Learning fraction through the context of Asian Games 2018

R I I Putri and Zulkardi

Universitas Sriwijaya, Bukit Besar, Palembang, Indonesia

E-mail: ratu.ilma@yahoo.com

Abstract. In August 2018, Indonesia will host Asian Games in two cities namely Jakarta and Palembang. As the researchers stay in the city of Palembang, we use this event as the context for designing mathematics lesson materials. This paper shares the results of the design research method, which aims to developing Learning Trajectory for primary school students. Three phases of design research were used namely preparing for an experiment, teaching experiment, and finally retrospective analysis. As the result, this research produces Local Instructional Theory (LIT) on fraction through the contexts of Asian Games 2018 sports namely swimming, shot put, rowing, running, and hurdles. The swimming context could stimulate students' informal knowledge about the meaning of fractions. By using shot-put context can assist students in learning the subtraction of fractions. Furthermore, running context can help students understand the division of fractions. Meanwhile, rowing context can help students understand addition and subtraction of fractions. Lastly, the context of hurdles can help students to realize their knowledge about the concept of multiplication of fractions with natural numbers. Therefore, this study contributes positively to the various parties on how to teach fractions using the contexts in the learning process of Indonesian Realistic Mathematics Education.

1. Introduction

Mathematics is not only material transferred by the teacher to the students [1, 2]. Students should not be treated as passive recipients who only receive materials with using formula and procedure to solve a problem, but students should be given opportunities and guided to the situation to reinvent mathematics concept with their ways. One of the branches of mathematics that deal with the number is the fraction. Fraction is one of the complex concepts, but students need it in the primary school [3]. Many students in the world have difficulties in learning problems that relate to the fraction [4]. In the many cities, the average of students did not have conceptual knowledge about concept, and the lesson was lack of daily lives of students [5].

According to Streefland [6], there are five levels on learning fractions based on the student's level, managing the strategy of teaching fraction, ordering the way of operation of the equation infraction, students operate fraction on their ideas with accuracy. These are relevant with the curriculum that learning not only about textual but more on the development of thinking. This skill will help students use thinking mathematically that transferable in every condition. As a professional teacher, she has to use various contexts, starting from informal to the things more formal. Instructional activity will interest in and meaningful for students and started with the realistic context which experientially real to the students.

In Curriculum 2013 stated that mathematics subject is important to give to the students starting from Primary School in order to make students competence in thinking in logically, analytics,
systematic, critics and creative and working collaborative [7]. These are relevant to the focus of the learning process. Students were expected to develop their understanding of the material that there are learning so they will more understand the given materials. Consistent with that, PMRI has character using students contribution [8]. PMRI was adapted from learning theory called Realistic Mathematics Education (RME) founded by Frudenthal [9] in the Netherlands. He suggested that mathematics should be connected to students daily lives [10]. Use of context and PMRI in designing lesson Indonesia has been conducted since 2001 [11]. It has been used in many researchers in efforts to improve attitude, motivation and knowledge of students either in the form of research by lecturers, student teachers and master students [12-16].

Learning mathematics in the school suggested connecting learning materials to the daily life. This suggestion good in the family environment, school, social with aims at finding the meaning of the materials for their daily life [17]. The role of context will make mathematics more accessible for students. Therefore, learning materials which support students improve their competencies and communication skills are needed. The learning process is not only an independent process or individual but also as social process [18, 19]. Here, interactivity is one of the five characteristics of RME or PMRI [20]. Interactivity stresses social interaction among students to support an individual process of each student. Therefore, the social norm is needed in the learning process.

The method of communication in mathematics is also supporting to develop meaning, publish ideas, and giving students opportunities to improve their understanding [17]. Therefore, activities for students are needed that support students to connect abstract thinking to more realistic so they can connect abstract thinking of students into the more real so mathematics understanding can be reached. Also, activities which used Indonesian local cultures are also has been shown in supporting students understand mathematics concept [21, 22]. However, contexts of sports in the event such as Asian Games are not used so far for research especially in mathematics for learning activities in primary school.

Asian Games 2018 is an international event which will be conducted in Jakarta and Palembang. It will be conducted from August 18th to September 2nd, 2018. This event supported by the president Republic of Indonesia with Instruction No.2 in 2016 with the aims success prestige and success in hosting the event. One of the multiplier effects are the Minister of Education and Culture to facilitate the students to join the game and to socialize the event. Therefore, activities for students using the context of Asian Games is significant to be designed. In Asian Games 2018, 37 sports will have competed. Since 2016, the citizen of South Sumatera have to make people Asian Games fever [23]. It shows that how important to socialize the event Asian Games 2018 through learning in the schools including mathematics in Primary Schools.

Based on the description above, therefore, the researcher interested into design learning realistic materials using Asian Games 2018 context in the primary school. The results of this research are expected as meaningful learning materials that support students develop mathematical thinkings from informal to formal. Therefore, the purposes of this paper are to know the role of Hypothetical Learning Trajectory realistic mathematics for primary school students using context sports in Asian Games 2018 and to produce Learning Trajectory on realistic mathematics for primary school students which are valid and practice using context sports in Asian Games 2018.

2. Method
This research used design research with the type of validation study as the research method. In collaboration with PMRI Primary Schools, data were collected using observation, interview, video camera, and test. Using design research aims at developing local instruction theory based on the theory-driven and empirically based through collaboration between researcher and teacher to improve relevance between research and regulation in educational practice [24].

This research produced five learning trajectory materials on fraction. Three phases of design research used namely preparing for the experiment, the experiment and the retrospective analysis [25, 26]. The research subjects are five PMRI schools with total of 170 students get involved.
3. Results and discussion
Using all steps of the design research, this research produced five Learning Trajectory (LT) on the materials subtraction with four operations that is the division, addition, subtraction, and multiplication of fractions. The following are the explanation of how to design the LT.

3.1 Preparing for the experiment
In this phase, the researcher discusses characteristics of students with mathematics teacher who performs as a teaching model. Based on the interview with the teacher model, the fraction is learned in the grade four. Also, the researcher explores literature on the fraction concepts and the 2013 curriculum edition revision. In addition, five contexts used namely swimming, shot-put, rowing, running and hurdles. Therea are several context implemented in learning process, such as the introduction of the fraction through rowing context (Figure 1), the addition of fraction using swimming context (Figure 2), the subtraction of fraction through shot-put context (Figure 3), the multiplication of fraction using integer and hurdles’ context (Figure 4), and worth fraction through Atletic’s context (Figure 5). Furthermore, this paper only explains the topic of adding fraction by using swimming context.

Figure 1. Rowing context [27].

Figure 2. Shot-put’s context.

Figure 3. Swimming’s context.

Figure 4. Hurdles’ context [28]

Figure 5. Running context [29]
3.2 The design experiment

3.2.1 Pilot experiment
The pilot experiment aims at as a bridge between the first phase and teaching experiment. This first cycle of the experiment tried-out the first prototype of the HLT. The experiment was followed by six students in the non-research class, which have three levels of performance. The researcher discussed the characteristics of students. Besides discussion, students were interviewed about their opinions on the learning process that was used for the restopctive analaysis. This paper focuses on the addition of fraction using the context of swimming.

3.2.2 Teaching experiment
This phase is the implementation of the revised HLT. The goal is to explore strategies and student thinking in the learning process. During the investigation, student’s conjectures can be used for the next lesson. During this phase, the role of the researcher is as both a teacher and an observer. At the end of the teaching and learning process, the researcher and the teacher do a reflection.

Results of the first phase are five topics with some activities on each. In swimming's context, three activities are designed that is understanding the fraction, adding the fraction, and fractions with same denominators or not. They do not understand the meaning of 'part' of a whole. In addition, they do not understand that two fractions with different demnumerator should be made the same before operated [16, 30]. The following shows a student has difficulties in solving a task that is related to adding of fraction. The task is as follow.

*Indah and Silvy swim in the pool, which has length, is 30 meter. After 20 seconds, Indah has been swimming 12 meters while Silvy 15 meters. What is the total distance both of them?*

From the task, students use model and understand the concept of addition of fraction with the same as well as the different denominator. Then, adding the fractions with different denominator using the context of swimming. In solving the problem, the activity used fraction bar as the media as well as the use of number line. In the activity with the swimming context, students have to add the distances reached by the athletes. First, students used fraction bar. Then, in the second activity, students used the number line. Students related to the addition operation of fractions with the different denominator.

Using swimming context, students have to add the distance of both students. In the first activity, students use the fraction bar. Then, in the second, students use the number line. Students related to the addition operation with different denominator. According to Van De Walle, *et al* [31], the long model with bar can support the student to invent components of the fractions. Figure 6 shows the right solution of the student in adding the different denominator of two fractions.

![Figure 6. A students’s solution.](image-url)
The student adds both fractions using the given fraction bar. Then, he moves the results to the given worksheet. This activity is relevant with the HLT. The following discussion shows the communication among students and the teacher about the fraction with different denominator.

Teacher : Kenapa nomor 5 [why number 5?]
Student 1 : Karena dia mau duluan sampai [because he the leader]
Student 2 : 50 meter

Teacher : Berapa bagian kolam? [how much the part of pool]
Student 2 : 100 meter... 50 meter... eh \( \frac{1}{2} \)

Teacher : Dapat darimana?[how to get it?]
Student 2 : Dari 100 meter itukan 50 meter. Setengah dari 100, 50 meter.

Teacher : Bagaimana mendapatkannya? [how to get it?]
Student 2 : 100 meter kan dibagi 2 sama dengan 50 sama dengan \( \frac{1}{2} \)

Teacher : Lalu bar kedua menunjukkan atlet nomor? [Then the second bar for who?]
Student 1 : 8
Student 2 : Atlet Jepang juga [Japan Athlete too]
Student 2 : Korea

Teacher : Korea, pintar! Berarti nomor berapa?[Korea,smart! Then what number?]
Student 2 : 8

Teacher : Bagiannya berapa?[ So, what is the part]
Student 1 : 25 meter
Student 2 : 100 dibagi 4 (100 divided by 4)
Student 2 : 25 meter

Teacher : Dapatnya darimana? [how to get?]
Student 2 : 50 dibagi 2 lagi (50 divided by 2 again)

Teacher : Berarti bagiannya berapa?[So, what is the part?]
Student 2 : \( \frac{1}{4} \)

In the next activity, students solve the different task, yet still the swimming context. Students added the two distances. The distances of both athletes were known using parts of the pool. In this task, the part of the pool using different fraction with different denominator. Then, students use the number line. It stated in the solution sheet. Students only have to measure. Example of student solution can be seen in the Figure 7.
Figure 7 shows students are able in doing addition of fractions using the number line. They are able to add fractions using the number line. In addition, a group has been understood that make the denominator are similar that can be found by using the Least Common Multiple (LCM) of both fractions. Students knew that addition of fraction with different denominators could not directly add. One has to make the denominator are the similar. It is consistent with the HLT. For more clear, it can be seen in the following transcript.

Student 1: \(\frac{1}{2}\)  
Student 2: \(\frac{1}{2}\) panjang kolam [length of the pool]  
Student 3: Sama seperti yang tadi itu [same with the previous]  
Student 2: Garis! [ line!]  
(Student menggaris pada garis bilangan- Student make a line in the number line)  
Teacher: Lalu? [ then]  
Student 3: Andi itu \(\frac{1}{3}\)  
Student 1: Seperti itu? [ Like that?]  
Teacher: Oke... Jadi itu dapat \(\frac{5}{6}\) dari mana? [Oke....then where 5/6 comes from]  
Student 2: Jarak yang ditempuh Ifan \(\frac{5}{6}\) jarak Andy \(\frac{1}{3}\) dijumlahkan [ the distance of Ifan]  
Teacher: \(\frac{1}{2}\) sama dengan \(\frac{3}{6}\) itu maksudnya?  
Student 2: \(\frac{2}{6}\) ditambah \(\frac{3}{6}\) [2/6 add by 3/6]  
Student 1: Kalau penyebutan beda harus disamakan dulu penyebutan [if the denominator is different then they have to be the same first]

In the second transcript, the students are able in pointing a point in a number line. When students have to add the two distances, students confused. This can be happened due to students have to find a value of the fraction in the decimal. Then, students order the fractios in the number line and add the two distances of the two atletes.

Then, students present their solutions in the front of the class. After classroom discussion, the teacher support students to conclude the lesson that adding fractions with different denominators cannot directly be added but one has to make the denominator are the same. All strategies can be using bar, the number line or LCM. Finally, the teacher closes the lesson.

The student's solutions are consistent with the HLT. Here one can see that sequences of instructional activities using PMRI theory shows how the characteristics of PMRI as basic of the learning process on each its activity.

There are three principles of RME or PMRI and five characteristics of RME or PMRI that are used in designing lesson materials [13, 15, 20, 32, 33]. Based on the principle of Guided reinvention and Didactical phenomenology, students were guided by the teacher using swimming's context in the Asian Games 2018. As a result, students reinvent the concept of fractions such as nominator and denominator.

3.3 The retrospective analysis

In the topic fraction using swimming context all data that were collected in the experiment were analyzed. Learning process in the first activity is consistent with the learning process in the first HLT. In other words, we can say many HLT are consistent with ALT. There are some differences such as to the students should be stressed about the meaning of fraction as a part of a whole. Students have difficulty in differentiating between part and distance. In HLT, the expected of the solution is the form of the fraction, but a number of students have the solution in the form of only the distance. This is not consistent with the assumption of the research in the beginning about adding fraction.
The first problem is about addition of problem with different denominators. Students asked to add the two distances reached by the two athletes using fraction bar. Then, students conclude their solutions. In the beginning, students are confused in using fraction bar with different denominators. However, after reread the guidelines in the worksheet, finally, students are able solve the problems. The results are consistent with the plan of HLT.

4. Conclusion
From activities can be shown that students can solve problem of adding fraction. Students work right on the track consistent with the hypothesized conjecture. Using PMRI, various solutions emerged in the student's solutions. Use of bar model in PMRI has a role in the learning of addition of fraction. Using bar model in the swimming context supports students in solving problem on fraction.

Acknowledgements
Researchers expressed acknowledgement to DIKTI-Indonesian Directorate General of Higher Education that has funded research this grants graduate.

References
[1] Gravemeijer K 1994 Developing Realistic Mathematics Education (Utrecht: CD–β Press)
[2] Gravemeijer K 2010 Realistic mathematics education theory as a guideline for problem centered, interactive mathematics education A Decade of PMRI in Indonesia eds R K Sembiring, K Hoogland, and M Dolk (Utrecht: APS International) pp 41–50
[3] Mamede E 2010 Issues On Children’s Ideas of Fraction when Quotient Interpretation is Used I-10
[4] Siegler R S, Lisa K F, Drew H B, and Xinlin Z 2013 Fraction: The new frontier for theoris of numerical development Trend in Cognitive Sciences 17 13
[5] Haris D, Putri R I I 2011 The role of context in third grader’s learning of area measurement Journal on Mathematic Education 2 55
[6] Streefland L 1991 Fractions in realistic mathematics Education (Dordrecht: Kluwer Academic Publishing)
[7] Kemendikbud 2013 Implementasi kurikulum 2013 (Jakarta: Kementerian Pendidikan dan Kebudayaan)
[8] Soedjadi R 2007 Inti dasar-dasar pendidikan matematika realistik Indonesia Jurnal Pendidikan Matematika 1 1
[9] Frudenthal H 1991 Revisiting Mathematics Education-China Lectures (Dordrecht: Kluwer Academic Publisher)
[10] Sembiring R, Hoogland K, and Dolk M 2010 A Decade of PMRI In Indonesia (Utrecht: APS)
[11] Zulkardi and Putri R I I 2006 Mendesain sendiri soal kontekstual matematika Prosiding Konferensi Nasional Matematika ke-13 (KNM13) (Semarang: Indonesia) p 1
[12] Zulkardi and Kohar A W 2018 Designing PISA-Like mathematics tasks in Indonesia: Experiences and challenges J. Phys.: Conf. Ser. 947 012015
[13] Putri R I I and Zulkardi 2018 Higher-order thingking skill problem on data representation in primary school: a case study J. Phys.: Conf. Ser. 948 012056
[14] Putri R I I and Zulkardi 2017 Fraction in shot-put: A learning trajectory AIP Conference Proceedings 1868 050005
[15] Sumarto S N, Van Galen F, Zulkardi, and Darmawijoyo 2014 Proportional reasoning: How do the 4th graders use their intuitive understanding? Int. Educ. Studies 7 69
[16] Gunawan M S, Putri R I I, and Zulkardi 2017 Learning fractions through swimming context for elementary school students Proceeding in the Fifth South East Asia Design/Development Research (SEA-DR) International Conference 2017 (Banjarmasin: Universitas Lambung Mangkurat) p 61
[17] Putri R I I 2011 Improving Mathematics Communication Ability of Students in Grade 2 Through PMRI Approach Paper presented in International Seminar and The Fourth National Conference on Mathematics Education (Yogyakarta: Universitas Negeri Yogyakarta)
[18] Cooke B.D and Buchholz D 2005 Mathematical communication in the classroom: Teacher makes a difference *Early Childhood Education Journal* 32 365

[19] Lopez L M and Allal L 2007 Sociomathematical norms and the regulation of problem solving in classroom multicultures *Int. J. of Educ. Research* 46 252

[20] Zulkardi 2002 Developing a learning environment on realistic mathematics education for Indonesian student teachers *Ph.D Thesis University of Twente* (Enschede, the Netherlands)

[21] Putri R I I, Dolk M, and Zulkardi 2015 Professional development of PMRI teachers for introducing social norms *IndoMs-JME* 6 1

[22] Mumu J, et al 2018 Construction and reconstruction concept in mathematics instruction *J. Phys.: Conf. Ser.* 943 012011

[23] Tribun Sumsel 2016 Masyarakat sumsel wajib demam asian games 2018 Available online at http://http://sumsel.tribunnews.com/2015/02/26/tahun-2016-masyarakat-sumsel-wajib-demam-asian-games-2018

[24] Gravemeijer K and van Eerde D 2009 Design research as a means for building a knowledge base for teachers and teaching in mathematics education *The Elementary School Journal* 109 510

[25] Gravemeijer K and Cobb P 2006 Design research from the learning design perspective *Educational Design Research* eds Van den Akker J, Gravemeijer K, McKenney S, and Nieveen N (London: Routledge) p 15

[26] Bakker A 2004 *Design Research in Statistics Education on Symbolizing and Computer Tools* (Amersfoort: Wilco Press)

[27] Nasution M F, Putri R I I, and Zulkardi 2017 Rowing sport in learning fractions of the fourthgrade students *Journal on Mathematics Education (IndoMS-JME)* 8 69

[28] Rahayu C, Putri R I I, and Zulkardi 2017 Multiplication of fraction with natural number by using hurdles *Proceeding in the Fifth South East Asia Design/Development Research (SEA-DR) International Conference 2017* (Banjarmasin: Universitas Lambung Mangkurat) p 43

[29] Roni A, Zulkardi, and Putri R I I 2017 Sprint context of asian games in the division of fractions *Proceeding in the Fifth South East Asia Design/Development Research (SEA-DR) International Conference 2017* (Banjarmasin: Universitas Lambung Mangkurat) p 22

[30] Halim N L A, et al 2018 Teaching strategies in the learning of highest common factor and lowest common multiple *J. Phys.: Conf. Ser.* 943 012041

[31] Van De Walle J A, Karp K S, and Williams J M B 2013 *Elementary and Middle School mathematics Teaching Developmentally* (United States of America: Pearson Educations)

[32] Putri R I I and Zulkardi 2018 Higher-order thinking skill problem on data representation in primary school: a case study *J. Phys.: Conf. Ser.* 948 012056

[33] Castle K and Needham J 2007 First Graders’ Understanding of Measurement *Early Childhood Education Journal* 35 315