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Developing learning trajectory on the circumference of a cycle with realistic mathematics education (RME)

Indriani N. , Julie H.

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[a] Mathematics Education Department, Sanata Dharma University, Yogyakarta, Indonesia

Abstract

According Nuranisa, the students' difficulties on a lesson about the circumference of a circle were to understand the concept of what was the circumference of a circle and solve problems associated with the circumference of a circle [8]. According Nuranisa, this is because the teacher only gives a formula to find the circumference of a circle without helping students to construct the formula [8]. The purposes of this study were (1) to develop the hypothetical learning trajectory (HLT) for the cycle circumference material, (2) to describe the student results from the HLT implementation. The type of research used in this research was the design research developed by Gravemeijer and Cobb (2006). According Gravemeijer and Cobb, the design research was divided into three stages: (1) preparing for the experiment, (2) design experiments, and (3) retrospective analysis [6]. In this study, researchers developed the student learning trajectories which were help students to construct their knowledge about the understanding and how to calculate the circumference of a circle. The context used on the students' learning trajectory was sports and arts event. The learning trajectory has been tried out for 15

grade five students on the Budya Wacana elementary school in Yogyakarta. In this paper, researchers would describe how the learning trajectory traversed students to construct their knowledge about the understanding and how to calculate the circumference of the circle and the student thinking process on the understanding and how to calculate the circumference of a circle. The results showed that students could construct about the understanding of the circumference of a circle and how to calculate the circumference of a circle through the student learning trajectory. © 2017 Author(s).

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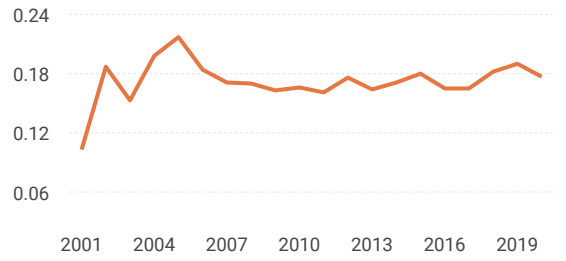

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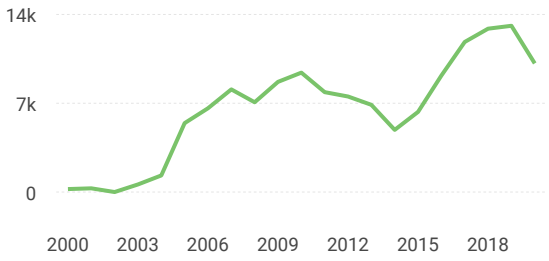

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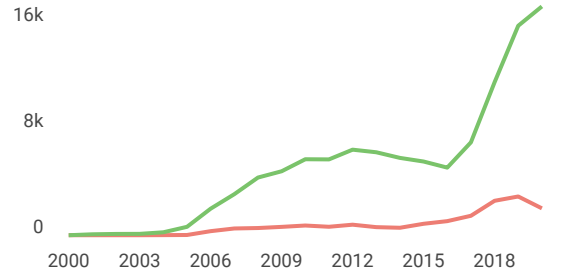

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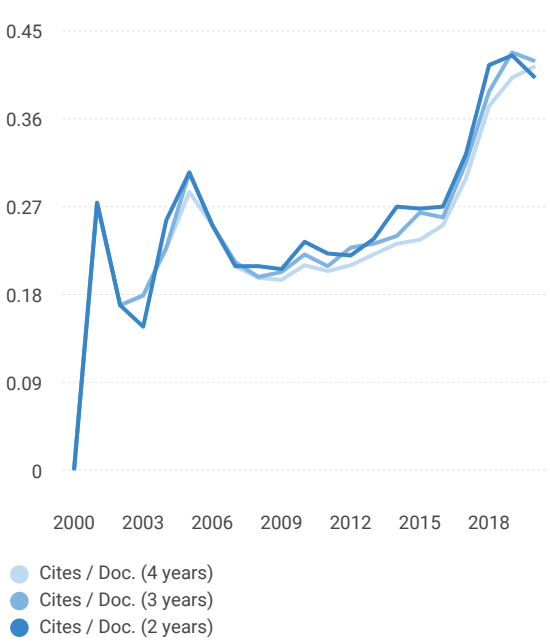

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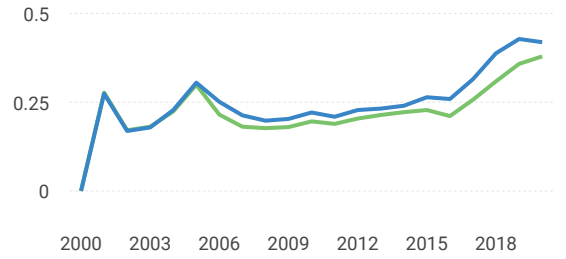

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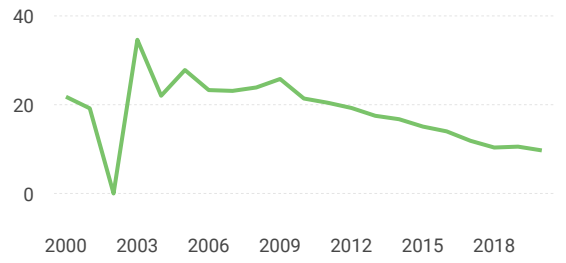

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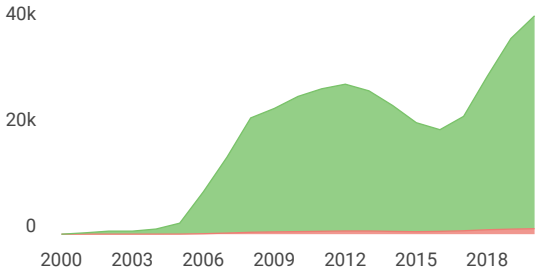

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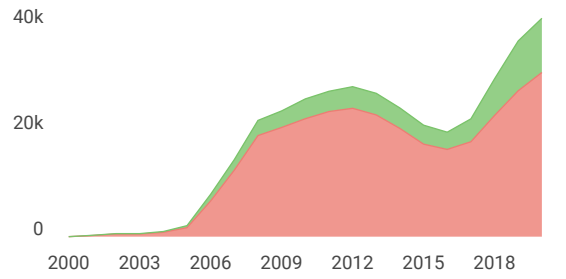

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Novi Indriani and Hongki Julie

Developing Learning Trajectory on The Circumference of A Cycle with Realistic Mathematics Education (RME)

Novi Indriani[b)] and Hongki Julie[a)]

Mathematics Education Department, Sanata Dharma University, Yogyakarta

[a)]Corresponding author: hongkijulie@yahoo.co.id
[b)]indrianinovia@gmail.co.id

Abstract. According Nuranisa, the students' difficulties on a lesson about the circumference of a circle were to understand the concept of what was the circumference of a circle and solve problems associated with the circumference of a circle [8]. According Nuranisa, this is because the teacher only gives a formula to find the circumference of a circle without helping students to construct the formula [8]. The purposes of this study were (1) to develop the hypothetical learning trajectory (HLT) for the cycle circumference material, (2) to describe the student results from the HLT implementation. The type of research used in this research was the design research developed by Gravemeijer and Cobb (2006). According Gravemeijer and Cobb, the design research was divided into three stages: (1) preparing for the experiment, (2) design experiments, and (3) retrospective analysis [6]. In this study, researchers developed the student learning trajectories which were help students to construct their knowledge about the understanding and how to calculate the circumference of a circle. The context used on the students' learning trajectory was sports and arts event. The learning trajectory has been tried out for 15 grade five students on the Budya Wacana elementary school in Yogyakarta. In this paper, researchers would describe how the learning trajectory traversed students to construct their knowledge about the understanding and how to calculate the circumference of the circle and the student thinking process on the understanding and how to calculate the circumference of a circle. The results showed that students could construct about the understanding of the circumference of a circle and how to calculate the circumference of a circle through the student learning trajectory.

INTRODUCTION

According Nuranisa, students had problems on a circumference circle lesson which were to understand the circumference circle concept and to solve circumference circle problems [1]. According Nuranisa, It was caused that the teacher only gave a circumference circle formula without helping them to understand and construct the formula [1].

A reality that has happened in the Budya Wacana elementary school in a trial exam at Tuesday 05th April 2016 was the most of students in grade six encountered an error in solving the question about the ¾ circle cirfumference calculation. There was a ¾ circle image and it knew that the radius of the circle was 40 cm. Researchers observed that the error occurred because in the process of problem solving, students directly applied the circle circumference formula without understanding the circle circumference concept correctly. When they solved the question, they used the ¾ circle circumference formula. Students did not understand that the length of line which limit circle's field should be considered in the calculation of the ¾ circle circumference. Through this case, furthermore researchers conducted an observation and some interviews with some mathematics teachers in the Budya Wacana elementary to find out how the learning process occurred in the classroom particularly in the learning process for the circle circumference. Based on the observation results, researchers found that teachers directly gave the circle formula, an example problem, and the solution to students in the beginning of the teaching and learning process regarding to the circle circumference material. However, the given questions were still quite simple and not complicated. Then, students were asked to do

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the given practice questions which are similar to the previous examples. Students only get the circle's circumference formula without understanding the concept and process to obtain this formula. Students do not understand the process to obtain the value of phi and their application in some issues regarding to the circle's circumference in daily life.

Learning mathematics would be more meaningful if it is associated with real situations in real children life with mathematical ideas. According to Van den Henvel-Panhuizen, if children learn mathematics which was not accordance with their daily experiences then they will quickly forget and cannot apply mathematics to other sciences or in their daily life [1, 3, 6]. This opinion was also expressed by Freudhental that knowledge would be meaningful for students if the learning process involves realistic problems [1, 3, 6]. If we used the realistic mathematics education approach in the teaching and learning process, then we started with realistic problems to direct students in the understanding of mathematical concepts [1, 3, 6].

Based on the facts, researchers tried to solve these problems in order to help students so they can have better understanding and construct the concepts about the circle's circumference using realistic mathematics learning approach. Researchers create the appropriate instructional design with realistic mathematics learning characteristics that will be implemented in the class V SD Budya Wacana Yogyakarta 2016/2017 school year to help students in mastering of concepts about the circumference of circle and able to apply it in the related problems.

The research question in this research was how the learning result of students on the topic of the circle circumference after they learnt using the Realistic Mathematics Education (RME) approach ?

THE REALISTIC MATHEMATICS EDUCATION (RME) AND THE DESIGN RESEARCH

The philosophy of RME was mathematics as a human activity. It meant learning mathematics should be able to make the students thought that there was mathematics in human activities, and it was be used by them in real life [2, 5, 9]. So, the learning process of mathematics first of all should not be connected with mathematics as a deductive system that was well organized and formal, but it should be connected with mathematics as a human activity [2, 5, 10]. If the mathematics which was learned by the student was connected with a formal deductive system, then the student will view that mathematics was resulted by the human thinking; it was an abstract and was not related to real-life. So, they will think that they could not find mathematics and using mathematics in their life [10].

There were five main characteristics in the RME [3, 4, 6, 9, 10], namely: (1) phenomenological exploration, (2) bridging by vertical instruments, (3) student contributions, (4) interactivity, and (5) intertwining.

According Akker, Gravemeijer, McKeney, and Nieveen, design research can be characterized as [7, 8, 11, 12]: (1) interventionist: the research leading to the design of an intervention in the real world, (2) iterative: the research incorporates a cyclic approach to the design, evaluation, and revision, (3) process-oriented: a model of research that avoids the measurement of inputs and outputs, focus on understanding and improving interventions, (4) oriented to usability: the benefits of design were measured by looking at the practicality of the design for the user in reality, and (5) oriented to the theory: design (at least partially) made by theories that already exist, and field testing of the design contribute to the development of the theory.

According Gravemeijer and Cobb, there were three phases in the design research, namely: (1) the first phase: preparation of trial design, (2) second phase: trial design, and (3) the third phase: a retrospective analysis [7, 8, 12].

METHOD

The type of research used in this research was the design research developed by Gravemeijer and Cobb. According Gravemeijer and Cobb, the design research was divided into three stages: (1) preparing for the experiment, (2) design experiments, and (3) retrospective analysis [7, 8, 12].

Research subjects in this study were students in grade V on the Budya Wacana elementary school. Research was carried out in the Budya Wacana elementary school at the first semester of 2016/2017 school year. In this study, data was collected by documentation method. Data from the study is a recorded learning video and documentation of the students's working results.

In planning learning design, researchers also design how student's reaction during learning and the strategies which were used by students. Gravemeijer stated that the learning hypothesis is activity hypothesis everyday in the designed learning [1, 6].

Data analysis technique in this research is conducted in a qualitative descriptive. In this study, data reliability is measured through a description of the learning process which is carried out by the researchers. The used steps in data

analysis data are: 1) data reduction which means to summarize, choose things, focus on the important things, look for themes and pattern and discard unnecessary informations; 2) data presentation which is a set of well-structured information giving the possibility of withdrawal of conclusions and 3) conclusion or verification which is intended to find the meaning of the data collected by finding relationships, similarities, or differences.

RESULTS AND DISCUSSION

The research results presented in this study were the results which were achieved by researchers in the process of trial design. Trials were carried out on Wednesday and Thursday, 9 - 10 November 2016 in class V. 3. The result of the learning process of the trial is as follows:

1. The First learning
   Students are given a problem with context PORSENI CLASS VI. In this context, the question is about a marathon runner who has to traverse a distance of 5000 m where the track field is rectangular. If the length of field is 750 m and the width of field is 500 m. Students are asked to determine number of laps which must be surrounded by a runner so that it can reach the track of the 5000 metres exactly.

   Following the work of students in solving problems "PORSENI CLASS VI":

   a) Group 1, II and IV

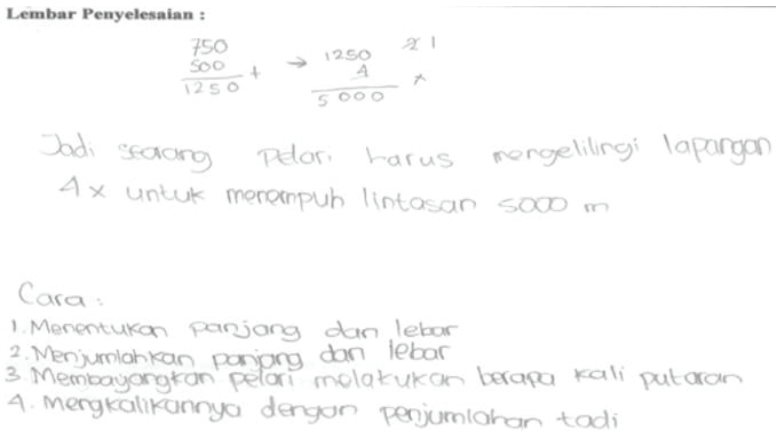


FIGURE 1.

The description of the students' work and the students' interview as follows:

The following passage between researchers with students:

P: "Please, try to explain what do you think when you get a problem PORSENI CLASS VI?"
B: "The first known Miss."
P: "Please described what is known from this given question!
C: "It' s rectangular shape field Miss, length of 750 m and a width of 500 m. Asked to look for the large number of runners spin 5000 metres distance Miss. "
A: "Rectangular-shaped field Miss."
P: "How do you solve the problem? "
A: "This length is added to the width and then added more length and width Miss."
C: "It's the length plus width plus length plus width again.

From the interviews, researchers knew that students already knew how to determine the circumference of a rectangle that is the length plus width plus length plus width, but from the work of students, the students calculate the length width i.e. 500 + 750 = 1250. Students have not added again that sum result with the length and the width again.

P: "After determining the circumference of the field, what are you working on again?"
B: "The distance that has to be pursued is 5000 m right. In order to be 5000, 1250 has to be multiplied four Miss. "

From the interviews with students, researchers knew that students were able to determine how to obtain the number of rounds that should be taken for by the runners, although the obtained results are not appropriate because of an error in the calculation of the rectangle's circumference.

From the explanation above, researchers can determine that:

(1) Students have been able to create its own model regarding to PORSENI CLASS VI question.

(2) Students have been able to do the horizontal and vertical mathematization processes related to material the circumference of a rectangle.

b) Group III and V

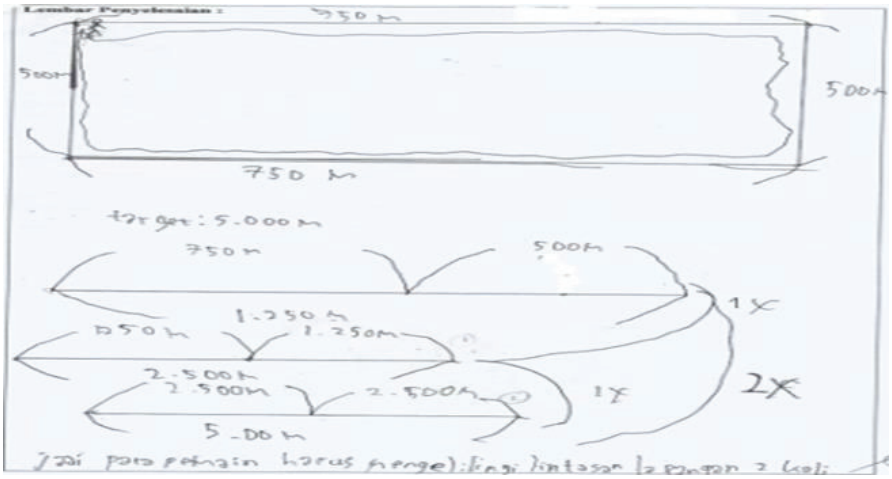


FIGURE 2.

The description of the students' work and the students' interview as follows:

The following passage between researchers with students:

P: "Please explain the work steps you have done to resolve these problems!"

B: "We are used to read and understand the problems Miss. What the purpose of this question, want to look for what. So we specify what is known and what the exact question is from about that. "

P: "Then, how is this solution step ?"

C: "Determined first round-square Miss."

B: "This is calculated first the length and width of rectangle, Then obtained 1250 m. Firthermore, 1250 plus 1250, 2500 the results. This means that for one round, rectangular 2500 m circumference. Well above 2500 2500 plus, resulting in a number of 5000 m. It means that runners must surround the path twice. Finish Miss? "

From the interviews, researchers discovered that students already knew how to determine the rectangle's circumference to half round i.e. length width, i.e. 500 + 750 = 1250. The circumference of a round rectangle is 1250 + 1250 = 2500. Students were able to determine how to obtain the number of rounds that should be taken for the runners, i.e. by multiplying the circumference of a rectangle with the number 2 so that it can be retrieved long trajectory of 5000 m. So, the number of rounds that should be taken for the runners was 2 laps.

From the explanation above, researchers can determine that:

(1) Students have been able to create its own model associated to PORSENI CLASS VI questions.

(2) Students have been able to do the horizontal and vertical mathematization processes related to material the circumference of a rectangle.

(3) Student already performed precisely in machining process and obtaining the exact result.

To strengthen the concept of the rectangle's circumference, the teacher gave problems: "PORSENI NEXT YEAR". In the context of PORSENI next year, it is explained that a marathon runner has to tranverse a distance of 5,000 m with the rectangular track field. Students are asked to help the organizers of the race determines the length and width of the field and determine the abundance of laps which should be surrounded by runners in order to tranverse the specified path distance.

Following are the results of group discussions in resolving the problem of the two provided:

a. Groups I, III and IV

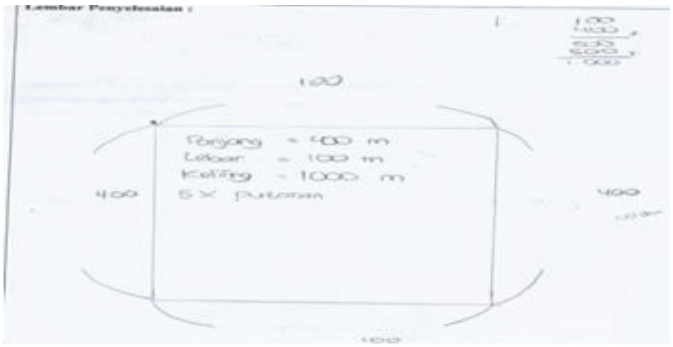


FIGURE 3.

The description of the students' work and the students' interview as follows:

The following passage between researchers with students:

P: "Please try to describe the results of your work in solving problems in PORSENI NEXT YEAR!"
C: "That Miss, asked to look for length, width and the number of rounds."
P: "Then, how you solve this question?"
A: "We need to determine the length, 400 m and width, 100 m, Miss."
P: "From where we can determine 400 and 100? Why we do not take another number except 400 and 100? "
B: "Trial calculation Miss. Select the easy numbers and the results can be correct. If we sum 100 and 400, the result is 500 then 500 multiplied 2 is 1000."

From the results of interviews, researchers discovered that students determine the length and width of the field, 400 m and 100 m respectively from trial calculation. Although trial method is used, students have been able to calculate the easy number and obtain the correct result.

C: "1000 multiplied 5 is 5000 Miss."
A: "If the length and width number have been found, all number sides are summed resulting 1000 m as rectangular's circumference number. Thus, the number of rounds was 5 times. "

From the results of interviews with students above, researchers told when students are able to determine the circumference of a rectangle by summing all the size of the side of the rectangle so that retrieved the circumference of a rectangle is 1000 m. Next the students doing a round-rectangle multiplication with numbers 5 so it can be retrieved number 5000. Students are able to conclude that the number of rounds that can be reached is 5 times the runner rounds.

From the explanation above, researchers can determine that:

(1) Students already understood the given problem and created their own models which are associated with problems in PORSENI NEXT YEAR.
(2) Students already did the horizontal and vertical mathematization processes which is related to material of rectangular's circumference.
(3) Students gained the experience to find their own concepts, principles or procedures.

b. Group II and V

The description of the students' work and the students' interview as follows:

The following passages of interviews with students:

P: "Please explain, what is the kind of information which you get from questions in PORSENI NEXT YEAR ?"
B: "Miss, it means that we are targeted to tranverse 5000 m, then we should determine the length and width of the field and also many rounds which should be done by runners. "

From the results of the interview above, researchers found that students are able to understand the problem correctly.

P: "So, what do you mean with the target is 5000 m ?"
A: "Target 5000 m is the distance that must be taken for the runner .. we should focus in 5000 m as mileage."
P: "Then the next step, what shoud you do ?"
C: " Specify the number of rounds used to be Miss, then calculate the circumference of a rectangle. The last step is trial calculation to determine the length and width of the area Miss. "
P: "Are there any difficulties you are facing in resolving this issue? "
B: "Nothing Miss, just need concentration to finish."

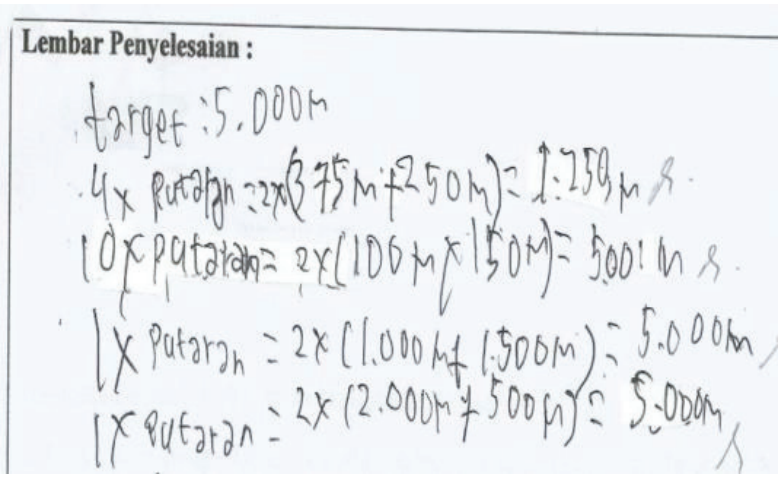


FIGURE 4.

From the results of the interviews, researchers found that students are able to specify the number of rounds that should be pursued by runners, determine the circumference of a rectangle, and the final step is to determine the length and width of the rectangle. From the results of the work of students, researchers stated that students are able to acquire 4 measures the length and width of rectangle and perform calculations on the circumference of a rectangle and the number of rounds appropriately.

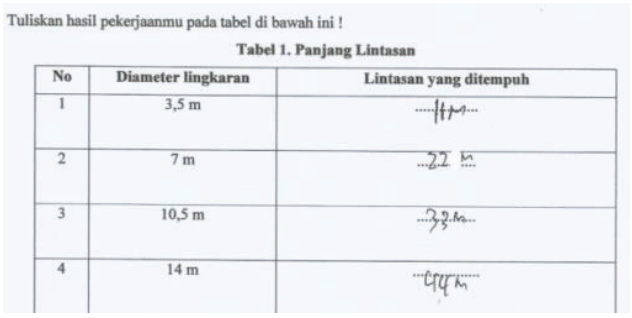
For the above explanation, researchers infered that:

(1) Students had understood the given problem and created their own models which are associated with a problem in PORSENI NEXT YEAR.
(2) Students had already done the horizontal and vertical mathematization processes related to material in the circumference of a rectangle.
(3) Students were already able to construct their own knowledge, the process of the settlement of a matter or a matter of realistic problem.
(4) Students more active in constructing their own knowledge so that it can perform calculations.

Teacher led the implementation of the class discussion to discuss some ways of problems solving. The teacher asked several groups to present the results of the group work. Furthermore, the teacher and students concluded the learning outcomes that have been exercised.

2. The second study

In this second study, students were given a problem with PORSENI CLASS III context. The given problem are some questions about sport competitions, one of questions is a marathon race for the grade III which has circular area as the running track. If the known diameter of circle areas consisted of 3.5 m, 7 m, 10.5 m and 14 m respectively, students are asked to determine the length of the track which will be tranversed by runners for one round on each diameter of the circle. The work results students in solving a problem in **PORSENI CLASS III:**


Tuliskan hasil pekerjaanmu pada tabel di bawah ini !

Tabel 1. Panjang Lintasan

No	Diameter lingkaran	Lintasan yang ditempuh
1	3,5 m	....11m....
2	7 m	...22 m...
3	10,5 m	....33 m....
4	14 m	....44m....

FIGURE 5.

The description of the students' work and the students' interview as follows:
The following passages of interviews with students:
P: "How did you do in the process of acquiring the track length which should be traveled to have in the shape of a circle ?"
S: "We do measurement Miss, by wrapping the yarn around the edge of the circle area"
P: "Are the obtained results already correct?"
S: " Yes, Miss."

From the results of the interview above, researchers discovered that students perform a circular field representation with a picture of the circle's shape, have the idea to do a measurement and obtain the circumference of a circle and do the measurement with the right results.

From the results of the interview and the work of students, researchers infered that:
(1) Students already understood the problem properly and determined resolution steps.
(2) Students already did representation in a context PORSENI CLASS III problem.

Teachers guided students to determine the comparison between the diameter and the comparisons of the measured track length.
Here is one of the results of the work of students in complete table 2:

Tabel 2. Rasio Antar Diameter

No	Diameter lingkaran	Perbandingan antar diameter
1	3,5 m	3,5 m
2	7 m	....2.... x 3,5 m
3	10,5 m	....3.... x 3,5 m
4	14 m	....4.... x 3,5 m

FIGURE 6.

The description of the students' work and the students' interview as follows:
The following passages of interviews with students:
P: "Children, how to determine the comparison of diameter between first circle (1) and second circle (2) and soon in Table 2 "
S1: "The second circle's diameter is 2 times of Circle 1 Mr. "
S2: "Circle 1 is a half of Circle 2 Sir "

From the results of the interviews, researchers told that students are able to specify the comparison between different diameter with precision and no difficulty in determining the comparison.

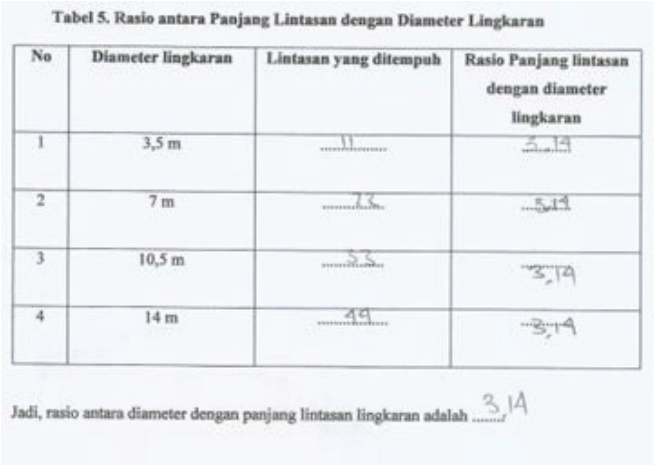
From the results of the interview and the work of students, researchers can infer that:
(1) The student has already mastered the concept of comparison, multiplication and Division of numbers.
(2) Students did not have difficulty in determining the comparison.

Students worked on Table 3. In Table 3, students were asked to pay attention to the area length between the circle's circumference which is already acquired by the students from the measurement using thread, ruler and a representation of the circle.

Then students worked on table 4. In this table, the students only wrote back the obtained results in table 2 and table 3. In table 4, all groups wrote down the results of the same tasks with the previous results. Discussion activities did with the liveliness of students, students are able to specify the comparison between the diameter and the comparison between the length of the path. But in answering questions from the teacher, the students still did not run the social norms, students still answered simultaneously. Next the students are given the opportunity to work on table 5. Of the five groups that worked on the reserved table 5, all the results of the work of the student acquires the same ratio between the diam to the length of the path is 3.14.

The description of the students' work and the students' interview as follows:
P: "How do you determine the ratio between the length of the path with a diam of a circle? "
S1: "Its difficult Mr."
P: "Which is difficult. Isn't that ratio comparison? There may be willing to argue? "
S2: "By dividing the path length with a diam of the circle Mr."
P: "Exactly once. We can divide. What is the number obtained?"
S2: "3,14 Mr."

P: “Nice. All results division track length with a diam of the circle, obtained the number of 3.14. There are a number of what is that makes the value of the diam and the length of the path have the same comparison ? “
S: “3.14 Mr.”



Tabel 5. Rasio antara Panjang Lintasan dengan Diameter Lingkaran

No	Diameter lingkaran	Lintasan yang ditempuh	Rasio Panjang lintasan dengan diameter lingkaran
1	3,5 m	11	3,14
2	7 m	22	3,14
3	10,5 m	33	3,14
4	14 m	44	3,14

Jadi, rasio antara diameter dengan panjang lintasan lingkaran adalah 3,14

FIGURE 7.

From the results of the interviews, researchers discovered that students already understood the steps of calculation, but had difficulty in performing the calculations of decimal. Students had difficulty in doing the division between an integer with decimal numbers. After students finished in table 5, teachers and students held classroom discussion. The teacher asked the students, "what is the number that the value of the diameter and the length of the path have the same comparison?". In response to questions the teacher, the students did the work calculation by dividing between the calculated track length and the diameter of a circle, as have ben done in table 5. Some students tried to present the results of his work on the Board, but still facing the constraints in decimal calculations. After some students presented their task results, the teacher concluded that the obtained values is called as the value of phi. The teacher explained that the value of phi is 3.14 or 22/7. Then the teacher and students formulated the way of determining circle’s circumference together.

CONCLUSION

The learning trajectory made up of three components: namely (1) the learning goals, (2) the learning activities and (3) the hypothetical learning process. Researchers create the appropriate instructional design to help students understanding and construct the concepts about the circle’s circumference using realistic mathematics learning approach. Based on the working results of students and the results of interviews with students, researchers drew conclusions as follows:

1. In context PORSENI CLASS VI, it is concluded that:
   a. A student already created mathematical models associated with a problem PORSENI CLASS VI.
   b. A student already did the horizontal and vertical mathematization processes related to material the circumference of a rectangle.
   c. There is a group of students who have already mastered the concept of the circumference of a rectangle, but experienced a process of calculation errors due to inaccuracies in the workmanship.
   d. There wa a group of students can do machining process correctly and obtain the exact result.
2. In the context of PORSENI NEXT YEAR, it is concluded that:
   a. A student can already understand the given problem and create their own models associated with a problem PORSENI NEXT YEAR.
   b. Students have already gained the experience in finding their own concepts, principles or procedures of problem resolution.
3. In the context of PORSENI CLASS III, it is concluded that:
   a. Students have understood the problem well and been able to master the concept of the circumference of a circle.
   b. Students have undertaken representation in a context problem PORSENI CLASS III.

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Dean,

Dr. Hartono
NIP.19620329 198702 1 002

Yogyakarta, May 16, 2017
The Head of Commitee

Joko Sudomo, MA
NIP.19590716 198702 1 001