monpera and looked up the ceiling of the building it will look like the picture above. Can you determine the ratio of the area of a pentagon with a yellow area of a pentagonal area (stainless)? Describe the strategy you use in solving the problem?

**Figure 5. Problem Number 5**
From the result of prototyping has produced two problems which categorized problem-solving. Both questions contain the context of South Sumatera. Problem number 1 contains the context of "Benteng Kuto Besak" with space and shape content and the strategy used for problem-solving is consider special cases. While problem number 5 is still related to content space and shape but its context "Monpera" and strategy draw a picture.

The difference in completion given by the student depends on the difference in the student's level of ability [21, 22]. Students who are low in understanding have low-level students. MI students make many mistakes in solving problems, not only wrong concepts but also wrong in choosing settlement procedures. The error is caused by not understanding the related concepts [23-25]. Different answers are obtained from students who are categorized have ability medium level and high level. Si W (medium-level students) already understands the concept but is still wrong in choosing the settlement procedure, while SrW (high-level students) is not only able to identify and understand the problem, but also able to complete and provide supporting arguments from the solution.

4. Conclusion
This studies produced 2 valid and practical problem-solving. The first problem is about “Benteng Kuto Besak”, and the second problem is about “Monpera”. From the expert review, the conclusion can be drawn that two problems which are developing are ill-defined problem-solving, and valid from content, construct, and its language. Besides that, the problems are practical because all students know and understand what the goal of the problems, sometimes they don’t know the solutions.

References
[1] Paridjo and Waluya St B 2017 Analysis mathematical communication skills students in the matter algebra based NCTM Journal of Mathematics IOSR-JM 13 60
[2] Mursiadi R 2013 Model pembelajaran matematika tipe group investigation untuk meningkatkan kemampuan pemecahan masalah matematis dan self-concept siswa MTs Tesis (Bandung: Universitas Pendidikan Indonesia)
[3] Al-Tarawneh H A 2012 The main factors beyond decision making Journal of Management Research 4 1-22
[4] Kusaeri 2006 Profil kemampuan dasar matematika mahasiswa jurusan tadri pendidikan matematika fakultas tarbiyah Qualita Ahsana 8 2
[5] Sari S Eliati S and Fauzan A 2014 Pengaruh pendekatan pembelajaran berbasis masalah terhadap kemampuan pemecahan masalah matematika siswa kelas VIII SMP Negeri 1 Padang Jurnal Pendidikan Matematika 3 54
[6] Patnani M 2013 Upaya meningkatkan kemampuan problem-solving pada mahasiswa Jurnal Psikogenesis 1 130
[7] The Cornerstone Tech Prep 1999 Teaching Mathematics Contextually (Texas: CORD)
[8] Charmila N, Zulkardi and Darmawijoyo 2016 Pengembangan Soal Matematika Model Pisa Menggunakan Konteks Jambi Jurnal Penelitian dan Evaluasi Pendidikan 20 198-207
[9] Ong R 2000 The Role Of Reflection In Student Learning: A Study Of Its Effectiveness In Complementing Problem-Based Learning Environments Centre for Educational Development Centre for educational development (Singapore)
[10] Carson J 2007 A problem with problem-solving: teaching thinking without teaching knowledge The Mathematics Educator 17 7
[11] NCTM 2000 Principles and Standards for School Mathematics (Reston VA: NCTM)
[12] Stacey K et al 2015 PISA’s Influence on Thought and Action in Mathematics Education, in Assessing Mathematics Literacy, edited by K. Stacey and R. Turner (Springer, Switzerland) pp 275–306
[13] Holyoak K J 1990 Problem-solving Thinking: An Invitation to Cognitive Science 3 117-146
[14] De Hoyos M, Gray E and Simpson A 2004 students’ assumptions during problem-solving *The 28th International Conference of the International Group for the Psychology of Mathematics Education* (Bergen: University of Norway) p 2

[15] Capraro M M, Capraro R M and Cifarelli V V 2007 What are students thinking as they solve open-ended mathematics problems? *Proc of the ninth international conference of Mathematics Education in a Global Community* (Charlotte, NC)

[16] Moursund D 2016 *Learning Problem-solving Strategies by using games: A guide for Educator and Parents* (Eugene. OR: Information Age Education)

[17] Polya G 1985 *How to Solve it: A New Aspect of Mathematical Method* (NJ: Princeton University Press)

[18] Putri R I I and Zulkardi 2017 Fraction in shot-put: A learning trajectory *AIP Conference Proceedings*

[19] Zulkardi Z 2002 Developing a learning on realistic mathematics education for Indonesia students teachers *Dissertation* (Nederland: University of Twente)

[20] Tessmer M 1998 *Planning And Conducting Formative Evaluations: Improving The Quality Of Education And Training* (London: Kogan Page)

[21] Felder R M and Brent R 2005 Understanding Student Differences *Journal of Engineering Education* 94 57

[22] Dunlosky J R et al. 2013 improving students’ learning with effective learning techniques: Promising directions from cognitive and educational psychology *Psychological Science in the Public Interest* 14 4

[23] Nurhasanah F, Kusumah Y S and Sabandar J 2017 Concept of triangle: Examples of mathematical abstraction in two different contexts *International Journal on Emerging Mathematics Education* 1 53

[24] Tanujaya B, Prahamana R C I, and Mumu J 2017 Mathematics instruction, problems, challenges, and opportunities: A case study in Manokwari regency, Indonesia *World Transactions on Engineering and Technology Education* 15 287

[25] Syamsuri, Purwanto, Subanji, and Irawati S 2017 Using APOS theory framework: Why did students unable to construct a formal proof? *International Journal on Emerging Mathematics Education* 1 135