Learning materials through saving water

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Abstract. The demands of the 21st century require students to be reliable communicators, creators, critical thinkers, and collaborators in solving problems through student involvement in learning. This research aims to explore the student’s mathematical reasoning abilities and problem-solving skills in mathematics using the cost of payments for water use as context. The subject of this research was eight-grade students of SMPN 19 Palembang. This research uses the method of design research with validation studies type which three stages, namely Preparing for the experiment; The design experiment consists of two cycles (Pilot Experiment and Teaching Experiment); and Retrospective analysis. The study results show that learning using receipts of water payments as a medium for saving water can help students develop reasoning and problem-solving skills in mathematics learning. However, students not accustomed to using information obtained from the analysis to solve the given problem. Students tend to provide non-mathematical arguments on each issue that require students to provide discussions about the learning material, especially data presentation.

1. Introduction
Indonesia's efforts to face the 21st-century education challenges, one of them by perfecting the curriculum used previously. The Deputy Minister of Education and Culture of Indonesia said the previous curriculum was considered too difficult for students in terms of cognitive aspects and lack of character development so that in the 2013 curriculum all learning was required to have a contribution to the formation of attitudes, skills, and knowledge [1]. Reaffirmed the Minister of Education and Culture Regulation Number 21 of 2016 concerning the content standards of primary and secondary education that the content standards adjusted to national education goals in the realm of spiritual attitudes and social attitudes, knowledge, and skills [2].

The ability to reading, writing, and counting does not provide full support students to compete with the global community. In the 21st century, students required to be reliable communicators, creators, critical thinkers, and collaborators to solve global issues through overall student involvement in learning to build 21st-century skills, gain meaningful and memorable knowledge, and actively apply learning outcomes to useful things [3,4].

Changes that occur in 21st-century learning include learning achievement not only concerned with the goals of achievement and evaluation of results but understanding the meaning of learning experiences and evaluating learning outcomes are qualitative; Another change is conventional learning into collaborative learning [5]. To provide such learning, researchers carry out learning with Lesson Study for Learning Community (LSLC).

LSLC is a system of activities and philosophies implemented jointly with the learning community and requires cooperative cooperation to develop teacher professionalism [5-8]. In addition to supporting the demands of learning in the 21st century, essential points from the definition of LSLC that emphasize
the development of teacher professionalism can be a highlight. Supported by several researchers who stated teacher professionalism could have a positive impact on work motivation and teacher performance [9,10]. Teachers expected to contribute to knowledge by providing innovation through involvement in collaborative research [11].

Collaborative learning, the formation of a relationship of mutual listening and mutual learning, and being open to the public are characteristic of LSLC [5,6]. LSLC helps teachers better understand how students think and focus on how students learn, not on how teachers teach and demonstrate a significant increase in student competence, attitudes, and psychomotor [12,13]. LSLC also gives a better influence on student learning outcomes [14]. Based on the description given related to LSLC, researchers believe that LSLC can meet the demands of learning in the 21st century. Based on the demands made by the Deputy Minister of Education and Culture of Indonesia, Minister of Education and Culture Regulation Number 21 of 2016 concerning content standards for primary and secondary education, and demands for learning and skills in the 21st-century researchers believe that LSLC can meet the standards of learning demands in the 21st century because during the implementation process it contributes to the formation of attitudes, knowledge, and skills only for students but also for educators.

In addition to focusing on the development in aspects of attitude, knowledge, and skills based on the Republic of Indonesia's Ministry of Education and Culture Regulation Number 65 of 2013 requires that the curriculum relates to each other with everyday life [15]. One approach that meets the regulation above is the Indonesian Realistic Mathematics Education or better known as Pendidikan Matematika Realistik Indonesia (PMRI).

PMRI is one solution that teachers can choose to make students interested in and understand mathematics. Supported by the opinion of Zulkardi and Putri, who said that PMRI is a solution to improve student’s interests, attitudes, and learning outcomes towards mathematics [16]. The ultimate goal of learning with this approach is to help students understand mathematical concepts from abstract to real by linking things in everyday life as learning contexts, so students find themselves the concept of material from the context given as a reference in learning, context is used as a source of application mathematics so that the understanding obtained becomes more useful [17,18]. Students do not learn from general formulas [19,20]. The context must be in every activity that uses the PMRI approach [21]. The use of context in learning is one that teachers can do to help students understand concepts, so concepts used by students are not believed to be finished products without learning their origin and how to reconstruct them [22]. Another reason researcher use PMRI as an approach in learning is that Indonesian students have difficulty completing problems that make context a reference in understanding the material’s concept to be taught [23]. PMRI is based on things that have been experienced by students, emphasizes skills in the process of working on mathematics, discussion, and collaboration, as well as giving arguments with classmates to find out for themselves how to use mathematics in solving problems both individually and in groups [24].

The context that the researchers used in this study are saving water using the payment receipt of the Regional Water Company as a supporting tool in learning to be implemented. Some researchers who have used the context of payment focus on discovering concepts of learning materials such as functions and systems of linear equations (both one variable and two variables) [25-27]. What distinguishes this study from previous studies is that students expected to understand the reasons for the importance of saving water before calculating the amount of water that can use to obtain minimal payment costs. The researcher's discussion focuses on how students apply the knowledge they have gained to their daily lives through the media of water payment structures. Based on previous studies, learning with PMRI and LSLC can help students develop reasoning and problem-solving skills in learning mathematic [28,29]. This study aims to explore the student’s mathematical reasoning abilities and problem-solving skills in mathematics using water payment as context.

2. Method
This research conducted in one of the junior high schools in Palembang, namely SMPN 19. The subject of the research was the students of class VIII.
The research method uses a design research type validation study. The stages in this research are preparing for the experiment; The design experiment consists of two cycles; the first cycle is called Pilot experiment and the second cycle is called Teaching experiment; and the final stage is The retrospective analysis [30-32].

In the first stage of design research is preparing for the experiment; in the form of a literature review, examining students’ initial abilities, developing and designing learning materials, designing HLT and making predictions of student answers, choosing a model teacher, and observing the class by looking at learning methods and conducting interviews with the teacher model [19]. Research preparation begins with reviewing the literature from journals, books, and other reading sources about material that supports the learning process to carried out. Followed by a Hypothetical Learning Trajectory (HLT) design and predicting student’s answers to the student worksheet that will give. Researchers and teachers validate student worksheets and predict student’s answers together. This is in line with one of the characteristics of LSLC that allows teachers to develop professionalism and knowledge gained with their communities [5,6]. In LSLC the stages are in the form of an informative plan preparation where the teachers discuss each other and explore the material to taught called plan [6].

The first cycle in the design experiment stage starts with a pilot experiment. Pilot Experiment conducted to try out HLT that had been designed for students in small groups to improve the quality of HLT that had made so that the implementation of planned learning was better [33]. When testing HLT simultaneously, the researcher also observes learning, in LSLC this stage called do [6]. Students who were the study subjects were two groups consisting of four people, each in a mixed group of male and female students [5,6]. Before proceeding to the second cycle, researchers improved the learning instruments that tested in the first cycle with the aim that the experiments in the second cycle would be better. Teaching Experiment tested in a larger class with 32 students taking part in learning activities.

In the retrospective analysis, all the data gathered in the teaching experiment will be analyzed whether the data is appropriate or not following the HLT that has been designed [19]. The retrospective analysis results were used as the subject of discussion to obtain better conclusions or HLT. The process of discussion in finding and expressing problems during learning activities in LSLC called see [6].

Data collection techniques with interviews, classroom observations, video and photo documentation, and notes during the field [19]. The data obtained are then analyzed with the supervisor to increase the reliability and validity of the research that has carried out.

This research produces a learning trajectory in the form of a series of activities with the aim of using the knowledge they have acquired during learning to minimize the use of clean water in their homes and understand the importance of clean water in daily life.

3. Result and Discussion
Based on the results of validation with the teacher in student worksheets, several things must change before proceeding to the next stage of research. Activity 1 consists of five questions and given information sheets relating to the questions to work on.

**Indonesia** is one of the most populous countries in the world and a country with the fifth-largest renewable water resource in the world. In 2019, several regions in Indonesia experiencing water crises include Bali, Cirebon, South Sulawesi, Jepara, Sragen, and other areas on the islands of Java and Sumatra. The clean water crisis is caused by several factors including climate change due to extreme weather changes, water pollution, excessive use of water, inefficient agricultural activities, and increasing population.

*Figure 1. One of the paragraphs in the information sheet was corrected on the teacher's advice, namely adding the name of the country that was the focus of the discussion*

Figure 1 shows one of the paragraphs on the information sheet before working on activity 1. Based on the results of validation with the teacher, one teacher suggested adding the name of the country that was the focus of the discussion. The researcher accepts the teacher's suggestion by adding the name of
the country to the paragraph in question. Another suggestion for information sheets that will use to complete activity 1 is to add definitions of words that are difficult for students to understand. Adding a definition of potential capacity and effective capacity, so students understand the definition of the word without asking the teacher to explain it when learning done. Figure 1 and Figure 2 show the improvements in Activity 1.

Activity 2 consisted of five questions. Before carrying out the learning activity 2 the model teacher was asked to remind students to bring the receipt of water payments and the size of the water storage in their home. Based on the validation results with the teacher, there is nothing that needs to change in activity 2. The teacher only recommends that the researcher add a formula for calculating the volume of water storage to make it easier for students to do the calculation. However, the researcher chooses only to give questions that help students remember the formula by themselves. Not much has changed before proceeding to the pilot experiment stage. One of the teachers asked the researcher to reduce the numbers in the diagram because the teacher assumed that students would not be able to answer if using these numbers, the researcher chose not to convert the numbers into easier numbers because the data used was real data from one of the research bodies in Indonesia. Researchers hope students are familiar with calculations that use real data.

In cycle 1 for activity 1, the first question aims to analyze student’s understanding of the data presentation (the relationship between the data and how it presented). Based on the analysis of the student answer sheets, it can conclude that all students understand the relationship between the data and how it presented as an easy way to read or view the data presented on the diagram chosen without regard to the type of data.

**Figure 2.** One of the student’s answers to problem number 1, students give a non-mathematical reason for the relationship between the data and how it presented (the same as one of the predictions of the teacher’s and researcher’s answers)

Figure 2 states the student’s answers when asked the reason why the bar charts used on the information sheet, 50% of students state if using other diagrams (especially line diagrams) it will be difficult to distinguish potential capacity data and effective capacity. The other 50% of students have almost the same answer, that is, bar charts are easier to understand or clarify than other diagrams (lines). In question number 1, even though the student’s answers were in the predictions discussed by the teacher and researcher, none of the students gave reasons with mathematical arguments for solving the problems.

In the second, third, and fifth questions aimed at analyzing students' ability to interpret information from the data presented, 50% of students can interpret information well (pay attention to the information sheet given to answer the question carefully). Student error in answering these questions is that 50% of students do not pay attention to the questions given so that the answer is limited to writing information (based on the information sheet provided) on the answer sheet provided without analyzing its usefulness on the problem solved.

**Figure 3.** One of the answers of students who write down information from the information sheets provided without regard to the meaning of the questions
Figure 3 states the student’s answers when asked about the effect of the availability of clean water and the number of water companies based on the information sheet. 50% of students answered only by mentioning the number of companies they got from reading information sheets. The rest stated that the number of companies influenced the supply of clean water by giving reasons outside the information sheets (the more water companies, the more water availability increased). Students do not give answers according to the expectations of researchers and teachers; none of them can use the data on the information sheet to provide arguments.

In the fourth question, students make predictions about the potential capacity of clean water in 2020 based on the conclusions of the data presented in previous years. When learning, all students have difficulty answering this problem, so the model teacher gives instructions so students can solve the problem. Some students ask, "How can we predict only based on the data presented?". Based on the question’s students submit during the learning process, the researcher concludes that students are not familiar with the questions whose answers cannot be obtained directly from the information they analyze. In the fourth question, the teacher's prediction states that the student is unable to solve the problem misses, even though students have difficulty solving the fourth problem but can complete the given problem.

Activity 2 consists of five questions; the first question is writing information obtained from the water receipt that will be analyzed per group. The second problem uses information obtained from the receipt to determine the smallest cost of the water payment used. In the second problem, students have difficulty in sorting out information that will be used in the calculation because this is because students not accustomed to seeing information on the payment receipt. The third question is about the size of the water storage in each student's house, which will be used to calculate the capacity in one filling of water in the fourth problem. Students again have difficulty in completing the fifth problem, which is determining every how many days students have to fill water based on the capacity and the smallest payment costs. Initially, the students only counted how much water was filled and forgot the focus of the question asking how many times the water refilled. However, after being given instructions, the students could solve the problem in the student worksheet well.

After the pilot experiment, some changes made before proceeding to the teaching experiment. The changes made include re-correcting the correct spelling of student worksheet according to the advice of the supervisor, in activity 1 the fifth question was abolished because after testing it turned out that the desired goal had been achieved in the second and third questions, in activity 2 the third and fourth questions were made one question according to students' suggestions because the questions are related to each other.

Improved student worksheets were used in the second cycle and tested on 32 students. The results of the analysis of student answers can see in Table 1 and Table 2.

| Question to- | Students Who Provide Answers (%) |
|-------------|----------------------------------|
| Give a mathematical argument | 1 | 28 |
| Analyze information well | 2 | 28 |
| Analyze information well | 3 | 100 |
| Use the results of information analysis to solve problems | 4 | 34 |

Table 1 shows that 72% of students are unable to provide mathematical arguments related to data and the way they presented in the first problem, for the second problem only 15% of students give an argument based on the analysis on the information sheet, for the third problem 37.5% students provide an argument based on the information sheet with copy one of the points in the paragraph. Only 34% of students can use the results of the analysis on the information sheet to predict the potential capacity of clean water availability by 2020.
Table 2. Analysis of student answers to activity 2.

| Question to Students Who Provide Answers (%) |
|---------------------------------------------|
| The analysis results are following the information provided on the payment receipt | 1 | 75 |
| Use the results of information analysis to solve problems | 2 | 21 |
| Use the results of information analysis to solve problems | 5 | 43 |

Table 2 shows that in analyzing information 25% of students did not provide the results of the analysis based on the information contained in the payment receipt, 79% of the students only focused on calculating the cost of water payment per m³ and did not discuss the cost or the minimum amount of water they could obtain from the information analysis on previous questions, and 57% of students could not use the information in questions 2 and question 4 to solve question 5. The error that occurred in solving question 5 was 43% of students who solved the problem focusing on the amount of water used in the payment receipt analyzed.

Based on the analysis of student answers during the implementation of learning activities, the use of payment receipts can help students understand the learning material provided. Students can understand the concept of material in the one-variable linear equation indirectly through learning activities. However, in this study, it does not focus on understanding concepts like previous studies [25-27].

From activity 1, it is clear that students cannot provide mathematical arguments about the relationship of data and how they are presented, students are not accustomed to interpreting data from diagrams, and the most of students do not understand how to predict data that will appear based on data that has been presented. From Activity 2, it can be concluded that students have no difficulty analyzing information from the water payment receipt as media used. However, students are unable to use the information they have analyzed for calculations.

Based on the analysis of student answers and interviews it can be concluded that although the material is given has been studied by students in elementary and junior high schools (class VII), students are not familiar with the questions that trigger reasoning and provide arguments, students are not accustomed to utilizing the knowledge they have gained in things around (limited only to questions in the textbook).

HLT that designed was following the results of the learning activities that tested. However, there were small improvements related to the instrument to make it easier for students to understand the questions well. LSLC which emphasizes collaboration and students’ way of thinking is fulfilled by students’ attitudes that actively learn from one another as an effort to solve the problems given [5,6]. Students can also understand the learning material that has been given by making water payment receipts as a medium, in line with PMRI, which emphasizes connecting what students can imagine a context in learning [14,15].

4. Conclusion
More than 60% of students analyze information thoroughly, but only 32% of students can use information that has analyzed to solve the problems given. No one student understood the relationship between the data and how it presented during cycle 1 and cycle 2. Students only focused on the data, and 61% of students did not provide mathematical arguments related to the material. Saving water with payment receipt as media can help students understand mathematics learning, especially in developing mathematical reasoning and problem-solving abilities. Learning with PMRI and LSLC can help students develop and improve mathematical reasoning and problem-solving skills. LSLC and PMRI can meet the demands of learning in the 21st century by contributing not only to knowledge but also to attitudes and skills.

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