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Sprint Context of Asian Games in the Division of Fractions

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***Abstract*—This study used sprint context on Asian games for Learning Trajectory (LT) that can help students understand the division of fractions in grade 5 of elementary schools. This study was conducted on 30 students in class V-e of MIN 2 Palembang, South Sumatra Province, Indonesia. This study used design research method with three research stages, namely the first preliminary design/ preparing for an experiment which was the stage of designing Hyphotecal Learning Trajectory (HLT) and instruments needed, design experiment namely HLT test phase consisting of pilot experiment and teaching experiment and the third one, retrospective analysis. Instruments for data collections were video recordings, documentation, and interviews, observation sheet, pre-test and post-test. Hypothetical Learning Trajectory (HLT) of learning division of fractions has been designed into Learning Trajectory (LT), so it can function as a Local Instructional Theory (LIT) which can be developed to provide the materials of the division of fractions for students. The results of this study indicated that the trajectory of learning produced can help students understand the division of fractions. Therefore, it will be able to contribute positively to the various parties who have an interest in the education such as teachers, students, schools and the government. Furthermore, it also can be used as a reference in the teaching and learning and developing materials of teaching mathematics.**

Keywords—Divisions Of Fractions, HLT, Sprint, Model Bar, Design Research

I. INTRODUCTION

The learning process in schools links the materials and real life studied by the students everyday. One factor of the learning process which can familiarize students in problem-solving is context. Context can be the start for learning mathematics [1]. The context in an area may be different from other areas, so using a real right context is preferred because it can help the students give the perception and can interpret information easily as a basic knowledge of students [2].

The previous concept also applies to learning division of fractions since fraction is one of the fundamental concepts in mathematics and science associated with the environment. According to several studies, one of the concepts of fractions which is difficult to understand is the concept of division of fractions, for the fractional division is one of the hardest materials in arithmetic [3][4][5].

In studying fractions, there are five levels of fractional operation which are: knowing fractions in accordance with students level, strategizing delivery of fractions material, arranging the rules in operating the fractions equation, operating addition and multiplication independently by the students and making the results of their own by following the rules for the accurate result [4].

Some research conducts had been done to build an understanding of fractional division material. As the first example, [4] conducted by using contextual situation and some real objects for students to learn fraction for the first time. The main focus of his research was the calculation of division and only showed informal solving strategy of the division problem. Another example, [6] used ribbon context in the 4th grade in the fractions division materials relating to fraction division. The given problem was "Holiday Bows". Moreover, [5] conducted a study at MIN 2 School Palembang with an entitled issue "Souvenir for Kartini day" to develop students' understanding of the inverse relationship between multiplication operations with fractional division operation from measurement division problems and positive division. Reference [7] conducted a study on measurements and created a partition to solve multiplication and division problems. Research by [3] separated the issue of division into two main problems, measurement and partition division.

Based on the description, the researchers used different ways to teach fraction, in this case, fractions division, by using Asians Games context held in Palembang, South Sumatra, Indonesia. The context used was sprint form of the athletic sport. There were several reasons why the researchers used the context of sprint sport at the Asian Games. The study using this context which has never been done would give the impression of something new and different. Asians games will be held in Indonesia in 2018, and in particular, some sports are held in South Sumatra that are more familiar among the public, especially for fifth grade students. The researchers wanted to provide information to the entire community, especially prospective teachers and mathematics teachers in teaching fraction. The context of the sprint context is a reference because the students are very familiar with this sport.

The purpose of this study was generating Hyphotecal Learning Trajectory (HLT) to help students in understanding the fractional division material through the context of Asians Games Athletics Sports. Major problem of this study is 'How

can HLT help students understand the fractional division material using Asians Games Sprint Sports context?

The benefits of the research can be categorized in two ways, namely, practically benefit and theoretically benefit. Theoretically, this study contributes to a grounded instructional theory in fractional division learning, namely the use of Van de Walle theories which are dividing by measuring and dividing by partitioning, in this case using partition bars. Practically, this research provides an overview for teachers and researchers on how to design a study that emphasizes understanding, especially on the topic of a fractional division. The benefits of the research can be categorized in two ways, namely, practically benefit and theoretically benefit.

II. METHODS

This research used design research method which had cyclical process of a thought experiment and instruction experiment ([8], [9], [10]). A process of cyclic (repeated) is a thought experiment to learning experiment in diagram form with experimental idea illustrations which shown from the image below [11]:

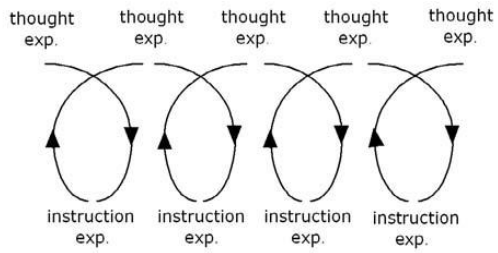

Fig. 1. Reflexive correlation between theory and experiment

Instructional design is done by designing and using three phases, namely Phase I which is preliminary design/ preparing for the experiment, Phase II which is the design experiment, and Phase III which is retrospective analysis [2][10][13]. Data collection was done using video recording, photo, observation, interviews, and documentation. Design Research is a qualitative research method, so the techniques of data analysis in this study were conducted qualitatively based on the results of data collection that have been done.

III. MAIN RESULT

This study used Design Research method by following the three stages that exist, namely Preliminary Design/ preparing for the experiment, the Design Experiment, and Retrospective Analysis. This study was designed to produce a Learning Trajectory (LT) in using a fractions division bar with the context of the World Sprint Record and implemented in MIN 2 Palembang involving three students at Pilot Experiment and 30 students at the Teaching Experiment. The results obtained in this study can be described as follows.

A. Preliminary Design/Preparing for Experiment

This stage began with the design of Hyphotecal Learning Trajectory (HLT) on the material division of fractions. Context sport at Asian games was selected for the track of presented bar and Asian games were familiar among students because it will be held in 2018 in Palembang, Indonesia. The previous researchers first reviewed the literature on the division of fractions. The concept can be used as a support for teaching material division of fractions (such as: material ratio, simplifying fractions, equivalent fractions, the operation of addition and subtraction of fractions and multiplication operation fractions). The concept was also used to examine the context of sport in Asian games, review instructional materials division of fractions in the curriculum, review PMRI approach, and examine design research used as the research method. Furthermore, the researchers discussed with the mathematics teacher who was the model of the HLT that has been designed and made allegations about the students' thinking activities. In addition to HLT, the researchers also designed lesson plans, teacher guidance, and assessment instruments. The HLT which has been designed is as follows.

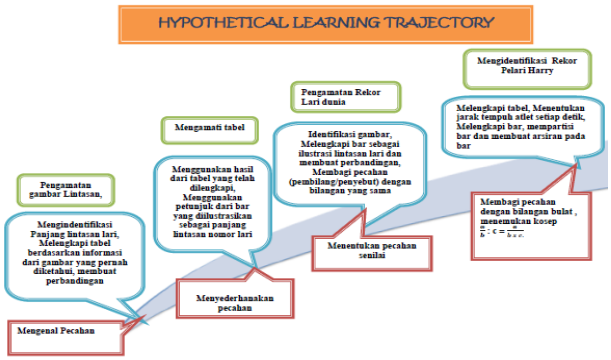

Fig. 2. Hyphotecal Learning Trajectory

B. The Design Experiment

On this stage, there are two sub-cycles of cycle 1, known as Pilot Experiment and second cycle known as the Teaching Experiment. However, this study was limited to the first cycle of design research.

In cycle 1, 3 students have been categorized as having good ability, moderate and low. All three students were given activity sheets that have been designed and validated by their subject teachers at stage 1. Then, the students' works were observed and interviewed to see the thinking in resolving the problems that exist in each activity. The results of the students' work can be described as follows.

1) Activity 1 (Introduction of fraction)

The purpose of this activity was to recognize fractions. At this stage, the context of the image track was given, and the students' background knowledge was dug up. The result can be seen from the transcript of the interview follows: (P = researcher), (S = Student)

Transcript 1.

1. P: "Read the questions, please" (pointing to the questions)
2. S: "Do you know how long the sprint, middle and long-distance track is?" (while reading the questions)
3. P: "What's your answer?"
4. S: "sprint track 100m, 200m, 400m. Middle distance track 800 m, 1500 m, 3000 m, long-distance track 5000m, 10,000m "
5. P: "How did you know?"
6. S: "from PE (Physical Education) class"

From the interview transcript 1 at point 4, the student has known the length of the track, and the information of the length was obtained from Physical Education class. Thus, the students' knowledge was partly used as a starting point for introducing fractions to students on the second activity. Student's work on activity 1 can be described as follows.

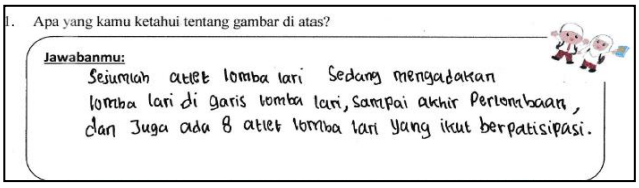

Fig. 3. The results of student's answer to question number 1 of activity 1

In question number 1, students wrote down what they knew and what they saw from the pictures. They have been able to describe the meaning of the rendered image so that it can explore students' initial knowledge about the context used.

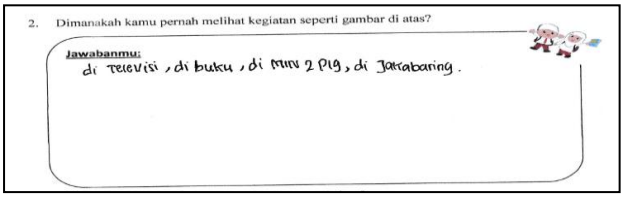

Fig. 4. The results of student's answer to question number 2 of activity 1

From the results of student's answers to the question number 2 of activity 1, it is known that the student knew the sprint sport through television, books and their experiences at school. Therefore, the context used was already well known by all students and it would be easier for students to be able to complete the next question.

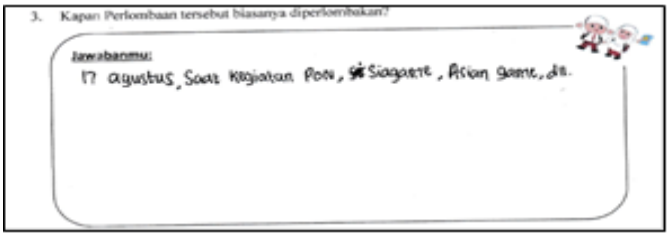

Fig. 5. The results of student's answer to question number 3 of activity 1

From the results of students' answers to the question number 3 of activity 1, the student already knew more about the context given. The student also turned out to have known that the sprint sport was conducted in the Asian Games.

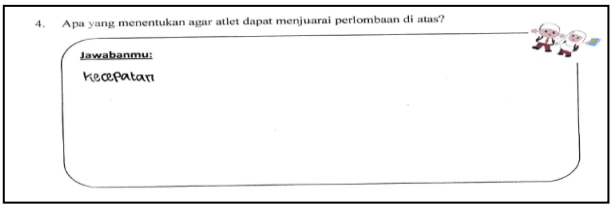

Fig. 6. The results of student's answer to question number 4 of activity 1.

The results of student's answer showed that they had good understanding about the track. The student have learned that the winner of sprint race is on speed, meaning that students will not have trouble completing the next activity. The students' knowledge about the context used in this activity is fairly good.

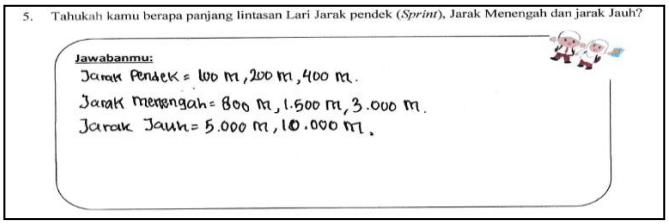

Fig. 7. The results of student's answer to question number 5 of activity 1.

From the results of student's answers, the student was able to explain the length of each running track. It was known by the students from Physical Education lesson. With the knowledge, they will not have difficulty in completing the next activity.

2) Activity 2 (Recognizing Fractions)

The purpose of activity 2 was to enable students to recognize fractions. In this second activity, students' knowledge about the sprint sport was used for completing the table provided to introduce fractions to students. The results of activity 2 can be seen from the transcript of the interview below. After students completed table 1 on activity 2, there was a process of interview.

Transcript 2

1. P: "Why can it be 100: 800?"
2. S: "100 for the sprints, 800 for middle-distance race"
3. P: "How can you make such comparison?"
4. S: "I have learned the ratio material"
5. P: "Why do you state 100:800?"
6. S: 'because this is a fraction form "(while explaining the results obtained)
7. P: "Have you learned about fractions?"
8. S: "I've learned it in 4th grade"
9. P: "It means you've known about fractions? Can you mention the numerator and denominator? (Pointing to a table equipped)
10. S: "I can" (student describes his work results)

From the interview, it is known based on points 1-4 in the transcript 2 that the the researcher asked where the student get the answer 100: 800, and then the student explained that the answer was obtained from the knowledge he had about the track, then the researcher asked back why the student can make the comparison. Apparently, based on point 4 at transcript 1, the student have learned the material in the previous class. Furthermore, in point 5, the researcher asked the student to give the reason for the answer of 100 : 800. The student explained that 100 : 800 was a fraction form he has learned in grade 4. Therefore, based on the transcript, the student has been able to determine the form of fractions and can determine numerator and denominator of the fraction. The work of the student in the second activity can be seen from Fig. 8.

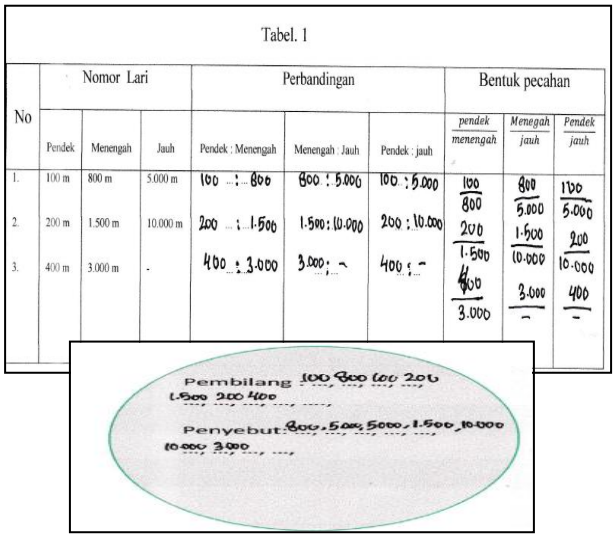

Fig. 8. The students' answers on fraction recognizion

From the results of students' responses, it appears that students have been able to make comparisons based on information about the length of the track from activity 1. After that, the students changed the comparison into the form of fractions. The students have been able to determine the numerator and denominator of the fraction in the given questions.

3) Activity 3 (simplify fractions)

The purpose of activity 3 was to find if students could simplify fractions. This activity was beneficial to students in finding equivalent fractions and fractions of the division. The results from activity 3 can be seen from the following interview transcript:

Transcript 3

1. P: "Why can it be 1/8?" (While looking at student work in simplifying the form of 100:800)
2. S: "because 100: 100 = 1, 800: 100 = 8"
3. P: "Why is it divided by 100?"
4. S: "because 100 is a factor of 100 and 800"
5. P: "There is 8/50, could it not be simplified any more?"
6. S: "It can be 4/25"
7. P: "What is your conclusion?"
8. S: "to simplify a fraction, the numerator and denominator are divided by the same number"

From the interview transcript 3 on point 1, the researchers asked where the student obtained 1/8, while initially the fraction was 100/800. The student explained on point 2 that the numerator and denominator of 100/800 were divided by 100. Then the researchers asked on point 3 of the transcript that why fractional numerator and denominator must be divided by 100. The student explained based on point 4 that 100 was a factor of 100 and 800. Furthermore, the researchers explores deeper into the student's work, and the researchers asked whether 8/50 fraction can be further simplified. The student explained that fractions 8/50 can be simplified into 4/25 that is divided by a factor of 8 and 50. According to point 8 of the transcript, it is known that the students have been able to make conclusions about how to simplify a numerator, namely by dividing fractions with denominators of equal numbers or factors.

The work of students in three activities can be described as follows. Students have completed table of activity 2. The next denomination results obtained by students in the activity of two were simplified by using the instructions presented by bar on the activity 3 as follows:

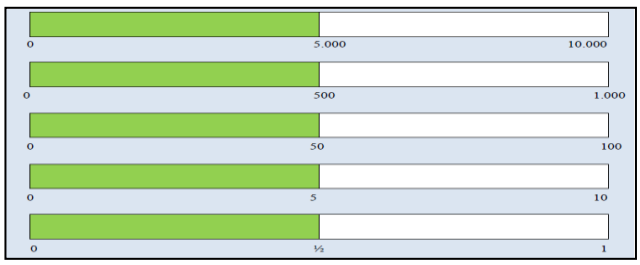

Fig. 9. The bar used as a hint to simplify fractions

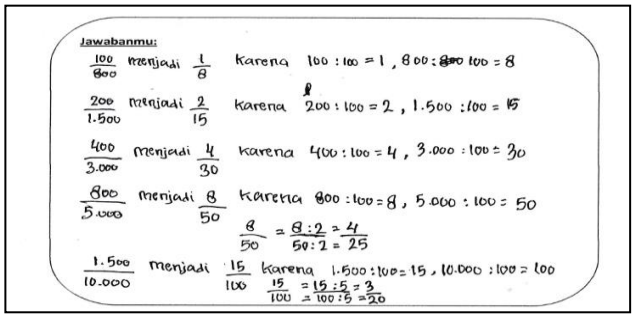

Fig. 10. Students work on simplifying fractions in activity 3

4) Activity 4 (Fraction Value)

The purpose of activity 4 was to find if students could determine equivalent fractions. Equivalent fractions are important to assist students in determining the division of fractions. The results of the activity 4 can be seen from the transcript of the interview below.

Transcript 4

1. *P: "based on the picture, now what was it?" (Pointing to provided bar)*
2. *S: "10, 20, 30 ...*
3. *P: "yes, write it down" (the students write the answers to fill in the blanks on a given bar)*
4. *P: "Which is the equivalent fraction of the fraction you mentioned?"*
5. *S: "10/100 = 1/10"*
6. *P: "Why 10/100 = 1/10?"*
7. *S: "because 10/100 was divided by the same number, namely 10, so 10/100 = 1/10"*
8. *P: "ok"*
9. *p: "What can you conclude from equivalent fractions?"*
10. *S: "Equivalent fractions have 2 fractions of equal value, meaning that one fraction is the simplest form of other denominations"*
11. *P: "Equivalent fractions are two fractions which have same value, meaning that one fraction is simplified from other fraction*
12. *S: "for example 10/100 can be simplified to 1/10"*

From the interview above, based on point 1 in transcript 4, the researchers asked students the contents of each bar on activity 4 based on the sprint context. On point 2, the student explained that the contents of the bars were 10, 20, 30, etc. to 100. The answer was obtained by the students based on illustrations presented. Then, when the researcher asked the equivalent fractions, the student explained on point 5 that the fraction value was 1/10 from 10/100. Furthermore, on point 6, the researcher asked further why 10/100 was equivalent to 1/10. The student explained that by using the knowledge obtained from activity 3, 10/100 is divided by the same number, namely 10. Therefore, the numerator and denominator of 100 were divided by 10 and the result was 1/10. According to the conclusions, two equivalent fractions have the same value in which one fraction is the simplest form of other denomination. The student thought that 10/100 was equivalent to 1/10, for 1/10 was a simple form of 10/100 showed by point 12 at transcript 4.

The work of students at 4 activity can be described as follows: In activity 4, the students presented a picture of the 7 world records including the fastest sprinter Usain Bolt as follows

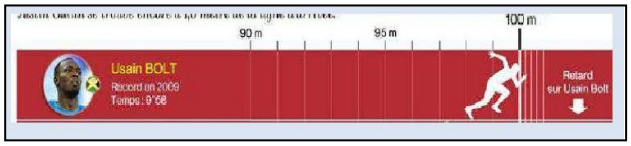

Fig. 10. The world record for the fastest runner

Then illustration above is used to supplement bars presented on four activities. The students' work can be seen from Fig. 11

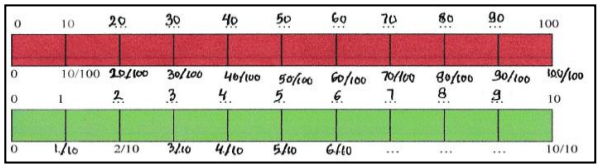

Fig. 11. Students' answer on the bar of activity 4

The student's answer on the bar in Fig. 11 was based on information obtained from the image presented by the student and also based on the track length of 100 meters. In the first bar, students would fill each box with a value of 0-100 based on a multiple of 10, and then the students would make a comparison. At the bar, two students will calculate the values in each box with the numbers 0-10 based on a multiple of 1, and then the students would also make comparisons. The results of the comparison made by students on both bars will be a reference for students to determine equivalent fractions. After the students completed the bar, then students would answer questions presented in activity 4. In question number 1, the students were asked to determine which equivalent fractions were. The results of the students' answers are as follows.

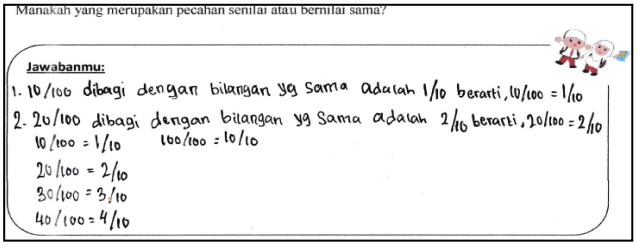

Fig. 12. The student's answers for question number 1 of activity 4

From the students' answer for question 1, it is known that the students have been able to determine equivalent fractions as well as the reason why fractions that can be categorized worth.

On question 2, students were required to conclude on equivalent fractions according to their perception. The result of the students' answer is shown in Fig. 13.

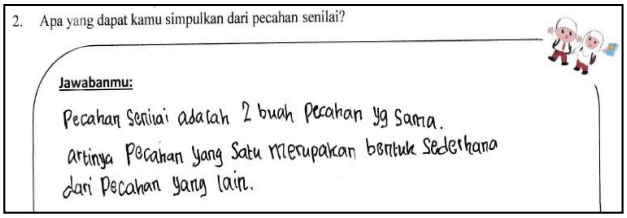

Fig. 13. The students' answers for question number 2 of activity 4

5) Activity 5 and 6 (Division fraction with integer)

The purpose of the activity 5 and 6 was to find if students can determine the distribution of fractions with integers. The results of activity 5 can be seen from the interview transcript below.

Transcript 5.

1. *P: "can you simplify 4/10?*
2. *S: "Yes, 2/5"*
3. *P: "how?"*
4. *S: "4: 2 = 2 and 10: 2 = 5"*
5. *P: "What is the results of ½ divided by 2?" (Student replied with a complementary bar)*
6. *P: "Why the contents of one box 10?"*
7. *S: "because there is a box, divided into 10 sections, can be seen from the picture above, from 0 to 100"*
8. *P: "What about the value that shaded-in?"*
9. *S: "25"*
10. *P: "how many part that be shaded-in?"*
11. *S: "2"*
12. *P: "How about results obtained?*
13. *S: "This is the same as 1/2 50/100, 50: 2 the can 25, so 25/100 = ¼, so ½: 2 = ¼"*
14. *P: "Ok, what can you conclude?"*
15. *S:"* $\frac{a}{b} : c = \frac{a}{bxc}$ *"*

From the interview, the students have been using their ability to simplify fractions. The researcher then asked how the if the fraction ½ was divided by 2. To answer the question of the researcher, the measurement taken by the student was to equip the bar and fill each box with number 10. Then the researcher asked why there was number 10 on every box on the bar? The student explained that the bar was divided into 10 squares and based on the image presented on activity 6 that its value ranging from 0 to 100 based on track length of 100 meters. The student shaded the bar and determined the position of ½ by dividing 100 into 2 parts in which each part scored 50. The student determined that equivalent fraction of ½ namely 50/100, and divided 50 into two parts, respectively 25. Subsequently, the student determined the simplified form of 25/100 which was ¼. Based on the work, the student could conclude by making common form of division of fractions based on his work in activity 6 namely $\frac{a}{b} : c = \frac{a}{bxc}$. It can be concluded that the students have been able to solve the division of fractions with integers. The strategy of the student in completing a given activity sheet was finally found. The student's work can be described as follows.

At activity 5, the students were asked to observe the sprint record image of Armin Harry. The students were required to complete the point of the track on the image, and complete table 3 provided on activitiy 5. Once the students completed the table, they were asked to infer from the results. The results of the students' answers are as follows.

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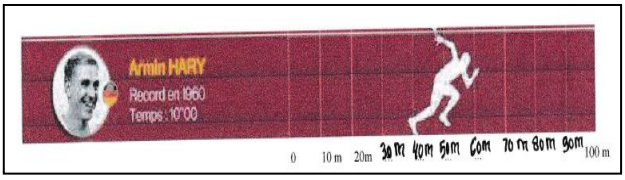

Fig. 14. Student's answer on the track points

No	Waktu (dalam detik)	Jarak tempuh (meter)	Perbandingan jarak tempuh tiap detik terhadap panjang lintasan
1.	1 detik pertama	10	$\frac{10}{100} = \frac{1}{10}$
2.	2 detik pertama	20	$\frac{20}{100} = \frac{2}{10}$
3.	3 detik pertama	30	$\frac{30}{100} = \frac{3}{10}$
4.	4 detik pertama	40	$\frac{40}{100} = \frac{4}{10}$
5.	5 detik pertama	50	$\frac{50}{100} = \frac{5}{10}$
6.	6 detik pertama	60	$\frac{60}{100} = \frac{6}{10}$
7.	7 detik pertama	70	$\frac{70}{100} = \frac{7}{10}$
8.	8 detik pertama	80	$\frac{80}{100} = \frac{8}{10}$
9.	9 detik pertama	90	$\frac{90}{100} = \frac{9}{10}$
10.	10 detik pertama	100	$\frac{100}{100} = \frac{1}{10}$

Fig. 15. The work of students completing the table at activity 5

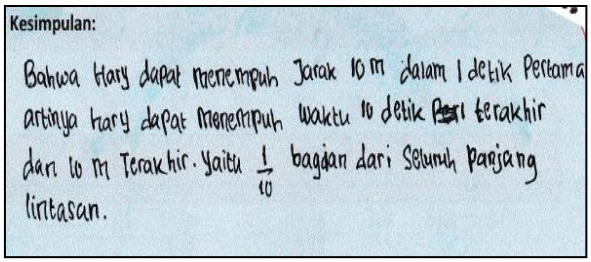

Fig. 16. Conclusions students about the activity of 5

From the work of activity 5, to complete the first table, all students observed the image on the sprint record of Harry at the final point of 100 meters and it was known that Harry takes 10 seconds to be able to reach the track of 100 meters. Based on this information, the student can determine that every second on average Harry is able to travel 10 meters, then the students

would make a comparison of mileage on every second to the length of the track. The results of the comparison made were simplified by the students. The results were used to help them to complete the work in activity 6. The work of students in activity 6 can be described as follows:

From the results of activity of 5, the average distance which is taken by sprinter Armin Harry every second is 10 meters. The students were required to complete the bar given in activity 6 based on illustrations presented before to answer questions in activity 6.

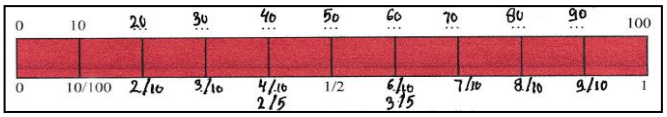

Fig. 17. The work of students in activity 6

Furthermore, the students answered the questions on the activity by seeking the division of 6 fractions with integers using the bar. The students were also required to shade the bar provided to determine the division.

In question 1, the students were looking for value ½: 2 as shown in Fig. 18.

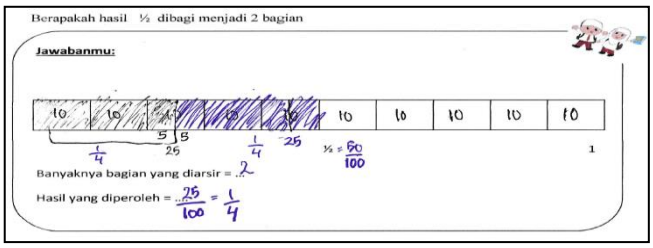

Fig. 18. The results of students' answers to question number 1 of activity 6

From the results of students' answers, to find the result of ½: 2, the students completed the bars provided. Each box was filled with a value of 10, so there were 10 boxes which means 100 as the total. The students filled in each box with number 10 because it is based on an illustration of the context of the sprint record on activity 5. Then, the next students' strategy was dividing 100 of the total value of all boxes on the bar with 2. In order to get 100: 2 which results in 50, 50 is considered as ½ part of 100, namely 50/100. Next, to determine ½: 2, the students divided 50 into two parts, so they got 25, and 25 is ¼ part of 100, namely 25/100. Thus, they found that ½: 2 was ¼.

In question number 2 of activity 6, students were asked to find 3/5: 3. The results of the students' answers are as follows.

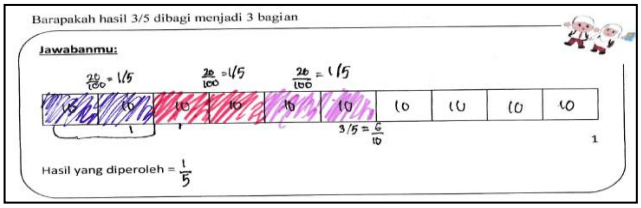

Fig. 19. The results of students' answers for question number 2 in activity 6.

From the results of students' answers, to find the value of 3/5: 3 in the same manner as the first task, the students filled in the boxes on the bar provided with the number 10. Then, the students determined the equivalent fractions of 3/5, namely 3/5 = 6/10 = 60/100, and then the students took 6 boxes of the bar with the total of 60, meaning 60/100. Furthermore, the students divided 60 by 3 = 20. Therefore, 20 is 20 parts of a 100 equivalent to 20/100 = 1/5. Meaning 3/5: 3 is 1/5.

In question number 3 in activity 6, the students were asked to find the value of 1/5 divided by 2. The results of the students' answers are as follows.

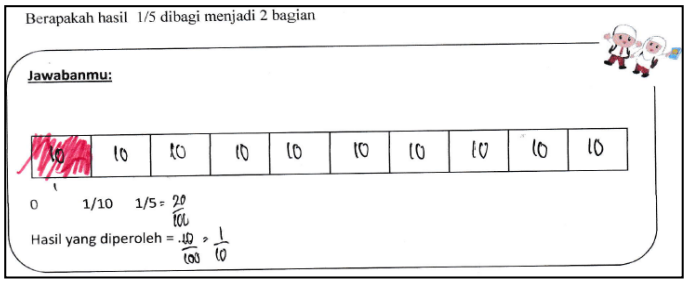

Fig. 20. The results of students' answers for question 3 of activity 6.

From the results of students' answers, to find the value of 1/5: 2, the students used the same strategy when answering questions 1 and 2, so the students could easily determine the value of 1/5: 2 = 1/10.

Furthermore, students were asked to infer the general form of the division of fractions with integers. The results of the students' answers are:

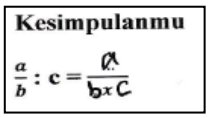

Fig. 21. The conclusion of the students in activity 6.

C. Restrospektif Analysis

From the work of the students, in general, the students could understand the activities which have been designed well enoughsince they used information obtained from the previous activities. Therefore, the students were able to find the results of division of fractions by partition bar provided as a guide. Based on the results in activity 1, 2, 3, 4 and 5, the students could conclude the general form of the division of fractions. There was no difficulty for students to solve any questions presented in corresponding activities with the HLT.

IV. DISCUSSION

The design of learning trajectory was designed and conducted by researchers to understand the division of fractions using the theory of Van de Walle. It is divided by using partition bar covering 6 learning activities that have been performed on the process of students' learning. By using PMRI approach, a series of activities to generate a trajectory study was carried out in every cycle, namely cycle 1 and cycle 2 for Pilot Experiment and Teaching Experiment.

This learning was based on the implementation of PMRI in designing each learning activity that shows the characteristics of PMRI at each activity. In general, from the first to the last activity, the students have done a whole set of measurement activity and create a partition in PMRI by using bar.

V. CONCLUSION

Based on the results and the discussion, it can be concluded as follows.

1. Hypothetical Learning trajectory that has been implemented in this study has become the Learning Trajectory that can help improve students' understanding of the lesson.
2. The Learning Trajectory implemented in this study is one of a positive contribution to developing the Local Instructional Theory (LIT) in learning division of fractions.

In general, the designed HLT has become the Learning Trajectory that helps students learn in performing operations of the division of fractions. Therefore, the researchers suggest the Learning Trajectory of divisions of fractions in this research results be implemented and developed in teachers' own learning activities. Teachers are also expected to be actively involved in designing the lesson to other materials using the suggested lesson to the curriculum that applies. Students should be more active and brave in expressing their opinions, thoughts, and ideas so that they will be able to get the ultimate the learning process in participating in learning activities. Finally, this study only focused on teaching divisions of fractions, so it is expected in the future that other researchers can develop this research not only for teaching division of fractions, but also for other materials.

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