Learning Design of Proportion Using Tangram Context

Andinasari¹*, Jayanti¹, and Y Wasiran²

¹Mathematics Education Department, Universitas PGRI, Palembang, Indonesia
²Politeknik Negeri Sriwijaya, Palembang, South Sumatera, Indonesia

*Corresponding author’s email: andinasari_yulianto@yahoo.com

Abstract. The aim of the study was to produce a design research method that aims to produce learning trajectories on comparative material based on the Indonesian Realistic Mathematics Approach. Design research through three stages, namely preliminary design, teaching experiment, and retrospective analysis was chosen to achieve the research objectives by designing hypothetical learning trajectory. This alleged learning trajectory was tested on 32 students in grade VII of SMP 30 Palembang. The instruments used in this study were recording devices, written test sheets; field notes sheets and questionnaire sheets. The results showed that a series of activities provided were able to stimulate informal knowledge and explore students' prerequisite knowledge as a bridge in understanding the comparison of values and turning values. The activity of drawing parts of objects to be intact stimulates students to the knowledge of comparative concepts and to the context of tangram problems students are able to model and represent problems. Furthermore, strategies used by students gradually developed into more formal mathematics where the area model was used as a model of the comparative situation of the tangram and a model for more formal reasoning such as a comparison strategy, in dividing the tangram image, as well as the multiplication of comparisons of values and turns value in solving the problem of completion of a job in the installation of tile / marble floor of the house.

1. Introduction
Mathematics is one of the lessons that must be taken by every individual through the world of education because learning mathematics has the aim of teaching in logical, systematic, structured, and critical thinking. Students are obliged to develop mathematical abilities that are useful for life in the future, where competition in the industrial era of the developed world is developing rapidly.

Indonesia seeks to implement the 2013 curriculum. The 2013 curriculum emphasizes the development of knowledge skills, attitudes holistically, and based on competencies that aim to improve the quality of national education. The 2013 curriculum formulated four basic competencies, spiritual competence, social competencies, knowledge competencies and skills competencies [1-4].

The 2013 curriculum is needed for a change in learning paradigm, where students are trained to observe, ask questions, collect data, analyze data, and communicate learning outcomes called scientific approaches, the characteristics of scientific learning used to form innovative skills namely: observing, actively asking questions, experimenting, associating and building networks [5].

The PMRI is suitable for learning methods that do a lot of activities in accordance with the 2013 curriculum at the SMP level comparative subjects in 7th grade SMP namely PMRI is a learning approach that emphasizes human activity, and is used in the context of learning according to the Indonesian situation. Mathematics learning using PMRI is a learning activity by analogy with real-life [6-8]. Based on the test results show that not all students or only a few are able to solve problems correctly, a series of tests on students' conceptual understanding of grade VII through the RME
approach, improving student learning skills based on three-tiered activities where student reasoning is formed through learning by visualizing in the first activity and comparing grades in the second act so that when answering the third activity, students are easier because students can imagine the analogy from the illustrations provided and can calculate grades [9].

After ten years of the development of PMRI, a lot of knowledge was gained about PMRI and what is considered a good PMRI education in Indonesia. Much experience contributes to standard ideas that are fully developed for various aspects of PMRI, including PMRI lessons [10]. The most important project was found to improve the mathematical abilities of students in primary schools in this reform process, namely PMRI [10]. PMRI media with tangram context in a study that tangram is a set consisting of seven flat geometric shapes that can be cut from a box. Flat structures are triangular, square, rectangular, parallelogram, trapezoidal, rhombic and kite [11, 12]. Tangram is one of the real objects that can be used as a learning medium. 1 set of tangram consists of 7 flat pieces that can be manipulated to form other shapes. With the introduction of cognitive, metacognitive, and discursive activities in studies, several methodological approaches from PMRI continue to be developed [13].

The RME theory is a theory that is constantly being developed and refined in a continuous cycle of design, experimentation, analysis, and reflection [13]. Research design plays a central role and differs from traditional learning design models, focusing on the learning process, enlarging specifically on the mental processes of students. Cyclic processes of thought experimentation and instructional experiments form the core of design research methods and serve multiple functions. They both clarify researchers about students' thinking and discuss pragmatic problems from revising the learning sequence [13].

2. Method
Research design is a research method that aims to develop LIT (Local Instruction Theory) in collaboration with researchers and educators to improve the quality of learning [14, 15]. This study uses a design research method that designs comparative material worth and reverses grades in class VII. In this study, the design that will be developed is the alleged learning trajectory or Hypothetical Learning Trajectory (HLT) which contains a series of learning activities on the topic of comparative worth and turn around grades in grade VII of junior high school.

Hypothetical learning trajectory is a researcher's guess about the series of activities a child goes through in solving a learning trajectory problem that gives a complete picture of what is happening or what is encountered, the areas that we travel through [16-18]. Design research is a cyclic process of thinking and teaching experiments [19]. The intended cyclic process is from thought experiments to teaching experiments. There are 3 stages in the implementation of design research, namely [3]

- In the first stage of preliminary design, at this stage the researcher poured an initial idea that began by studying various kinds of literature, then the researcher designed the HLT which contained the learning objectives, learning activities and alleged students' way of thinking from informal to formal stages.  
- In the second stage of the teaching experiment, at this stage, the HLT that was created was tested in stages. First, the pilot experiment stage where at this stage the researcher as teacher and model teacher observes the learning process. The second stage of the teaching experiment is conducted on a large group that is done by a model teacher.  
- In the third stage of retrospective analysis, at this stage, the researchers reflect on the learning that has been done. At this stage, the HLT that has been designed is compared with the actual student learning process and in this case, the researcher can answer the research problem formulation.
3. Result and Discussion

HLT is the relationship between learning theory and teaching trials. HLT design research serves as a developed teaching guide. Furthermore, the trial phase of HLT teaching functions as a guide for educators and researchers in teaching activities, interviews, and observations [12, 28]. The implementation in this research was held 4 times. At the first meeting the student activity sheet was given regarding the comparison material by making students draw tangram sketches. In the second meeting also provided an activity sheet about the comparison material by making it possible for students to fill in the completion time of the table in the comparison. Likewise, at the third meeting there is also an activity sheet where students can solve questions in the form of stories about worth and turn around grades. While the evaluation was given at the fourth meeting in learning in class VII of the middle school.

3.1. Exploring the Tangram Concept of the first activity

In the initial learning, the teacher first explains the concept of comparison and then comparison of values and reversals in order to direct students to their apperception activities before comparative learning is worth and turn around and what is PMRI to mathematics in accordance with dialogue quotations by showing the tangram, and ask again what images are ahead them, as shown in quote 1:

Teacher : Today we will learn mathematics with the PMRI Approach. I will share you a tangram to discuss with your group friends!
Adi : Oh this is Tangram ma’am
Ani : I have never seen Tangram ma’am
Teacher : Alright son, some of you know and have seen Tangram and some are not good at all. Let’s learn, please discuss

In LAS 1 there is Tangram picture, then students are asked to explore their initial abilities in the Tangram model where there are many flat shapes if examined deeper.

Figure 1. Student work outcomes when exploring knowledge about Tangram.

In Figure 1, students were asked to draw back the shape of a tangram consisting of 16 square flat shapes and also students were asked to find the ratio or comparison of the flat shape being worked on.
In figure 2, students can find the concept of comparison where students can find the form $a/b$ in mathematics.

3.2. Second activity: Find the concept of comparable values and inverse values

On the second day, students do several activities ranging from solving problems in tabular form to making conclusions.

For the initial context the problem given is the activity in completing tile or marble floor installation, i.e. asking whether the speed of completion of tile installation is determined by the size of the location and also the time in the tile installation.

In LAS 2 there is a table to find and determine the comparative worth and turn around the value of student work on the discussion of the installation of floor tiles that use the time speed and distance of completion space. A variety of student answers but essentially the same can use the time multiplication formula or by dividing the known.

Figure 2. Finding the comparison concept of value on tiles installation.

Figure 3. Finding the comparison concept of value and turn around value on tile installation.
In Figure 4 and Figure 5 is the way in which students solve problem-solving problems about the comparison of the value and the comparison turned around. Where can we use the ratio and also multiplication to get the results of solving the problem?

**Figure 4.** Problem solving in value comparison.

**Figure 5.** Problem solving in comparison of reverse values.
In Figure 6 in the learning process it can be Learning Trajectory (LT) in flashbacks and implementation to the end in learning the results can be seen drawn, the implementation process until the end of learning. The use of the tangram context has a role in the comparative material worth and turns around so that it supports the understanding of the concepts of Grade VII students through the PMRI approach. Students can explore their knowledge by holding the tangram and playing and learning with the tangram [20-22]. The tangram provided in this study is a starting point in mathematics learning that has a positive effect on students. Students are motivated to observe and draw tangram sketches. Students can find several ways to make students creative. The first activity is that students can make models off, namely designing and making their own tangram sketch forms.

Students can make a model by determining the completion table how much time is needed to complete the installation of tiles/marble in one room, determine the distance with a predetermined speed, make the relationship between speed and time, solve the problem of reversing value comparison, differentiating value comparison and comparison of value reversal.

The use of the tangram context has a role in the comparative material worth and turns around so that it supports the understanding of the concepts of Grade VII students through the PMRI approach. Students can explore their knowledge by holding the tangram and playing and learning with the tangram. The tangram provided in this study is a starting point in mathematics learning that has a positive effect on students. Students are motivated to observe and draw tangram sketches. Students can find several ways to make students creative. The first activity is that students can make models off, namely designing and making their own tangram sketch forms.

Students can make a model by determining the estimated completion time table needed to complete the installation of tiles / marble in one room, determine the distance with a predetermined speed, make the relationship between speed and time, solve the problem of comparative worth and reverse value.
comparison, differentiate value comparison and comparison turned around value. The provision of comparative story questions and value reversal associated with problems in everyday life can support students' understanding of formal understanding and motivate students to do activities so as to make students more creative.

The resulting learning trajectory is a number of trajectories of the learning process through which students start from exploring the tangram, finding the concept of comparative worth and turning around values, determining speed and time from a predetermined distance, concluding the relationship of speed and time, calculating the results of times the speed with time will always fixed or the same, resolving problems related to value comparisons and turned values.

4. Conclusion
It can be concluded that the Hypothetical Learning Trajectory (HLT) that has been implemented can support students to understand and solve problems of comparative worth and turn around values.

The learning trajectory consists of three activities, namely exploring knowledge by exploring tangram, modeling using measurements on tile or marble installation so that finally they can understand and discover concepts from comparable worth and turn around values. And Find/solve the problem of comparative worth and turning around more complicated values. The learning trajectories that have been generated in this study then contribute to the formation of Local Instructional Theory (LIT) for comparative material worth and turn around.

5. References
[1] Amat J, Hariyanto V L and Nuryadin E R 2014 JOE 7 14
[2] Al-Tabany, Trianto, Ibnu B 2014 Pengembangan Perangkat Pembelajaran Tematika (Jakarta. Prenamedia Group)
[3] Ghilay Y and Ghilay R 2015 International Electronic Journal of Elementary Education 7 383
[4] Jupri A 2008 Computational Estimation in Grade Four and Five: Design Research in Indonesia Postgraduate Thesis (Netherlands: Utrecht University)
[5] Darma I K 2018 J. Phys.: Conf. Ser. 953 012099
[6] Widyastuti E and Susiana 2019 J. Phys.: Conf. Ser. 1188 012052
[7] Setyaningsih 2017 Unnes Journal of Mathematics Education 6 44
[8] OECD 2016 Educational Research and Innovation (Paris. OECD Publishing)
[9] Andinasari, Zulkardi, Somakim and Wasiran, Y. 2019 J. Phys.: Conf. Series 1166 012018
[10] Zulkardi Z 2002 Developing A Learning Environment On Realistic Mathematics Education For Indonesian Students Teachers Dissertation (Netherlands:The University of Twente)
[11] Dina T, et al 2017 Journal of Open Distance Learning 9
[12] Bakker A 2004 Design Research in Statistics Education on Symbolizing and Computer Tools (Amersfoort: Wilco Press)
[13] Gravemeijer K and Cobb P 2006 Educational Design Research (New York: Routledge)
[14] Gravemeijer K and Erde DV 2009 The Elementary School Journal 109 510
[15] Hadi S, Zulkadi and Hoogland K 2010 Quality assurance in PMRI. Design of Standards for PMRI. In A Decade of PMRI in Indonesia (Bandung: Ten Brink Meppel)
[16] Simanjuntak E, Hutabarat H D M and Hia Y 2019 J. Phys.: Conf. Ser. 1188 012048
[17] Kaune C and Nowinska E 2011 Yogyakarta. The International Seminar and the Fourth National Conference pp 62-71
[18] Van Galen, et al 2008 Fractions, Percentages, Decimals, and Proportions: A learning-teaching trajectory for Grade 4, 5 and 6 Sense (Publisher: The Netherlands)
[19] Sembiring R K, Hoogland K and Dolk M 2010 A Decade of PMRI in Indonesia (Utrecht: Ten Brink)
[20] Idris I and Silalahi D K 2016 Yogyakarta Jurnal Pendidikan Matematika dan Sains 1 73
[21] Kaune C, Nowinska E, Paetau A and Griepe M 2013 JME 4 129
[22] Rasmussen C, Zandieh M, King K and Teppo A 2005 Mathematical Thinking and Learning 7 51