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The Development of Students' Worksheets Based on Combinatoric Reasons in Elementary School

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ABSTRACT

This study was motivated by the many shortcomings of students' worksheets so far, including the incapability in developing students' scientific skills and high-level thinking. Meanwhile, the learning objectives of the elementary school level get students to think reasonably and solve problems. Therefore, developing students' worksheets based on combinatoric reason is the solution, as it drills students to have sustainable thinking. This study aimed to see the validity, practicality, and effectiveness of students' worksheets based on combinatoric reason. It is a Research and Development study with the Plomp model. The plomp model consists of preliminary investigation; design; realization/construction; and test, evaluation, and revision. The research instruments were students' worksheets, validation form, questionnaire, and test form. The subject involved 40 students in the sixth grade of elementary school. The data analysis used is descriptive qualitative and descriptive quantitative. It resulted in 91,5% for the validity (very valid), 90,9% for the practicality (very practical), and 92,5% for the effectiveness (very effective). Thus, it indicates that students' worksheets based on combinatoric reason are valid, practical, and effective, which are proper for elementary school. So, it is recommended that mathematics teachers use it in learning, because it trains students to use combinatorial reasoning. As a result, students become flexible and logical in determining strategies, as well as being systematic in solving problems. As a result, elementary school students' Problem-solving and higher order thinking abilities become better.

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A. INTRODUCTION

This study was motivated by the low quality of current education in Indonesia, compared with other countries (Kusumawati, 2021). One effort by the government to improve current education quality is by developing Curriculum 2013 into Curriculum Merdeka, which gets students to be more independent, creative, and have critical thinking, including in learning mathematics in elementary school, given that mathematics in elementary grade is the beginning of inculcating the basic knowledge of mathematics (Susanto, 2013). Two competencies in mathematics learning objectives are the ability to think and to solve problems (Nurani et al., 2022; Peng et al., 2018).

Problem-solving is an ability that has focus on mathematics learning, not only in Indonesia, but throughout the world. This is because Problem-solving abilities can involve people's efforts to find solutions to problems by using analytical thinking, critical thinking, creativity and reasoning from available information (Ellerton, 2013). Therefore, elementary school students'

Problem-solving and reasoning abilities must be improved as part of achieving mathematics learning goals in elementary schools. Because, the two are interrelated. When students solve problems, they must reason.

There are many types of reasoning, one of which is combinatorial reasoning. Following Piaget, combinatoric reason was classified into the phase of formal operational thinking and It started at 11 years old up (Piaget, J, Inhelder, 2019). However, English claimed that 7-year-old up to 12-year-old children could think combinatorically in a simple way (Lyn D. English, 1993). The first reason why we need to do this current study was that combinatoric reason by elementary graders still has less attention although it may help students to solve problems. This is due to the fact that combinatoric reason is a process of finding some alternative strategies for solutions to problems (Nurul Aini et al., 2020; Ammamiarihta et al., 2017; Uripno et al., 2023). So it can be said that combinatorial reasoning has a strong relationship with ease in problem solving (Medová et al., 2020).

If elementary graders have already drilled their combinatoric reason skills, they will be able to think in a more flexible way, and more creative to find alternative strategies for solutions; the second reason is that if students use combinatoric reason skills, they train themselves to have reasonable and sustainable thinking in solving problems (N. Aini et al., 2019; Ammamiarihta et al., 2017; Cahyanti et al., 2020). Thus, they will get used to thinking critically in identifying problems early, and expectedly, it may improve their reasoning and problem-solving skills, which results in achieving the objectives of learning mathematics.

Drilling combinatoric reason can be done through students' worksheets. However, the existing students' worksheets still have many shortcomings, including those with the incapability to develop students' scientific and high-level reasoning skills (Payudi et al., 2017). It is contradictory to the function of the students' worksheets. This refers to a learning instrument that helps teachers to train their students to think reasonably and solve problems, in addition to helping students more active during their learning process, and encourage their interest and curiosity to use their skills (Ariyati et al., 2019; Barniol & Zavala, 2016; Harwati & Rokhmat, 2021).

Therefore, this is why we decided to use students' worksheets based on combinatoric reason as our problem-solving approach. Many researchers have discussed about combinatoric reason in qualitative way, but none of them is linked to the development of students' worksheets. Similarly, many researchers have discussed students' worksheets, but none of them are based on combinatoric reason. This suggests the R&D study of students' worksheets based on combinatoric reason in elementary grade is original. The development of this students' worksheets based on combinatoric reason expects the rise of students' combinatoric reason skills, which makes them able to determine some alternative strategies for solutions to problems, and they will experience the process of reasoning, which may improve their problem-solving competence, and at the end, it may improve the quality of education in Indonesia.

In this study, students' worksheets based on combinatoric reason referred to tasks that make student do a reasoning process and problem-solving experience based on the indicators of combinatoric reason through which they could achieve the learning objectives, as they got used to thinking combinatoric. The indicators of combinatoric reason included investigating

various factors, considering any possibilities, and evaluating and generalizing the use of strategy (Nurul Aini et al., 2020). Each indicator of combinatoric reason was spread out in the form of questions that led students to combinatoric reason.

In this study, the combinatoric reason is simple, given that it is for elementary grade. There are five strategies of listing in combinatoric reason. They are trial and error, emerging strategy, a cyclic pattern, odometer with errors and odometer complete (Lyn D. English, 1993). So, it is hoped that the results of student work in the students' worksheets will show one of the combinatorial reasoning strategies above. Overall, this current study aimed to see the validity, and practicality, of students' worksheets based on combinatoric reason that was being developed.

B. METHODES

This is an R&D study, conducted in elementary school for students' worksheets trials. The subject consisted of 40 students in the sixth grade. Due to the limitation of time, It applied PLOMP model with four stages including: preliminary investigation; design,; realization/construction; and test, evaluation, and revision (Nieveen & Folmer, 2013). The research and development design can be seen in Figure 1.

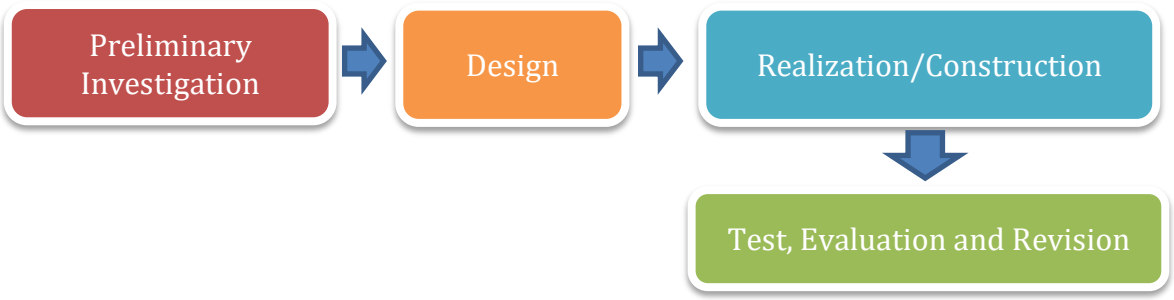

Figure 1. Four Stages Of PLOMP Model Development

The following description explains those four stages of PLOMP in more detail: Preliminary investigation such as collecting data of curriculum, syllabus, and courses for the sixth grade of elementary school, and identifying some issues related to students' worksheets; Design, we create an initial prototype design; Realization/construction, we construct the designed initial prototype; Test, evaluation, and revision. In this stage, we validated the initial prototype to test its validity. We validated the initial prototype to two expert validators, with criteria of expertise in mathematics education. One of them was a mathematics teacher of an elementary school, and another one was a lecturer of mathematics education. The parts validated by the validator are the format, content, language, and benefits of the initial prototype. Next, we did field test to see its practicality. The research instruments were students' worksheets, validity forms, questionnaire, and test form. The data analysis used is descriptive qualitative and descriptive quantitative. Test the validity of the initial prototype using a percentage value (Sugiyono, 2013), as in (1):

$$f = \frac{gained\ score}{the\ highest\ score} \times 100\% \qquad (1)$$

Note: f = the percentage of validity or practicality

Table 1. Criteria of Scoring

Criteria	Score
Very Good	5
Good	4
Quite Good	3
Less Good	2
Not Good	1

Second, the test for practicality considered the analysis of students' responses, as in (2).

$$f = \frac{gained\ score}{the\ highest\ score} \times 100\% \quad (2)$$

Note: f = the percentage of practicality

Table 2. Criteria of Scoring

Criteria	Score
Very Agree	4
Agree	3
Disagree	2
Very Disagree	1

Interpreting the data of validity, and practicality based on Table 3 as follow (Setyosari, 2016):

Table 3. Range of Percentage and Criteria of Interpretation

Scoring	Criteria of Interpretation
$80\% \leq x \leq 100\%$	Very valid or very practical
$61\% \leq x < 80\%$	Valid or practical
$40\% \leq x < 61\%$	Quite valid or quite practical
$21\% \leq x < 40\%$	Less valid or less practical
$0\% \leq x < 21\%$	Not valid or not practical

Students' worksheets based on combinatoric reason being developed was considered valid if the average score of validity was in the criteria of minimum interpretation Of being valid. Next, it was considered practical if the result of the questionnaire was in the criteria of minimum interpretation of being practical.

C. RESULT AND DISCUSSION

The following section describes the result of developing students' worksheets based on combinatoric reason.

1. Preliminary Investigation

The researcher interviewed the deputy head of curriculum on July 13 2023, because the deputy head of curriculum knew the curriculum used, teaching materials, teachers who taught in grade six. The result of interviewing the Deputy Head of Curriculum showed that the currently applied curriculum was Curriculum 2013; a module designed by teachers was used

for the teaching-learning process; the module provided some students' worksheets; students had more chances to learn while teachers acted as their facilitators. Next, researchers interviewed mathematics teachers on July 14 2023, because mathematics teachers understand the problems that occur in class and the LKPD used in class. The result of interviewing the mathematics teacher found some points such as the subject matter that students felt difficult to understand was negative integer; the teacher asked how to make students easily understand the material, since the designed module only gave a brief explanation, and almost had no picture at all; the students tended to be less interested in completing the existing students' worksheets; no how-to-do steps were found in the module; students had less narrative tasks, therefore, it needed worksheets that could concern on narrative tasks; and materials in the designed module was unclear.

Toward this issue, we saw a potential development of a worksheets based on combinatoric reason. It because that the school expected their students to be active in completing the given worksheets, especially those containing narrative tasks. It corresponded to the basic concept of combinatoric reason, which referred to assisting students to solve problems, and thus, combinatoric reason fits for narrative tasks. It was in line with some research suggesting that combinatoric reason could drill students to have reasonable and sustainable thinking for problem-solving (N. Aini et al., 2019; Nurul Aini et al., 2020; Ammamiarihta et al., 2017; Cahyanti et al., 2020). Hence, students could proceed and find some alternative strategies for solution of problems, in addition to thinking in more flexibly and creatively.

2. Design

Students' worksheets based on combinatoric reason is designed paper-based. Students' worksheets are designed based on data of the preliminary investigation, such as we made a students' worksheets that consisted of materials and examples along with its comprehensive explanation and attractive pictures. Besides, we designed a students' worksheets that reflected the indicators of combinatoric reason corresponding to integers and the learning objectives. The following section shows the phase of designing students' worksheets. First, the arrangement of students' worksheets should be as interesting as possible. Second, it needed an attractive cover design that consisted of two kinds of cover; the front and the group name. The front referred to the very front page. Meanwhile, the group name cover contained the name of the material to be taught (i.e., integer) and the group name along with its members.

Third, it designed the chapters on basic competence, learning objectives, and guidance. Fourth, it designed the page of material to be taught, which presented the definition of integer, the operation of addition using the number line, and the example of a narrative problem along with interesting pictures. Fifth, it designed narrative task based on combinatoric reason. Sixth, it designed the how-to-do steps of performing tasks based on combinatoric reason. After completing the students' worksheet design, the researcher proceeded to the construction stage.

3. Realization/Construction

We designed an initial prototype that corresponded to the predetermined designs. It resulted in students' worksheets based on combinatoric reason. This means that each step of the worksheet contains indicators of combinatoric reason. Combinatoric reason indicators function to direct students in the reasoning process when solving problem. This initial prototype included a cover up to the exercise task. The initial prototype is made as attractive as possible so that students are interested in working on this initial prototype, such as being given interesting pictures and bright colors. So, students do not feel bored while working on students' worksheets. Apart from that, some sentences motivate students when working on students' worksheets.

4. Test, Evaluation, and Revision

a. Test of Validity

We validated the initial prototype with two expert validators. One of them was a mathematics teacher of an elementary school, and another one was a lecturer of mathematics education. Figure 2 shows a chart of validation by those two validators, as follows.

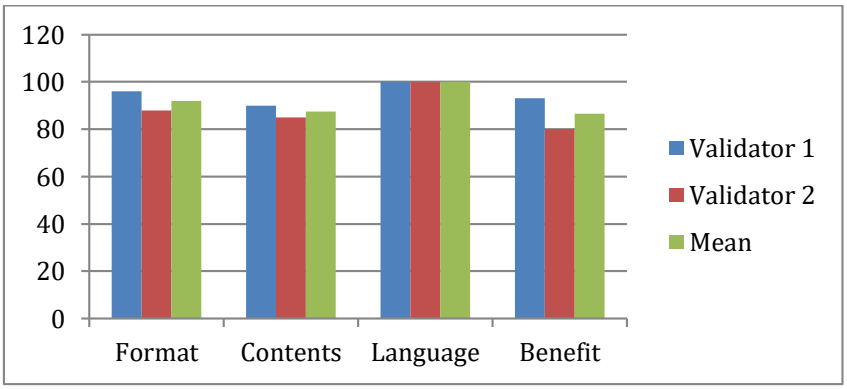

Figure 2. The Result Of Validation By 2 Validators Along With The Mean Score Of Validation Of Students' worksheets based on combinatoric reason

Figure 2 shows that. On average, every aspect started from format, content, language, and benefit of LKPD was in *very strong* criteria which percentage scores were 92%; 87,5%; 100%; and 86,5% respectively. Based on this percentage score, the highest one went to 'language' aspect (100%), while the lowest one went to the 'advantage' aspect (86,5%). The mean score of all aspects was 91,5%, and it indicated that these aspects were very valid criteria. Hence, students' worksheets based on combinatoric reason was considered very valid.

b. Test of Practicality

This test of practicality was organized in elementary school. 40 students from the sixth grade participated in this test. The trial was performed twice. This is because the first experiment did not get maximum results, so the researchers carried out several revisions to the initial prototype. After that, the researchers conducted a second experiment on the same students. The mean score of students' responses for both the first and second trials is seen in Figure 3, as follows.

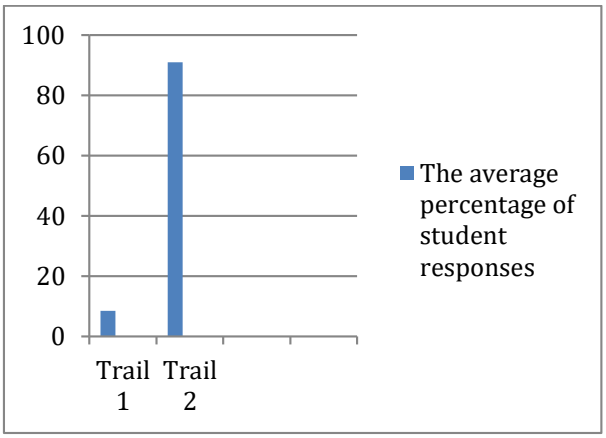

Figure 3. The Mean Percentage Score of Students' Responses for Trial 1 and Trial 2

Figure 3 shows the increasing mean score of students' responses between trials 1 and 2, from 86,37% to 90,9%. Thus, students' worksheets based on combinatoric reason was considered very practical. The students could easily complete the narrative task as the indicators of combinatoric reason were systematic, and it was consistent with previous studies suggesting that combinatoric reason could help students complete the given narrative tasks (N Aini et al., 2018; Nurul Aini et al., 2020).

Furthermore, they could already think combinatorically although in a simple way, which was listing. Some strategies of listing that were mostly found included trials, odometer with errors and odometer complete. It was consistent with studies claiming that 7-12-year-old children actually could have already thought combinatorically in simple way. Five strategies of listing in combinatoric reason were trial and error, emerging strategy, a cyclic pattern, odometer with errors, and odometer complete (Lyn D. English, 1993). LKS based on combinatoric reason can train elementary school students in combinatoric reason, because at each step of the LKS there are indicators of combinatoric reason. This has an impact on students' way of reasoning in solving problems, such as students becoming logical in investigating problems, students becoming flexible and logical in determining strategies, and systematic in solving problems. So, students find it not too difficult to solve math problems, especially story problems. This is in accordance with previous research which states that combinatorial reasoning is the process of looking for several alternative strategies for solving a problem and combinatorial reasoning has a strong relationship with the ease of solving problems (Nurul Aini et al., 2020; Ammamiarihta et al., 2017; Uripno et al., 2017; Uripno et al., 2020; ., 2023; Medová et al., 2020).

c. Test of Effectiveness

This test was given to the students who participated in students' worksheets trials. We distributed a test containing problem-solving skills based on combinatoric reason. It consisted of an essay related to integers based on combinatoric reason. The Minimum Mastery Criteria (MMC) that the school has determined was 70.

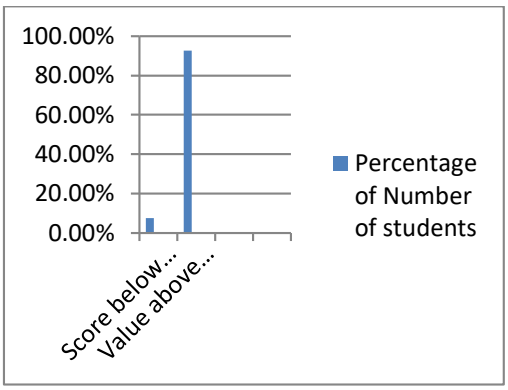

Figure 4. Percentage Of Students' Solving Ability Scores After Using Students' worksheetss

Figure 4 shows that, among 40 students who participated in the test, 37 students (92,5%) were considered to complete the MMC, while the other 3 students (7,5%) were under the rate of MMC. This incompleteness was probably due to several factors related to students' problem-solving skills. It was consistent with what had been suggested (Carlson & Bloom, 2005; Mills, 2021; Schoenfeld, 2016; Soto-Ardila et al., 2022)that many factors, either internal or external, could affect students' skills. Some internal factors were like students' capability to understand the scope of the problem in order to seek its solution, students' capability to select any mathematical approach/strategy/model to solve the given problem, students' capability to reasonably think and solve the problem, students' confidence or doubt in performing the given problem-solving task, students' capability to organize any identified data, and students' accuracy to review their works. Therefore, the test result was varied. 92,5% of the total participants had successfully complete the MMC, and thus, it was classified into high criteria. Hence, students' worksheets based on combinatoric reason could be considerably effective. It was consistent with an idea (Megahati et al., 2018) that the effectiveness could be identified from the achievement of learning objectives, and therefore, the test of effectiveness referred to a test that aimed to see the achievement of learning objectives by applying a developed product in the learning process.

D. CONCLUSION AND SUGGESTIONS

It concludes that the students' worksheets based on combinatoric reason is valid, practical, and effective. It is proper for elementary grades. Suggestions that can be given are as follows: (1) We expect that teachers should get students to drill their combinatoric reason in solving narrative problems, as the indicators of combinatoric reason may assist them in finding solutions; (2) The students' worksheets based on combinatoric reason is recommended that mathematics teachers use it in learning, because it trains students to use combinatoric reason. As a result, students are , being flexible and logical in determining strategies, as well as being systematic in solving problems. As a result, elementary school students' Problem-solving and higher order thinking abilities become better; dan (3) The students' worksheets based on combinatoric reason are only at elementary school level, so further research can be developed at every level of education. So, every student at any level of education can train and improve combinatoric reason through students' worksheets.

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