INVESTIGATING THE ACT OF DESIGN IN DISCHARGE CONCEPT USING PMRI

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Abstract

The goal of this research is to investigate the act of design in discharge concept using Pendidikan Matematika Realistik Indonesia (PMRI) approach with Lapindo's Mud phenomenon as a context. Design research was chosen as method used in this research that consist of three phases, namely preparing for the experiment, teaching experiment, and retrospective analysis. Based on the result of investigating from findings and the data obtained in this research, it can be concluded that the use of instructional design using PMRI can support students' understanding in learning the concept of discharge. Observing activities Lapindo mud photos, watching videos Lapindo mud, observing miniature discharge of Lapindo mud, volume of water and time of data collection are needed, and finding discharge of Lapindo mud are conducted in this research.

Keywords: discharge, design research, PMRI

Abstrak

Tujuan penelitian ini adalah untuk menginvestigasi pergerakan desain pembelajaran dalam konsep debit menggunakan pendekatan Pendidikan Matematika Realistik Indonesia (PMRI) dengan fenomena Lumpur Lapindo sebagai konteks. Penelitian ini menggunakan metode penelitian *design research* yang terdiri dari tiga tahap yaitu persiapan untuk penelitian (*preparing for the experiment), teaching experiment*, dan *retrospective analysis*. Berdasarkan hasil investigasi dari temuan dan data yang diperoleh dalam penelitian ini, dapat disimpulkan bahwa desain pembelajaran debit menggunakan debit Lumpur Lapindo berdasarkan pendekatan PMRI dapat mendukung pemahaman siswa dalam pembelajaran konsep debit. Desain penelitian dilakukan dengan dengan melakukan aktivitas mengamati foto lumpur lapindo, mengamati video lumpur lapindo, mengamati miniatur debit lumpur lapindo, pendataan volum air dan waktu yang diperlukan, dan menemukan debit lumpur lapindo.

Kata kunci: debit, design research, PMRI

Debit is one of the concepts in mathematics that widely applied in everyday life. The real application of the discharge is the construction of embankments of water in reservoirs or rivers in Indonesia (Akuntono, 2013). If the discharge of water from the existing embankments in reservoirs or streams addressed, it can prevent flooding in the rainy season. Therefore, the discharge needs to be introduced to students early on. In Indonesia, students begin to learn about debit since they were in sixth grade of elementary school (SD) (Depdiknas, 2006).

Based on the observation that researchers have done, it is known that many elementary school students who have difficulties to understand the basic concepts of discharge. This is in line with the results of interviews with teachers of mathematics that the learning outcomes of students on the subject of discharge is lower than in other subjects. According to Rahmawati, F. (2011) the difficulty

of students in learning the discharge caused by a learning process that is still dominated by conventional methods, and teacher centered without any attempt to develop mathematical ideas' students through interaction or discussion.

Based on the problems mentioned before, we need an approach which engaging and meaningful to the students in learning the discharge so that the students are more motivated to learn and able to develop students' mathematical ideas through interaction or discussion. This learning is in line with the approach of Pendidikan Matematika Realistik Indonesia (PMRI). In PMRI, mathematics learning activities is presented as a process or human activity and not as a finished product. PMRI developed according to the context, cultural values, or natural phenomena that exist in Indonesia (Lestariningsih, Putri & Darmawijoyo, 2012; Zulkardi, 2002).

The researchers chose Lapindo mud, a natural phenomenon that occurs in Sidoarjo, as starting point in a learning activity because it constitutes the basic concepts of debit and measurement. Researchers provide alternative problems to students by designing and developing students' learning trajectories in the form of Lapindo mud as a context that is associated with the discharge concept using PMRI approach.

Learning activities using PMRI approach is based on the characteristics PMRI adopted from the characteristics of the RME approach. Treffers in Wijaya (2008) state that there are five characteristics of RME and in Indonesia become PMRI characteristics, namely: 1). *phenomenological exploration or the use of contexts*, 2). *using models and symbols for progressive mathematization*, 3). *using students' own construction and production*, 4). *interactivity*, *5).intertwining.*

The use of context in learning mathematics is one of references for the application of PMRI approach. In this research, the researchers chose a scientific context, the situation with regard to natural phenomenon and scientifically substance or related to mathematics itself. Lapindo mud is a natural phenomenon that can be used as the local and national context because these natural phenomenon has become a national problem that must be faced together by the Indonesian nation.

Sidoarjo mud or better known as the Lapindo mud disaster is the spreat events drilling mud at the site of Lapindo Brantas Inc. in Balongnongo, Renokenongo Village, Porong, Sidoarjo regency, East Java, since May 29, 2006. The hot mud phenomenon is the hot mud cause swept away the settlement areas, agricultures and industries in the three districts in the vicinity, as well as affect the economic activities in East Java.

The government has finally decided to throw away mud in Sidoarjo directly into the Porong River. The decision was made due to the increase in the volume of mud (discharge) of 50,000 cubic meters per day to 126 000 cubic meters per day, to provide additional time to seek termination of the mud and simultaneously prepare for handling other alternatives, such as the establishment of wetland the new coastal of Sidoarjo regency. Discharge of the Lapindo mud from year to year are constantly changing can be used as starting point meaningful learning activities in elementary mathematics,

especially on the subject of the discharge. This natural phenomenon will be attractive to students because of Lapindo mud has become part of the lives of residents in Sidoarjo.

Method

This research uses design research method. Gravemeijer and Cobb (2006) states that there are three stages in the implementation of design research, namely: 1).Preparing for the Experiment, 2). Teaching Experiment, 3). Retrospective Analysis

The subjects were students of class VI SDN Siwalan Panji, Sidoarjo. The research also involved a teacher who acts as a model for discharge concept. During the research, some data collection techniques such as video recording, student worksheets, and interviews and field notes were collected and analyzed to improve the HLT that has been designed.

Results and Discussion

In the preliminary design, learning activities and the development of students' learning trajectories was an important part to be observed and studied. Before designing learning activities, first, the researchers analyzed the path of learning and students' learning trajectories for discharge concept. Furthermore, learning trajectory, learning activities and learning contexts used in the discharge learning will be learning trajectory.

Figure 1 is a diagram illustrating students' learning path for learning discharge concept in 6th grade:

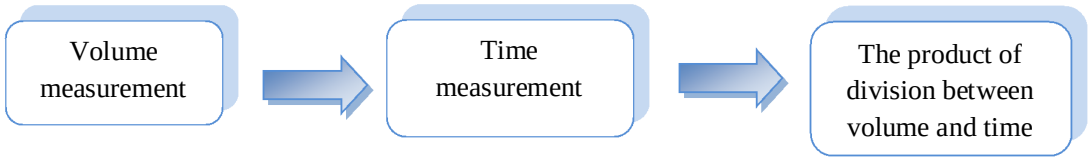


Figure 1. Learning path for Discharge concept

Pilot Experiment was conducted in class VI B SDN Siwalan Panji that consist of 50 students with 5 activities. Activities include: observing photo Lapindo mud, watching video Lapindo mud, observing miniature Lapindo mud, water volume data collection and time required, finding discharge of Lapindo mud. Pilot experiment aims to determine students' prior knowledge and collect data to adjust student learning trajectory before.

The first activity starts with the teacher to show some photos Lumpur Lapindo through using the LCD screen. Students pay attention to the photos displayed. Then the teacher gives the students questions about the photo. The second activity was begun by having students to watch the video of the Lapindo mud. Teachers provide some questions to stimulate students. Here are questions and answers of teachers and students in observing activity Lapindo mud video:

Teacher: Students, how is the direction of Lapindo mud in a video that you've seen?
Students: Bursts leads from the bottom and toward the top.
Teacher: Is the magnitude of the mud same for all locations?
Students: Different mom ....

Based on the questions asked by the teacher and the answers given by students, we can know that the students are able to analyze videos of Lapindo mud showed. The third activity was observing Lapindo mud. This activity is done by creating a miniature lapindo mud using syringes filled with water. Furthermore, under the syringes, there is a beaker glass as the place for water so it does not spill onto the floor or table. Then injecting faced upward and pressed so that the water gushing from the ground up. Students pay attention to the Lapindo mud miniature that shows that mud gushing from the bottom up. Then teachers stimulates to students with questions so the students know that the volume of water flowing through syringes per unit time can be determined. Here are conversation between teacher and students:

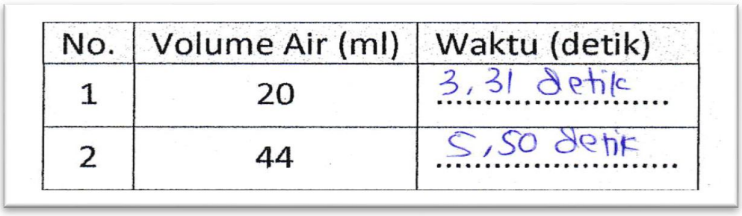
Teacher: Students, do you see the spray of water? can you determined the volume it occupies?
Students: ..... (Silence)
Teacher: How about the time is required. Can you measure it?
Students: Yes, using timer mom ...

Based on the students' answers, it can be seen that the students still do not know how to measure volume.

The fourth activity is about volume and the time required water. In this activity, students work in groups of 6 to 7 students. Each group received props in the form of a beaker glass that is already filled with water, syringes, duster, pens and worksheets that already contain instructions that are ready done with different questions for each group.

In the first problem, students are asked to fill syringes with water based on the worksheet. The first group was asked to take water as much as 10 ml and 48 ml, the second group was asked to take water as much as 20 ml and 44 ml, a third group was asked to take water as much as 36 ml and 30 ml, the fourth group was asked to take water as much as 28 ml and 40 ml, the fifth group asked to take water as much as 50 ml and 26 ml, the sixth group was asked to take water as much as 60 ml and 14 ml. Then the students in the group asked to determine the time required removing the water from the syringes by using a stopwatch.

Students answered the first problems with writing number after comma as shown Figure 2. Based on observations of researchers it is known that some of the students write the time by rounding the decimal point and there are some groups that just write numbers and ignore the numbers behind the stopwatch.



No.	Volume Air (ml)	Waktu (detik)
1	20	3,31 detik
2	44	5,50 detik

Figure 2. Students write time with numbers behind the comma

In the second problem, students were asked to fill the syringes with teh water. Then the students were asked to determine the volume of water that is emitted within the time specified in the worksheet. The first group was asked to determine the volume of water that is emitted within 20 seconds and 12 seconds. The second group asked to determine the volume of water that is emitted within 15 seconds and 25 seconds. The third group was asked to determine the volume of water that is emitted within 16 seconds and 14 seconds. The fourth group asked to determine the volume of water that is emitted within 30 seconds and 8 seconds, and the last, the fifth group asked to determine the volume of water that is emitted within 40 seconds and 8 seconds. The sixth group asked to determine the volume of water that is emitted within 24 seconds and 12 seconds.

Based on the results of field notes, the second problem is solved by reducing the number shown by the water before it is emitted by the volume of water after emitted during the time specified in the table. Some students look directly into the volume of water in a beaker glass. There are several students who write the number after comma and the other group wrote volumes of water using integer with rounding system.

In the fifth activity, finding discharge of Lapindo mud, students are asked to determine the product of division between the volume of water and time from the first activity until the fourth activity. Then the students were told that the product of division between the volume of water emitted with the time required is called discharge. Then students are asked to do the questions about the Lapindo mud and the problems that related to around the students.

Most of the students use the data obtained in the first activity until the fourth activity and writes the results in the form of fractions. There are some students who still cannot perform the operation indicated by the error calculating in dividing the volume of water with time as shown in figure 3.

No.	*Volume Air (ml)*	*Waktu (detik)*	$\frac{\textit{volume air}}{\textit{waktu}}$
1	10	1	5
2	48	6	8
3	44	20	2, 2
4	20	12	1,6

Figure 3. The error in calculating

Based on the results of the pilot experiment and discussion with the teacher in the classroom we can conclude several things related to improvement of students' learning trajectories. First, photos, videos, stopwatch, syringes, and beaker glass can be used as an effective media in learning activities

in discharge concept because students become more motivated and train students to perform the calculation of volume and time activity directly. Second, in the third activity of observing the Lapindo mud, students need to be introduced first with beaker glass and syringes and their functions because most of the students do not know how to measure the volume of water. From the fourth activity, students need to be told how to write time that shown in stopwacth when using rounding number or in the form of integer.

In the teaching experiment, teacher teach beased on lesson plan for students in sixth grade that consist of 50 students. Students are divided into seven groups and each group consisted of 7 or 8 students. This study is also equipped with 4 observers on duty to observe classroom activities and fills observation sheet that has been provided.

The first activity starts when the teacher shows some photos Lumpur Lapindo through using the LCD screen. Students pay attention to the photos displayed. Then the teacher gives the students questions about the photo. Here are questions and answers of teachers of students in observing activity Lapindo mud photo:

Teacher: Students, what do you know about this photo?
Students: Photo of Lapindo mud, mom.
Teacher: Where is the location of existing images in this photo?
Students: In .... in Porong, Sidoarjo ....
Teacher: Who among you have ever visited this place?
Student: Me..me...me... (Most of the students raised her hand with full enthusiastic)

Based on the results of conversation between teacher and students it can be seen that the students can identify the photos displayed and located Lapindo mud in Porong, Sidoarjo. These results were same with the result of pilot experiment.

The second activity begins by having students watch the video of the Lapindo mud. Teachers provide some questions to stimulate students. Based on the conversation in second activity, the students are able to analyze videos of Lapindo mud displayed. Students' responses in the teaching experiment were same with the responses of the students in the pilot experiment.

In the third activity, observing Lapindo mud is done by creating a miniature Lapindo using an syringes filled with water. Furthermore, under the existing syringes as a beaker glass of water will be emitted so it does not spill onto the floor or table. Then injecting faced upward and pressed so that the water gushing from the ground up. Students pay attention to the Lapindo mud miniature that shows that mud gushing from the bottom up. Then teachers stimulate students with questions that the students know that the volume of water flowing through syringes per unit time can be determined. Here are the results of conversation between teachers and students:

Teacher : Students, do you see a spray of water? Can you determine it volume?
Andi : Yes mom, of course ..
Teacher : How is the way?
Andi : Using a beaker glass ..
Teacher : How about the time. Can you measure it?

Student : Allright ... Yes mom, Using clock Mom... Using the stopwatch ...
Teacher : Children, if you already know the volume and the time required,
can calculate the the product of division between volume of water and time needed?
Student : Yes, mom ....

Based on the students' answers, it can be seen that the students already know how to measure volume and time. In the fourth activity, of the data about volume and the time required for water begins by working in groups. Students work in groups of 6 to 7 students. Each group received media in the form of beaker glass that is already filled with the water, syringes duster, pens and worksheets that already contain instructions that are ready done with different questions for each group.

The first problem is that students are asked to fill syringes with water based on the worksheet. The first group was asked to take water as much as 10 ml and 48 ml, the second group was asked to take water as much as 20 ml and 44 ml, a third group was asked to take water as much as 36 ml and 30 ml, the fourth group was asked to take water as much as 28 ml and 40 ml, the fifth group asked to take water as much as 50 ml and 26 ml, the sixth group was asked to take water as much as 60 ml and 14 ml. Then the students in the group asked to determine the time required removing the water from the syringes by using a stopwatch.

Based on observations, it is known that most of the students answer the problem by rounding the number after comma as shown in Figure 4 and there are some students that just write numbers before comma and ignore the number after it in the stopwatch.

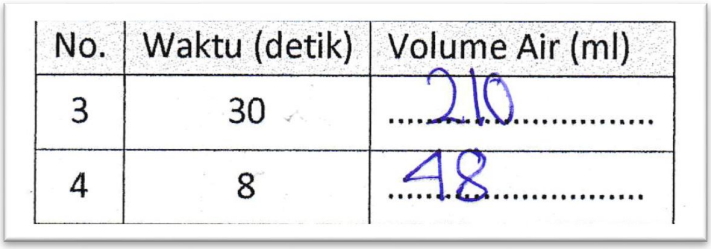
No.	Volume Air (ml)	Waktu (detik)
1	36	.....
2	30	.....

Figure 4. Students write time using integer

In the second problem, students were asked to fill the syringers with water syringes. Then the students were asked to determine the volume of water that is emitted within the time specified in the worksheet. The first group was asked to determine the volume of water that is emitted within 20 seconds and 12 seconds. The second group asked to determine the volume of water that is emitted within 15 seconds and 25 seconds. The third group was asked to determine the volume of water that is emitted within 16 seconds and 14 seconds. The fourth group asked to determine the volume of water that is emitted within 30 seconds and 8 seconds. The fifth group asked to determine the volume of water that is emitted within 40 seconds and 8 seconds. The last, the sixth group asked to determine the volume of water that is emitted within 24 seconds and 12 seconds.

Based on the results of field notes, students solve problems by reducing the number shown in beaker glass that represented the volume of water before emitted by by the volume of water after

emitted during the time specified in the worksheet. Some students look directly into the volume of water in a beaker glass and there are students that solve the problem by using integer from the result of rounding as shown Figure 5.



No.	Waktu (detik)	Volume Air (ml)
3	30	210
4	8	48

Figure 5. Students write volume of water using integers

In the fifth activity, finding the discharge of Lapindo mud, students are asked to determine the product of division between the volume of water and time needed from the first activity until the fourth activity. Then students were told that the product of division between the volume of water that emitted and the time required is called discharge. Next, students are asked to do the questions about the discharge of Lapindo mud and the problems that exist around the students.

Based on observations and student worksheets that have been done it can be seen that most of the students use the data obtained in the first activity until the fourth and writes the results in fractions. There is a group that is still unfinished work because of their ability to operate the division operation is weak as shown in Figure 6.

No.	*Volume Air (ml)*	*Waktu (detik)*	$\frac{volume\ air}{waktu}$
1	36	9	4
2	30	8	3,75
3	20	16	1,25
4	18	14	

Figure 6. Unfinished Answer

The discharge of Lapindo mud has an important role in learning and it is includes the volume measurement, time measurement, the product of division between volume and time. To know the act of design in discharge concept using PMRI approach with Lapindo mud as a context, we need to pay attention to a series of learning activities then determine instructional design. Knowledge of students about the concept of discharge that appears in the context of the Lapindo mud described as follows:

a. Volume measurement

Volume measurement in this research is conducted by taking the water using an syringes because this medium is equipped with a label of volume and its unit. Volume measurement in this research have not yet used the difference unit or unit conversions. Data obtained by students from the results of taking the water using syringes used in the next activity to determine the discharge of water.

b. Time measurement

Time measurement in this research was conducted by using a stopwatch. In the first activity for the time measurement, students are asked to determine the time needed to remove all the water present in the syringes. This activity is done with the experiment using two problems that have been solved by the students.

c. The product of division between Volume and Time

To determine the product of division between volume and the time in this research was conducted by dividing the volume of water that is taken by syringes by the time required to take water from the first activity until the fourth. The data used is based on the result of experiments that have been done in a group.

CONCLUSION

Based on the investigation result from findings and the data obtained in this research, it can be concluded that the instructional design in discharge concept using PMRI approach with Lapindo mud as starting point able to support the students' understanding in learning the discharge, in addition, learning process conducted using student centered learning and they are able to develop students' mathematical ideas through discussions and interaction with their friends in one group or class. This study was designed with a series of activities ranging from observing activity Lapindo mud photos, watching videos Lapindo mud, observing miniature Lapindo mud, volume of water and time of date collection are needed, and finding the discharge of Lapindo mud.

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