Realistic mathematics education with local instruction theory for enhancement students’ procedural fluency

I Nuraida¹*, Y S Kusumah², and B G Kartasasmita²

¹Departemen Pendidikan Matematika, Mahasiswa SPs. Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi, Bandung, Indonesia
²Departemen Pendidikan Matematika, Universitas Pendidikan Indonesia, Jl. Dr. Setiabudi, Bandung, Indonesia

*Corresponding author’s email: idamath@student.upi.edu

Abstract. This research is motivated by the lack of application of realistic mathematics learning and the low procedural fluency ability in schools. The research objective is to analyse the improvement and achievement of procedural fluency based on students' initial mathematical abilities in learning realistic mathematics and LIT. The research method used was design research with two cycles. Population in SMP Negeri 5 Kota Tasikmalaya with sample class XI. The instrument used in this study is the question of the ability of procedural fluency in the form of a description. Data processing uses statistical tests and research results show that realistic mathematics learning with LIT can improve procedural fluency.

1. Introduction

School mathematics learning is expected to be able to develop mathematical skills because mathematical skills are one of the goals that must be achieved in the face of modern times [1]. School mathematics learning must be able to develop mathematical skills consisting of five strands, namely: 1) Conceptual understanding (understanding of concepts): knowledge of concepts, operations and mathematical relations; 2) Procedural fluency (application of procedures): the ability to implement procedures accurately, efficiently and precisely; 3) Strategic competence : the ability to formulate, present and solve problems; 4) Adaptive reasoning : the ability to think logically and reflectively and the ability to explain; 5) Productive disposition : the tendency to view mathematics as something meaningful, useful and valuable, as well as confidence in one's own persistence and potential [2].

The teacher is expected to think about the estimated learning trajectory (HLT) that will occur in the mathematics learning. HLT development is formulated in three components, namely: 1) learning objectives; 2) learning instruments to be used; 3) hypothetical learning process that anticipates how students' mathematical thinking processes are developed. Based on this, then in developing a design of learning design it is necessary to formulate hypothetical learning trajectory (HLT). [3]

Regarding what has been stated, mathematics learning should be given by encouraging students and giving opportunities to students to try to find out for themselves through the help of teachers [4], so as to create a Local Instruction Theory (LIT). The appropriate learning approach is the learning approach Realistic Mathematics Education (RME). Regarding RME learning, mathematics should not be seen as teaching material that must be transferred directly as a ready-made mathematics, but must be viewed as a human activity [5]. Mathematics learning is done by giving the widest opportunity to students to try...
to find their own, known as guided reinvention [6]. RME should be applied in schools in Indonesia, so that student learning is more meaningful [7].

Mathematics is a human activity that emphasizes the activities of students to find, find, and build their own knowledge needed so that learning becomes student-centred. RME formulates a mathematical process, in the context of mathematics education, into two types namely horizontal and vertical mathematical [8].

The ability that is the focus of this research is the Procedural fluency ability, because this ability is an ability that needs to be given to students in solving material problems in building a side space curved. Procedural fluency is related to knowledge of procedures or algorithms, namely knowledge relating to when and how to use procedures appropriately and the skill to use procedures in a flexible, flexible, accurate and efficient manner [9]. Learning that emphasizes understanding the steps of a procedure can improve understanding of concepts in addition to the ability of the procedure itself. Procedural fluency seems to have not been maximally given to students in learning mathematics in school [10]. Learning programs that emphasize on improving procedural fluency provide opportunities for students to develop their own procedures, so students have the experience of connecting between concepts they know with procedures that make sense to them.

The analysis in this study links the students' initial mathematical abilities and school level, so that the results of this study provide novelty and a great contribution of thought to mathematics learning in particular and education in the world at large.

2. Methods

The method used in this research is the method of design research (research design) to design materials with curved side using realistic approach (Realistic Mathematics Education). This research design is a design that is suitable to answer research questions and achieve research objectives [11]. This study aims to design Hypothetical Learning Trajectory (HLT) and develop a prototype Local Instruction Theory (LIT). So far no one has researched by designing HLT and developing LIT about curved-side space building material, that is the reason researchers take research design research. This study consists of three stages: Stage preparing for the experiment / preliminary, stage teaching teaching and finally retrospective analysis [12].

The initial design stage (preparing for the experiment / preliminary) serves to implement the initial ideas obtained from the literature review on the subject matter namely curved side space, RME approach, curriculum, and research design as the basis for formulating the students' initial strategy hypothesis in material learning. Wake up the curved side space. Furthermore, design was carried out hypothetical learning trajectory (HLT) which is a series of learning activities to construct curved side space using the RME approach in which the HLT contains 3 aspects [13]. The aspects contained in HLT are: 1) learning objectives; 2) learning activities; and 3) predictions of students' thinking. This prediction is dynamic so that it can be adjusted to students' reactions during learning and revised in the process teaching experiment.

Teachers should try to guess before the onset of mental activity of students (thought experiment), then try to find the thinking of students who are actually related to suspected in the teaching process (teaching experiment) [13]. Therefore, the experimental design was divided into 2 experiments: (1) Pilot experiment which was a bridge between the initial design phase and the teaching experiment. The purpose of the pilot test activity is: (a) Tracing students' initial knowledge, (b) collecting data to support adjustments to the previous learning track plan. (2) Teaching experiments, aimed at collecting data to answer research questions. In the phase teaching experiment, researchers carried out learning in the experimental class with RME and LIT learning, while the control class with RME learning. Schools that are used as research sites are high and medium level schools.

The third stage is the teaching experiment, at this stage the data is analysed and the results of the analysis are used to plan activities and develop the design of activities in subsequent learning. In general, the purpose of retrospective analysis is to develop LIT. The research design used the pretest posttest control group design.
3. Result and Discussion
Based on the first stage, the researcher obtained products in the form of teaching materials and student activity sheets about curved side material that would be given to students to be used as material for realistic mathematics learning (RME). In the next stage, the second stage discussed data analysis related to the improvement and achievement of procedural fluency between students who received RME LIT learning and RME learning. The process of designing student learning activities, cannot be separated from the LT which has material design and concept maps that students must go through during learning. HLT development in each learning activity is a very important part in designing each student learning activity.

LT in the design research that was developed to improve the ability of procedural fluency has two cycles which ultimately produce an LIT in the material that builds up the curved side space. The following is presented the LT which was designed by the researcher:

![Figure 1. LT on spherical geometry](image)

Figure 1. Shows RME learning has a collection of activities designed based on LT and students' thinking processes that have been determined by the hypothesis. During the learning process, students are expected to improve skills procedural fluency, as in the purpose of this study. The link between the flow of student learning and ability procedural fluency is an LT that has been designed and hypothesized before. Curved-side space learning activities based on HLT.

The following is a table that describes procedural fluency achievement based on students' initial mathematical ability categories using the t-test as follows:

| Category | RME | Conv | T   | Sig. | H₀   |
|----------|-----|------|-----|------|------|
| PMK low  | 7.08| 5.75 | 3.330 | 0.003 | denied |

H₀ : There is no difference in the mean of procedural fluency achievement

Based on Table 1, the significance is less than 0.05, which means that there is no difference in the average procedural achievement of fluency between learning groups RME + LIT and RME learning groups. To analyze procedural fluency achievement based on the initial mathematical ability category and school level, the Mann-Whitney test statistical test was carried out as follows:
Table 2 Test Mann-Whitney U Achievement Data Procedural Fluency Based on categories (SA and PMK)

| Category | RME | Conv | Z      | Sig.  | H0    |
|----------|-----|------|--------|-------|-------|
| Over     | 8,44| 5,94 | -5.947 | 0,000 | denied|
| SA       | 7,47| 5,40 | -4.543 | 0,000 | denied|
| High     | 10,38| 5,67 | -4.294 | 0,000 | denied|
| PMK Average | 7,41| 5,66 | -5.400 | 0,000 | denied|

H0: There is no difference in the mean achievement of procedural fluency

Based on Table 2 obtained a significance value of less than 0.05, the null hypothesis is rejected which means that there is a difference in the mean achievement of procedural fluency between the RME learning group and the RME learning group.

4. Conclusion

Based on the formulation of the problem, the results of the study, and discussion and data analysis, the conclusions related to the development of Local Instruction Theory (LIT) in RME learning can improve skills procedural fluency. Local Instruction Theory (LIT) builds a curved side space is the result of learning trajectory that is specifically designed for the material, so that LIT has its own distinctiveness and characteristics for its own material as well. LIT development is still rare and almost never developed. LIT in RME learning is designed to improve the procedural fluency of junior high school students in grade IX. The results of the research that have been concluded are in line with the opinions of experts [14, 15]. The steps of activities that must be taken by students are as follows: (a) Activities identify elements in building curved side spaces (tubes, cones, and balls); (b) Activity finds the concept of blanket area and tube surface area; (c) Activity finds the concept of blanket area and cone surface area; (d) Activity to find the concept of spherical surface area; (e) Activities find the concept of tube volume; (f) Activities find the concept of cone volume; (g) Activity to find the concept of ball volume; (h) Activity finds the concept of volume change problems.

The achievement and improvement of procedural fluency for students who receive RME learning with LIT is greater than students who receive RME learning seen from PMK.

5. References

[1] Hudojo H 2004 Curriculum Development and Mathematics Learning (University of Malang: Japan International Cooperation Agency)
[2] Kilpatrick J, Swafford J and Findell B 2001 Adding it up: Helping children Learn Mathematics (Washington, DC: National Academy Press)
[3] Larsen S P 2013 A local instructional theory for the guided reinvention of the group and isomorphism concepts. The Journal of Mathematical Behaviour 32 (4), 712-725
[4] Gravemeijer 1994 Developing Realistic Mathematics Education (Utrecht: Technipress, Culemborg)
[5] Tall D 1991 Advanced mathematical thinking Vol. 11 (Springer Science & Business Media).
[6] Cobb P, Confrey J, DiSessa A, Lehrer R, and Schauble L 2003 Design experiments in educational research. Educational researcher 32 (1) 9-13.
[7] Nuraida I 2017 Merancang Uji Coba Realistic Mathematics Education (RME) SJME (Supremum Journal of Mathematics Education) 1 (2) 68-78.
[8] Sarama, J and Clements D H 2009 Teaching math in the primary grades Young Children 64 (2) 63-64.
[9] Laswadi 2015 Developing Mathematical Skills of Middle School Students through the Model-facilitated Learning Approach (MFL) (Dissertation is not published).
[10] Dahlan J A 2004 Analysis of Mathematical Curriculum. open University
[11] Creswell J W 2012 Research Design. Pendekatan Kualitatif, Kuantitatif, dan Mixed
[12] Akker J V D, Gravemeijer K, McKenney S and Nieven, N 2006 Educational Design Research (London: Routledge Taylor and Francis Group)
[13] Prahmana R C I et al. 2014 Local Instuctional Theory on Division in Mathematics Gasing: The Case of Rural Area’s Student in Indonesia Jurnal IndoMS-JME 5 (1) 17-26
[14] Widjaya W, Fauzan A and Dolk M 2009 The Role of Contexts and Teachers Questioning to enhance students Thinking. In U.H
[15] Prahmana R C I and Kusumah Y S 2016 The hypothetical learning trajectory on research in mathematics education using research-based learning Pedagogika 123 (3).

Acknowledgments
I would like to express my deepest gratitude to Prof. Yaya Sukjaya Kusumah as the director of the UPI postgraduate program, chairman of the UPI mathematics department Dr. Sufyani Prabawanto, Chancellor of Galuh University Dr. Yad Rospia Brata and dean of Galuh University Dr. Awang Kustiawan