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The Development of Mathematica Handout based on Local Wisdom Nuanced for Secondary Students

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ABSTRACT

This study aims to develop a mathematics handout based on local wisdom nuance to increase secondary students' mathematical problem-solving skills. This study used four phases of developmental research including investigation, design, realization, and test, evaluation, and revision. The characteristics of local wisdom were acquired within the design or context in the mathematics handout to develop secondary student's problem-solving skills. Results showed that the students followed Polya's stages of problem-solving in developing the handout and got the maximum score. Another finding revealed that students gave a positive response on the handout developed. This study considered the developed handout as valid, practical, and effective. Future studies are encouraged to develop learning materials that have a guide to accomplish phases of problem-solving skills and apply them to solving some mathematical problems.

Keywords: *handout, local wisdom, problem-solving skills*

1. Introduction

Developing learning materials for teaching a certain mathematics topic is currently important due to the fact that learning materials are considered important in building student's mathematics problem-solving skills [1]. Studies on mathematical problem-solving have been an intensive experts' discussion mainly dealing with essential questions regarding the teaching and learning of mathematics [2]. To reinvent mathematics through its nature, teachers have to adapt to how their students generate rationales and help them build up their thought [3]. Therefore, in order to have a broader insight on the needs of increasing student's problem-solving skills, an effective handout is essential to be developed [2][4][5].

Handout consists of two components namely identity that contains the information of the handout and materials that explain the main topic discussion and exercise [6]. Previous mathematics handout is only based on problem-based and guided inquiry learning approaches [6][7][8]. This implies that handouts have been developed by different teaching approach. The use of effective mathematics handout will ease teachers to teach mathematics material and can motivate students to follow the learning process, including but not limited to learning the mathematical knowledge and the value of local wisdom [9][10]. Regulation of the Minister of Education and Culture of the Republic of Indonesia, learning materials should be able to motivate students to learn the local, national, or international values and correspond to the

characteristics taught. The learning materials comprising local contents can make students comprehend the local values in their areas, such as the values of Javanese community in Indonesia. Unfortunately, many learning materials distributed in number of schools in Indonesia lack of local wisdom exposure and less original content [11]. This local content is rarely found in some mathematics textbooks even though mathematics has always been part of human culture [12][13]. Hence, the learning materials should be developed based on local contents where the school is located in the region in Indonesia. This learning material will be the complementary instrument that increases the student's mathematical problem-solving skills along with the understanding of local wisdom content permeated in various problems [14][15][16]. This handout also gives an effectual explanation of the main point of the topic that will not make the students bored, especially when they learn about the social arithmetic topic.

The present study chose social arithmetic topic students have obstacles in solving social arithmetic problems according to the early investigation undertaken by the researchers. The students thought that this topic is full of formulas and they must memorize them. However, when they memorized all of them and found the developed problems, they could not use the formulas that had been given by the teacher to solve the problems. It happened because they just memorized the formulas without getting the main point of this topic material. Thus, they need a learning assistance to acquire their problem-solving skills such as mathematics handout that can give them the explanation of the topic and some problems with local wisdom nuance [17] [12]. Indonesia's local wisdom will make the learning activity more fun and tangible as the values have been in the student's surrounding environment for longer times [18]. So, providing an effective mathematics module with the exaggeration of local contents is important to enhance student's problem-solving skills [19][20].

Regarding problem-solving skills used in mathematics, the seminal contribution of Polya highlights four steps namely understanding the problem, devising a plan, carrying out the plan, and looking back. Even though this model originates in mathematics [21][22]. other frameworks have specific foci. For instance, Helenius model consists of five steps covering generating a problem, specifying a problem, finding possible ways to solve the problem, testing these ways, and putting the solution into a larger context [3]. Kasik et al. also contribute to arrange steps in problem-solving [23] [24]. They focus on the following general step encompassing identifying a problem, defining the problem, generating solutions, evaluating/choosing solutions, and assessing the outcome.

All the aformentioned steps of problem-solving have been a reference for the researchers to evaluate how the mathematics handout based on local wisdom nuance can enhance students' mathematics problem-solving skills. The research question formulated in the present study is "How can the mathematics handout with local wisdom nuance increase the problem-solving skill of secondary school students in social arithmetic topic?

2. Method

This study used a research and development research design to devise mathematics handout based on local wisdom. The present study used Plomps' development model that includes five steps namely (1) preliminary investigation, (2) design, (3) realization, (4) test, evaluation, and revision, and (5) implementation [25]. However, in this case, the researchers only did up to the 4th phase. The subjects of this study were two students of junior high school who could not show problem-solving skills to solve some mathematics problems. Students' involvement as a subject was to know the level of validity, practicality, and effectiveness of this handout so that it included good criteria. The instruments were the validation sheet to obtain data on the validity of handouts, pre-test, post-test, and questionnaire to know the students' response.

There were two types of indicators namely indicators of local wisdom nuance and indicators of proper handout.

I. Indicators of local wisdom nuance on the mathematics handout included:
   a. Handout design that was about local wisdom in Indonesia, especially in Java Island.
   b. The mathematical problems given including Javanese tradition or local wisdom.

II. Indicators of the proper mathematics handout included:
   a. Validation, the experts' evaluation showed that the mathematical handout based on local wisdom nuance was suitable for use in learning mathematics.
   b. Practicality, the activities undertaken by students must show the problem-solving process by Polya, such as:
      1. understanding the problem
      2. devising a plan
      3. carrying out the plan, and
      4. looking back.
   c. Effectiveness, the students' responses revealed in the questionnaire showed positive responses and the students' exercise scores were more than 80.

3. Result and Discussion

3.1 Preliminary Investigation

In this phase, the researchers analyzed the curriculum, students, and the materials. The preliminary stage was conducted on two students who currently studied in junior high school and had a difficulty in problem-solving process. They were asked to answer the mathematics questions from researcher's interview. They used the K-13 curriculum that gave priority in students' activity and the teacher only became the facilitator who helped the students when they felt difficult to solve the problems. Based on the results of the interview, the students had a problem to memorize the formula of the arithmetic topic. Thus, the researchers chose the social arithmetic topic

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3.2 Design

In this phase, the researchers designed the product including the design of mathematics handout along with the problems so that it could be based on the local wisdom nuance. Then, the researchers designed the instruments used to evaluate the mathematics handout including the validation sheet of material and media, questionnaire for students, and the pre-test. For post-test, the researchers used the problems in the exercise stated in the end of the handout.

3.3 Realization

This handout was designed in simple language and complemented by examples of real problems about social arithmetic in student life that contained the context of Javanese local wisdom. Handout was considered good if it had been properly applied in learning, with evidence that it did not cause problems when tested in a limited manner and got positive responses from students. The developed handout had been adapted to the basic elements of making a handout including the identity and material. Figure 1 conveys a part of the handout design showing the nuance of local wisdom.

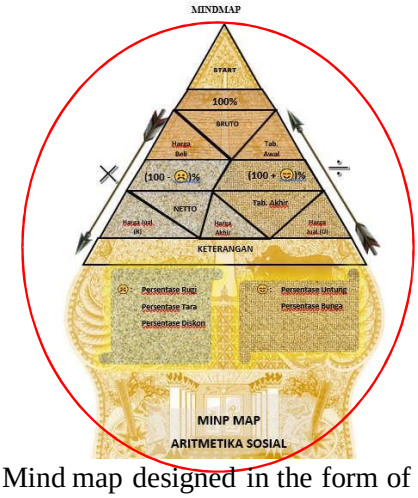

Figure 1. Mind map designed in the form of a *gunungan* corresponding the criteria of local wisdom nuance

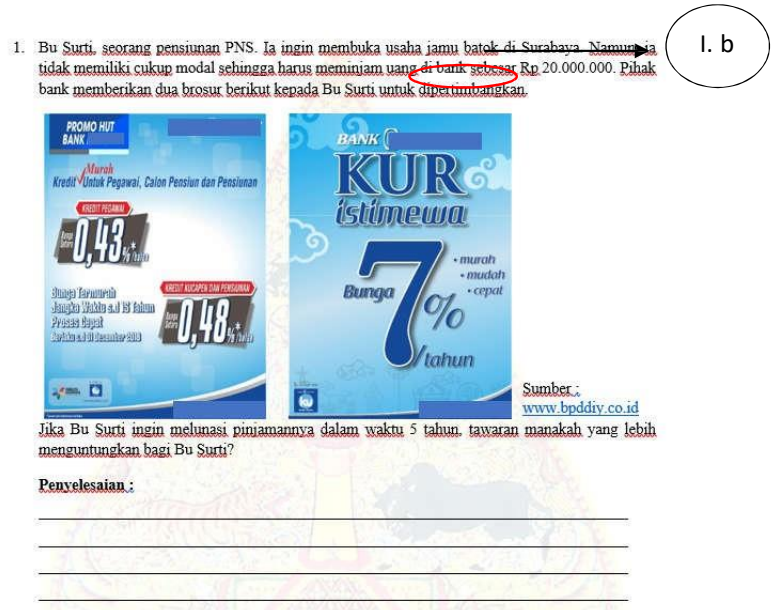

Figure 2. Problems with the context of local wisdom namely *jamu batok* [13], as one of Javanese local wisdoms

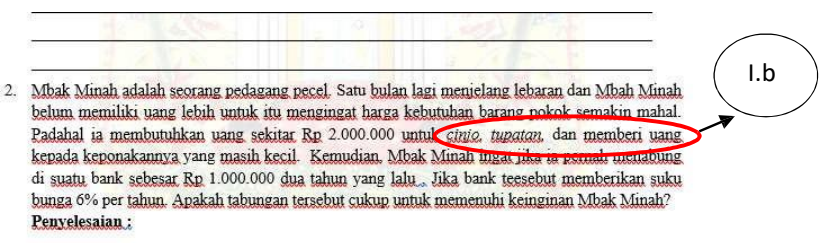

Figure 3 Context of Javanese local wisdom in practicing questions namely cinjo, tupatan, and the tradition of giving money as a form of gratitude

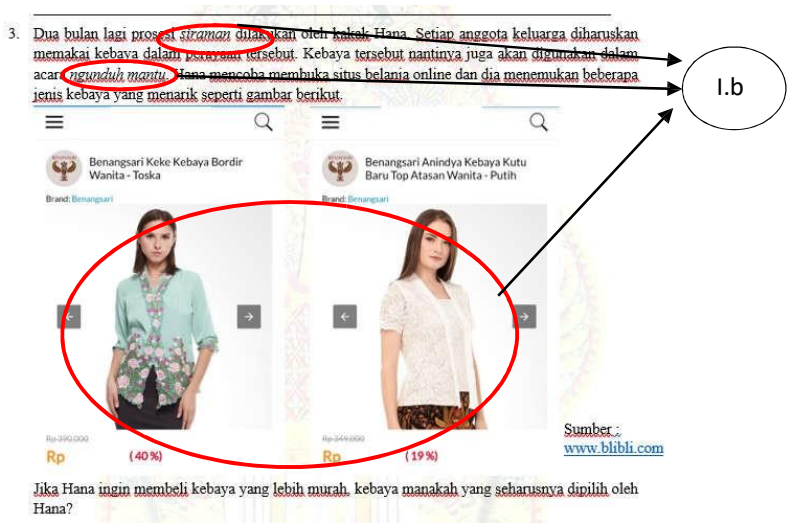

Figure 4. Context of Javanese local wisdom namely *siraman* and *ngunduh mantu* to welcome the arrival of new families, as well as pictures of *kebaya* as an icon of Javanese local wisdom.

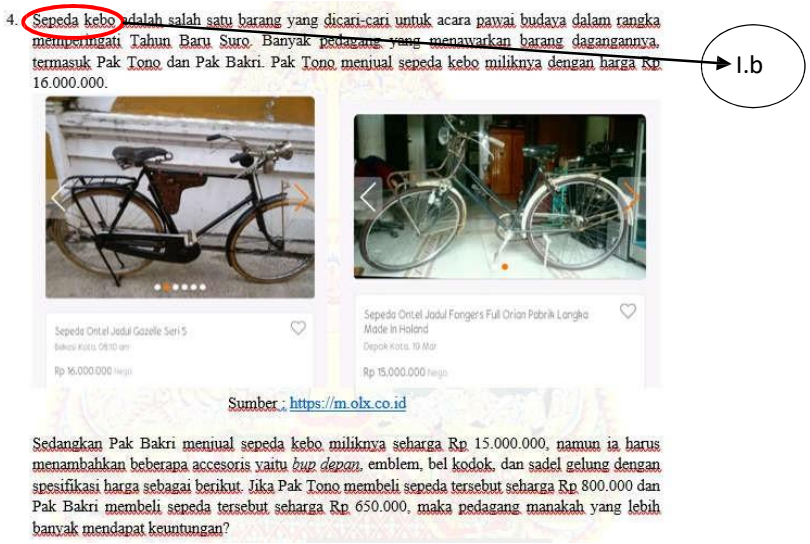

Figure 5. Context of Javanese local wisdom namely *Kebo* bicycle as a local wisdom invented in colonial time

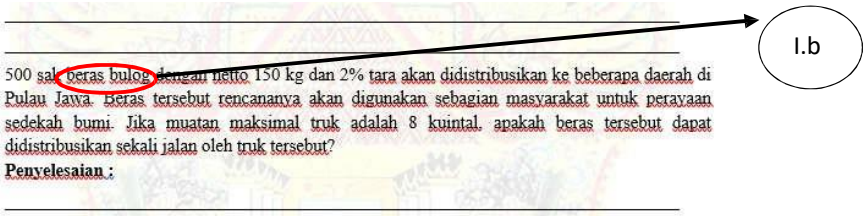

Figure 6. local wisdom of Bulog rice a process of distributing citizen crops throughout Indonesia

Based on the above explanations, the mathematical handout was nuanced with Javanese local wisdom in terms of its design and context of the

problems presented, following the indicators of the local wisdom nuanced in the mathematics handout. At this stage, the developed handout was called prototype 1. Meanwhile, prototype 1 was given to some expert validators so that it could be known as the validity of content, construct, and language. The validation score obtained from the validator showed that the developed handout was included in the valid category with several revisions. Furthermore, at the same time, the researchers asked a revision including correction of mistyping, the use of capital letters, more effective sentence writing, and clear pictures. The result was used to revise prototype 1 and produced prototype 2. Thus, mathematics handout based on local wisdom nuanced had met the indicators of validity proposed in the study.

Afterwards, the handout was tested under a limited basis with two junior high school students in Surabaya. Limited basis trial aimed to determine the students' response to the use of handout in a form of revealing their opinions on the preparation of handout as well as the validity of handout viewed from the observation of learning activities. Furthermore, the researchers performed analysis prototype 2 evaluation with small group subjects. It aimed to obtain an overview of the students' various responses to the learning activities that were applied by the mathematics handout based on local wisdom nuance. Based on the results of the researchers' observations and the results of the students' work, it showed how the problem-solving process could be done. According to Polya, the problem-solving steps included (1) understanding the problem, (2) devising a plan, (3) carrying out the plan, and (4) looking back.

Figure 7 shows some sample results of student works.

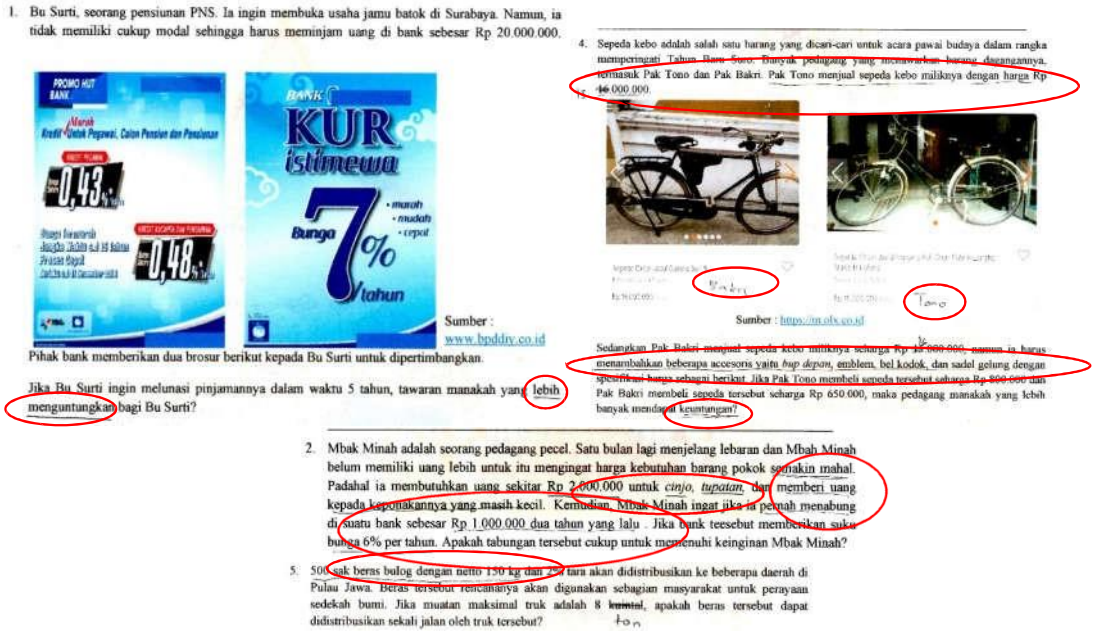

Figure 7. Process in understanding problems conveyed by students in the first stage of the problem-solving process (II. b. 1)

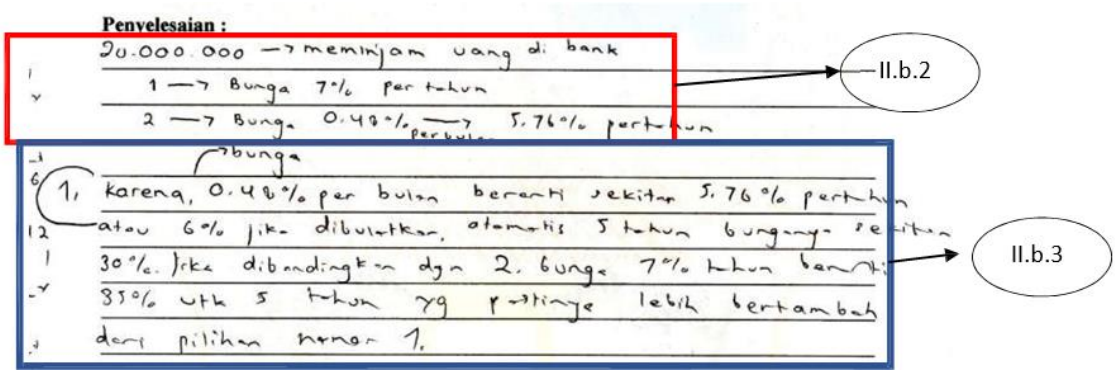

Figure 8. shows the detail of the solution solved by students

For the first problem, the students showed the problem-solving steps by Polya. Figure 8 portrays that the students showed the first step by underlining the point of the problem to comprehend the problem that should be solved (II. b.1). The students wrote the plan such that they identified the main problem and developed the next problem (II.b.2). They compared the previous information and carrying out the plan to get the conclusion (II. b. 3)

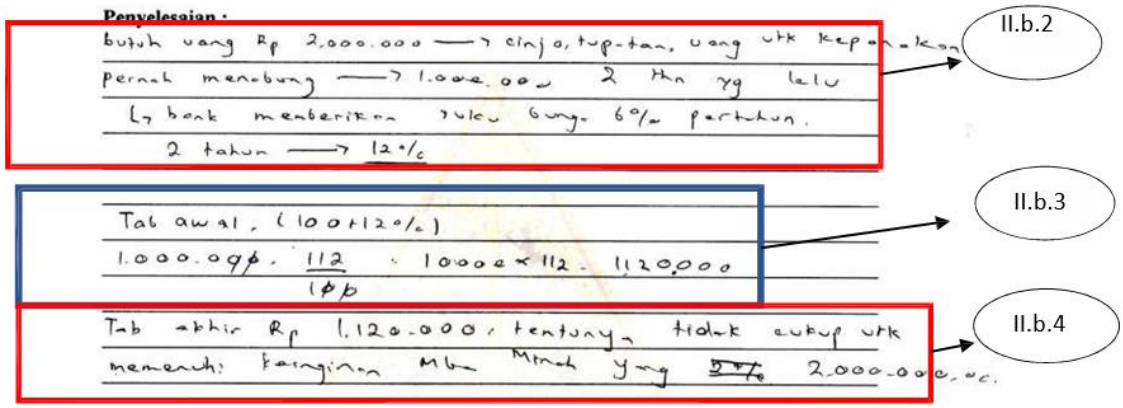

Figure 9. Students' answers for the first problem

In the second problem, the students understood the problem by underlining the main point of the problem (II. b. 1). Then, they came to devising a plan (II . b. 2) to get the interest rate. Using the interest rate, they could solve the problem by a formula given by the researchers in the mind map section, so they carried out the plan (II.b.3) to get the answer. Using this answer, they made a decision to solve the problem by rechecking the first information given and the final result (II.b.4).

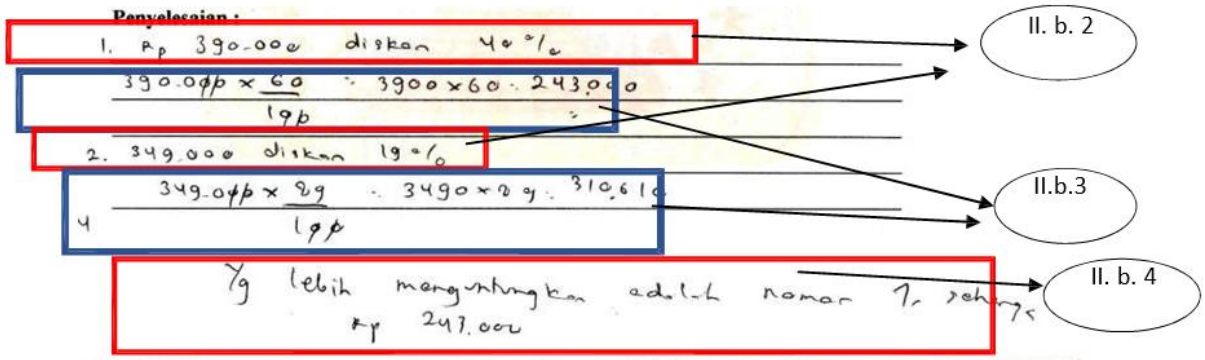

Figure 10. Student answer for the third number

In the third problem, students got the point of this topic. To understand the problem, students scanned the questions (II.b.1) and wrote the discount to devise which formula was used to solve this problem (II.b.2). Then, they used the chosen formula to get the result (II.b.3). Afterwards, the students rechecked and compared the first and the second result to make a decision (II.b.4)

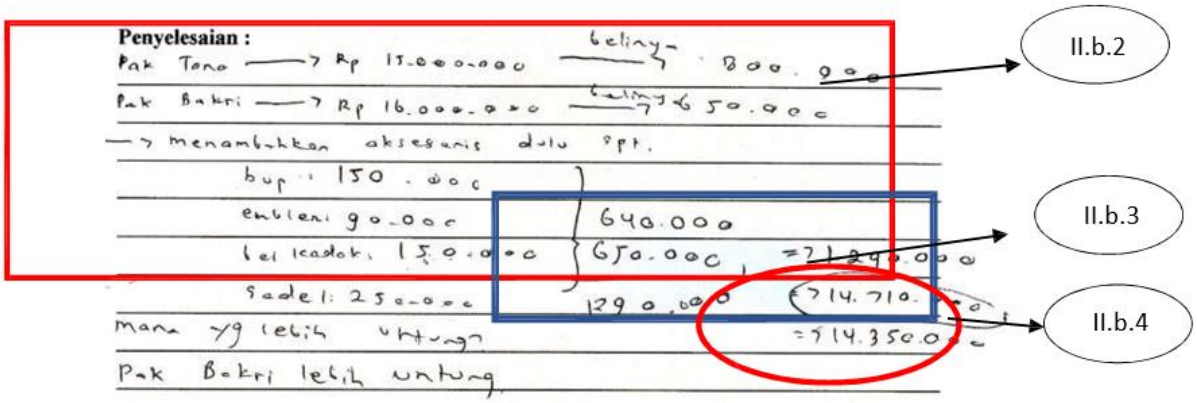

Figure 11. Students' answer for the fourth problem

In the fourth problem, the students understood the problem by scanning and underlining the main point (II.b.1) and wrote the main point to devise a plan (II.b.2). Then, students calculated the result by the plan (II.b.3). After that, they compared the result to make a decision (II.b.4).

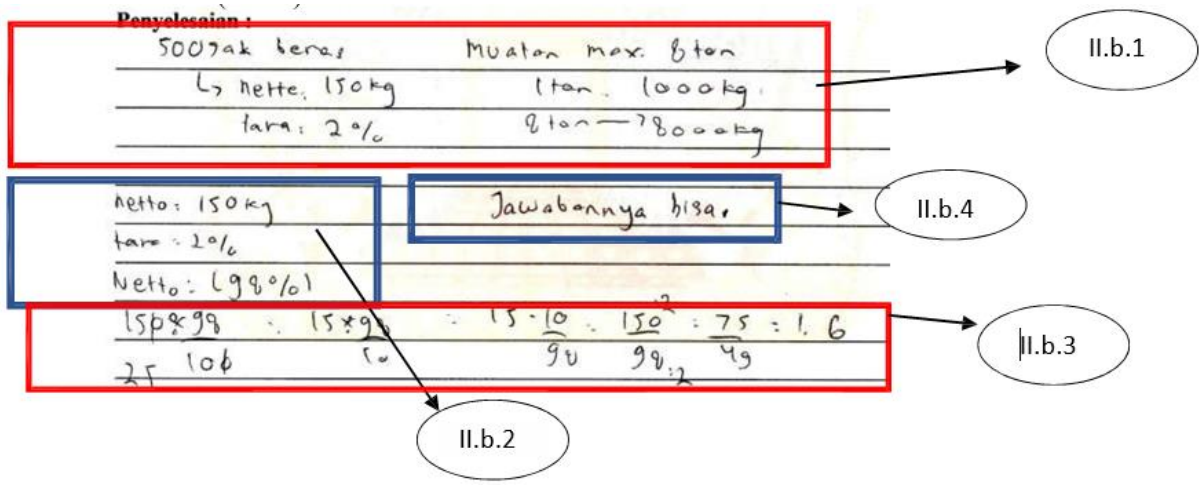

Figure 12. Students' answer for the fifth problem

In the last problem, the students showed all problem-solving steps by Polya. Students understood the problems by underlining and writing the main point (II.b.1). Then, students devised a plan by writing the components that could be applied in the formula (II.b.2) and used the formula to calculating the result (II.b.3). After that, the students rechecked to make a decision (II.b.4). However, the students had the wrong answer because of carelessness when calculating the number. By observing and interviewing the students, the students rechecked the result but they said that errors to remember cancelation in the division case were not allowed.

Furthermore, teaching material was said to be practical according to experts and practitioners. The figures above showed that the students had carried out the stages of problem-solving by Polya, where the inspection stage was returned with the process of rechecking the results of the process [26][27]. Hence, this handout could improve students' problem-solving skills including the knowledge, characteristics, and process of

problem-solving [15] [17] [22] [28]. From these problems, students solved problems according to the steps expected by the researchers. Learning problem-solving needed to be done through activities such as sharing experiences, discussing each other, and implementing problem-solving strategies in the right place [29][30][24]. Learning activities using the handout in a small group got positive responses from the students [21][1] [31]. Thus, it could be concluded that the developed handout met the aspects of practice.

From the problems solved by students, a value of 9.5 was obtained. Students did not get a perfect score due to a calculation error in solving question number 5. Besides, based on the student response questionnaire, the results showed that the appearance aspects of 3.17, material aspects of 3.4, and language aspects of 3. It could be said that the handout was in a good quality. Furthermore, analysis of students' responses from the interview showed a positive response. These results indicated that the students' responses were in the positive category. Henceforth, it could be concluded that the developed mathematics handout met the aspect of effectiveness.

4. Conclusions

The mathematics handout based on local wisdom nuance meets the aspects of validity, practicality, and effectiveness. The validity is indicated by the experts' judgments which result in a good category and can be implemented. The practicality is demonstrated by the results of the implementation of learning using mathematics handout based on local wisdom nuance. The effectiveness of this handout can be shown by the score obtained from the students along with their positive responses on the handout developed.

Future studies are encouraged to develop learning materials that have a guide to do phases of problem-solving process and apply the way to solve some problems in mathematics.

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