E.ISSN.2614-6061
P.ISSN.2527-4295 Vol.7 No.2 Edisi April 2019

DEVELOPMENT OF *LOCAL INSTRUCTION THEORY* TOPIC STATISTICS BASED ON *REALISTIC MATHEMATICS EDUCATION* IN PRIMARY SCHOOL

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Abstract

This study aims to develop a local instruction theory (LIT) based on realistic mathematics education (RME) that is valid, practical, and effective on the topic of Statistics in the fourth grade of elementary school. The research method used is research design type Gravemeijer & Cobb (2013). The research was conducted in three phases, namely preparing for the experiment, experimenting in the classroom, and conducting retrospective analysis. This data is collected using curriculum analysis, observation, interviews, field notes, tests, and questionnaires. The collected data was analyzed qualitatively and quantitatively. Based on the research that has been carried out, LIT is produced which is valid, practical, and effective against students' mathematical problem solving abilities. Students can find Statistics with a series of activities, namely understanding data, collecting data, presenting data, and reading data.

Keywords: LIT, HLT, RME, Statistics

1. INTRODUCTION

Mathematics is one of the important lessons in elementary school. The main purpose of learning mathematics in schools is so that students are able to develop mathematical abilities to solve problems in everyday life. According to (National Council of Teachers of Mathematics, 2000) suggesting standards and benchmarks of mathematics learning is the ability to solve problems, reasoning and verification, communication, connection, and representation.

Skills in solving mathematical problems in Indonesia really need to be implemented, this is also supported by the application of Minister of Education No.22 (Permendiknas, 2006). This is also supported (Hoogland, Pepin, Bakker, Koning, & Gravemeijer, 2016) by arguing that the main purpose of mathematics education is to develop students' ability to use knowledge and abilities to solve problems from everyday life. According to (OECD, 2018), the main purpose of education is not only to regulate knowledge, abilities, skills but also they are able to use it in everyday life.

Some of the results of previous studies, found that students experience difficulties with the topic of Statistics. According to (Jacobbe & Horton, 2010), it is suggested that students in grades 3-5 (9-11) understand problems in statistics, including difficulty in grouping data, difficulty in knowing the information contained in data, and it is difficult to compare data with other data. This is also supported according to (Hayat, 2014) proposing the *Guidelines for Assessment and Instruction in Statistics Education* (GAISE) Report at the level A level of thinking (ages 5-11) students will be taught a variety of data learning to be able to develop thinking skills assimilation and distribution. This is also supported according to (Franklin & Mewborn, 2008) to improve statistics in elementary schools having a scenario in place, formulating questions with data, collecting data, analyzing data, and interpreting data.

Statistical learning carried out in schools is only the reading of the data presented. So that problems arise from the results of previous studies, also found from the results of preliminary studies that have been done. Only 50.5% of students are able to answer correctly to the 5 questions given. The difficulty experienced by students is that students do not understand the problems given and students are not able to solve problems given with statistics (49.5% students). The results of interviews with the teacher also found that learning is done by listening to the teacher's explanation of each step of statistical learning. Then students are given a number of questions in the textbook, then mention the highest data and the lowest data only.

There are problems encountered, so learning based on *realistic mathematics education* can be an alternative solution. This is evidenced by several studies that have been conducted by previous researchers, such as (Mcgatha & Cobb, 2016) the title An *Analysis of Stundent Statistical Understanding is* able to create an interesting and meaningful process of statistical learning in learning. Then Walle (2013) entitled the book *Elementary and Mindle School Mathematics Teaching Development.*

RME is an approach to learning mathematics which was first born in the Netherlands. RME interpreted as an approach in mathematics education that teaches mathematical concepts based on student experience so that it

becomes steady and meaningful (Fauzan & Sari, 2017, p. B55). In designing RME-based learning, a teacher needs to pay attention to the main principles of the RME to achieve the desired goals. Gravemeijer (Fauzan, 2002, pp. 35-43) presents three main principles of RME that must be understood, namely *guided reinvention through progressive mathematization, didactical phenomenology, and self developed models or emergent models*.

Based on the main principles of the RME, through this studywas developed *Local Instructional Theory* RME-based(LIT)for Statistics topics in elementary school classes. LIT is a theory about the learning process for a particular topic with supporting activities (Gravemeijer & Eerde, 2009, p. 512). These topics are related to Statistics. The LIT was developed in such a way as to pay attention to the principles of the RME, so that students are able to build their own knowledge through the activities contained in it. The initial form of product developed is the *Hypotetical Learning Trajectory* (HLT). This is in accordance with the statement of Prahmana (2017, p. 21) that LIT is the final product of HLT that has been designed, implemented, and analyzed the results of learning.

HLT is an activity carried out by a teacher by imagining how students think and learn in the learning activities involved. These activities are listed in the HLT component, as expressed by Simon (1995, p. 136), namely student learning goals, learning activities that students will experience, and hypotheses about student processes during learning. Learning objectives are related to the specific objectives of the topic to be learned. Learning activities are related to activities to solve constitutional problems based on the principle of RME. In addition, the hypothesis relates to the teacher's predictions about students' thinking in solving the problems given, so that the teacher also includes anticipation of predictions that arise to achieve the expected goals. Based on these findings, this study takes the title "Development of Statistical Topics Local Instruction Theory Based on Realistic Mathematics Education in Primary Schools" with products produced by Local Instructional Theory (LIT) in the form of HLT, and supported by RPP and LKPD as an alternative to overcome statistical learning problems that occur .

2. METHODS

The research method used is research development (*developmental research approach*). The development model used is *research design* type Gravemeijer & Cobb (2013). There are three phases, namely preparing for the experiment, experimenting in the classroom, and conducting retrospective analysis. This design is used in developing *Local Instruction Theory* (LIT) with the initial form of HLT. The activity begins with a *thought experiment* that is thinking about the learning path that students will go through, then reflecting on the results of the experiments conducted. If the goal has not been achieved, then thecarried out *thought experiment* andalong *instruction experiment is* with the same material, so that LIT guides the *thought experiment* and *instruction experiment*. In the long term period, the relationship is illustrated as shown in Figure 1. The HLT has been made, then the RPP and LKPD are designed according to the activities at HLT. This research was carried out in two schools, namely the SD UNP laboratory. The subject of the trial was the fourth grade students of semester 2 of 2019.

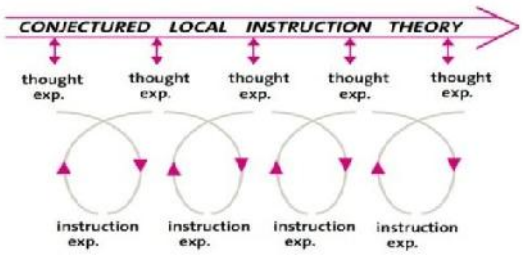

Figure 1. Reflection relationship between theory and experiment (Gravemeijer & Cobb, 2013, p. 85)

phase *Preparingfor the experiment*

In this phase, the aim is to design the product that wants to be produced , namely HLT, RPP, and LKPD. Various activities are carried out in this phase, namely needs and context analysis, literature review, product design, and formative evaluation. Need and context analysts are carried out by analyzing curriculum, concepts, students, and the environment. The literature review was conducted by reviewing the literature on RME and Statistics. The results obtained are guidelines for designing products. Meanwhile, formative evaluation activities are doing *self evaluation* and *expert review*. *Self evaluation is* done by reviewing typing errors, content conformity, and product attractiveness before being given to the validator in the *expert review*. *Expert reviews are* carried out with discussions with the content, language, and child development validator of the product designed. The results that appear in the discussion are subject to revision.

No	Nama Validator	Ahli
1	Prof.Dr.Ahmad Fauzan,M.Ed.	Mathematics
2	Dr.Darnis Arif,M.Pd.	Languange
3	Dr.Syahniar,M.Pd.	Child development

Fase *Experimenting in the Classroom*

Phase Experimenting in the Classroom

Activities carried out in this phase are product implementation that has been validated by the validator as a continuation of the stages of

formative evaluation, namely small group, and field test.

The product is implemented to three people who are selected based on their low, medium and high abilities, this phase is called one to one . Then proceed with the Small group consisting of three small groups of students consisting of 3-5 people to evaluate the practicality. The small group is divided into low ability groups, moderate ability groups, and high ability groups. Grouping is based on the results of interviews with teachers. During the learning process based on the HLT and RPP, students carry out learning activities using the LKPD. Furthermore, learning activities that have taken place are analyzed by looking at the achievement of the product, while determining the practicality, namely HLT that has been designed, such as goals, activities, predictions, and anticipation of the learning process. The results of the analysis, followed by making revisions to produce the products to be carried out in the field test.

Field tests in an effort to determine practicality and effectiveness. Practicality is determined by giving questionnaires to students and filling out observation sheets, as well as field notes. Meanwhile, effectiveness is carried out to find out the effects or impacts of LIT. Activities are focused on evaluating the tests given at the last meeting to find out whether the designed LIT has an effect on students' problem solving abilities.

This phase of the Conducting Retrospective Analyze

is in conjunction with thephase experimentingin the classroom. This phase is very instrumental in pilot activities during small groups and field tests. This phase aims to reflect on the implementation implemented. When HLT lacks achievement, the teacher reflects deficiencies that occur during implementation. The teacher can determine the probing question that can guide students to solve the problems given. After making improvements to the shortcomings encountered, the teacher implements these improvements again until the desired goal is achieved. In the end, HLT which has been carried out until the end of themeeting field test and has not been repaired, has become a product called the local instructional theory (LIT).

3. RESULTS AND DISCUSSION

Phase preparing for the experiment

results of the curriculum analysis found that Statistics that learned in grade IV is conducting an analysis of teacher and student books book in circulation, and KD were used in pembelajaran.Terdapat pengembanan in the indicator, into understanding the data, collect data , presenting data, and reading data. In this case, the expected achievement is that students are able to use statistics in solving problems found in everyday life. Then, the results of the student analysis found that fourth grade students of the UNP Laboratory as the subject of this study had a preference for red, blue and yellow LKPDs. Meanwhile, the results of the environmental analysis found that most parents worked as traders, a habit given by the school as a routine program was supplementary eating, eating fruit together, tahfiz, and breakfast together.

The results of a literature review on RME found that RME learning is very concerned with three main principles, namely guided reinvention through progressive mathematization, didactical phenomenology, and self-developed models or emergent models.

In the principle of reinvention, students are given the opportunity to experience processes that resemble mathematics created. With regard to this principle, the learning path must be mapped by allowing students to find their own mathematics. Then, Didactical Phenomenology deals with instructional development that must give students contextual problems taken from real and meaningful phenomena. Meanwhile, self-developed models play an important role in bridging the gap between informal knowledge and formal knowledge.

The learning process involves horizontal mathematization and vertical mathematization. Students have the opportunity to solve contextual problems by using informal language as horizontal mathematization. After students experience a similar process in some time, informal language develops into more formal or standard language. In the end, students are able to use mathematical algorithms. This is called vertical mathematization. In this case, horizontal mathematization and vertical mathematization are illustrated in 4 learning objectives that will be achieved, namely students can find the meaning of data, able to collect data, able to present data, and able to read data as shown in

Figure 2. Statistical Learning Flow of Class IV Students Primary

Four objectives achieved by students until students are able to find and use Statistics carried out with a series of continuous activities. The activity of each meeting begins with giving constellation problems regarding the previous material, explaining the purpose of learning, dividing students into small groups, asking about contextual problems, conducting questions and answers, discussing problems in the LKPD,

responding to problem solving by other groups, discussing , and evaluate.

Products that have been designed and carried out self evaluation, followed by validation to three experts, namely the content validator, language validator, and graphic validator to produce a valid product. The results of the content validator that the product generally has a B value with a slight improvement. The suitability is the use of problems and alleged student activity. Then, the language validator also gives B value to the product. Suggestions given are font usage, font size, and sentence suitability. Meanwhile, the product value graphically is B. The advice given is the suitability of paper size and image clarity.

Phase Experimenting in the Classroom and Thephase Conducting Retrospective Analyze

Producthas been valid, followed by conducting atrial small group and field test. The small group trial phase was carried out on 9 fourth grade students at the UNP Laboratory. The trial is carried out outside the learning hours. The trial began on February 11, February 12, February 13, February 21, February 22, February 25, and February 26. The results encountered, for 4 meetings for one to one and 4 meetings for thephase Small group there are several forms of answers written by students.

On the first day, students are expected to understand the concept of data. With 2 activities given, there is horizontal mathematization to become vertical mathematization. This is found in the form of answers written by students, although there are still some students who do not understand the meaning of data. However, students' answers to Activity 1 and Activity 2 have different forms or answer patterns. In activity 1, students are presented with a data that contains 3 kinds of information, but in the activity 2 students are presented with data that contains 5 kinds of information,

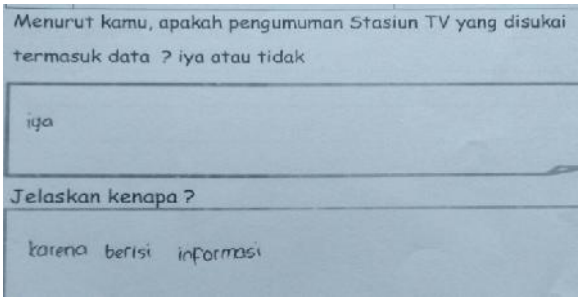

Figure 2. Student Answers to LKPD 1

On the second day, students are expected to be able to determine strategies in collecting data consisting of interviews, observations and questionnaires. In this case, the concept of completion that has been used before becomes horizontal mathematization of students to complete activity 1 and activity 2 LKPD 2 .. Based on the answers found in activity 1, students have determined strategies in collecting data on the problem that has been determined, but there are still students who unable to determine the strategy in solving the problem of collecting data.

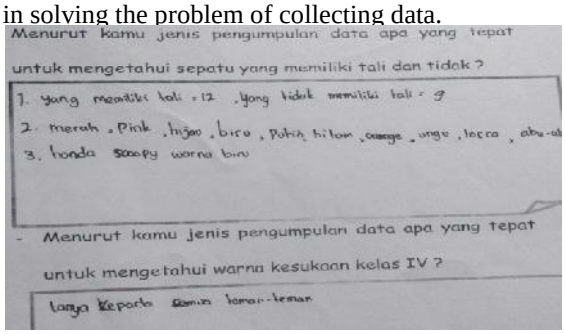

Figure 3. Answers of LKPD 2

On the third day, students are expected to be able to resolve the statistical contextual problems by presenting data that has been collected at the previous meeting. The results of two activities are given that students are able to present data. The thing found in Activity 1 is that students choose a lot of data presentation with bar charts. While activity 2, students prefer bar charts than other forms because they are often found in everyday life.

On the fourth day, the previous learning experience is a provision for students to reach the top of the learning path that is implemented, namely reading data In activity 1, students are presented data then students read any information contained in the data, students find the highest data information, the lowest data and compare data. While activity 2, some students only determine the highest, and lowest data, and do not compare data.

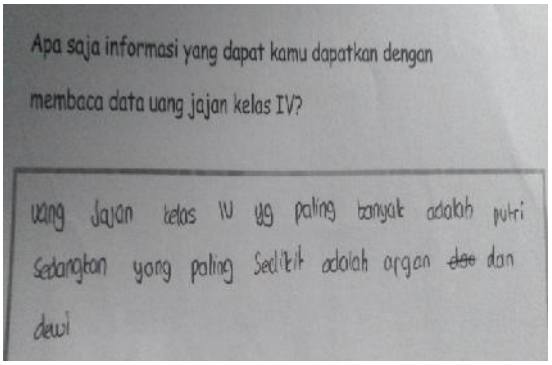

Figure 4 LKPD Answers 4

The results found in the small group trial became an improvement material for product implementation in the actual class trials. Various improvements were made, namely the prediction of problem solving activities to be carried out by students and anticipation to be made through probing questions.

Day 1 Understanding Data

During activity 1 in the LKPD, there are students who are just silent and do not understand what is being done to solve it. At that time, the teacher gives questions to students, such as the conversation below. The question is an anticipation

that the teacher has prepared to guide students during learning activities.

Teacher : Do you understand the problems that occur in the problem given?
Student :No sir?
Teacher :Have you read the question?
Student :already
Teacher :Try to repeat the question again, and what is meant by the question?
Student :Sir, the question is whether this information includes data.
Teacher :So, do you think the information above includes data?

This is in accordance with (Ryan, nd: 2007) revealing that there are several problems that occur in statistics of students aged 4-15 years, namely: misreading, missing meaning of the task, transformation of errors, incorrect processing, and incorrect encoding.

When activity 1 has been discussed, students are then given the same problem but with more diverse data on activity 2 in the LKPD. The results of the comparison of answers to the two activities found that many students experienced confusion again in terms of data, so that before starting the lesson the HLT had been prepared as a guide in implementing learners to help achieve learning goals like this.

No	Prediction	Anticipation
1	**If students appear confused or silent to solve problems the**	teacher gives a *probabing question* "What should we do in solving the problem given?
2	**If the student does not understand the question (*missreading*)**	teacher gives a *probabing question* "try to repeat the question given?
3	**If the student understands the question but cannot answer (*Miss Comprehension*) The**	teacher gives a *probabing question* "try to read the information title and what is contained in the information provided
4	**If the student is able to answer, but cannot make conclusions the**	teacher gives a *probabing question* " what do you understand from the information above?

Figure 5. Hipotytycal Learning rajectory meeting one

Day -2 Collecting Data

On the second day, there were two activities completed by students. The expected end result is that students can use Statistics ten to solve a contextual problem regarding Statistics. The tool used to help students solve problems is fake money. However, on that day, students chose not to use the tools provided in solving problems.

In activity 1, students determine the right strategy in collecting data. Then, the teacher provides guidance through a series of questions, as below.

Teacher : *Do you understand the question given?*
Student : *Understand sir, we determine th strategy of collecting data.*
Teacher : *How is the most appropriat strategy used to find shoes thc have straps and those that wea straps?*
Student : *We collect all the shoes an group them*
Teacher : *Is that the right way to solve th problem*
Student : *Hmm ...*
Teacher : *Discuss with your group friends!*

In activity 2 LKPD, students have started to collect data, there are three techniques to collect data that is done by students, namely asking questions, interviewing, and observing data collecting.

Figure 6: Data Collection Activities withinterview

3rd Day. Presenting Data

On the third day, students are expected to be able to present data that has been collected at the previous meeting. To support the achievement of learning objectives researchers designed HLT for the third meeting which was adjusted to the results of the study (Cobb & Mcclain, 2003), (Cobb & Mcclain, 2003) and (Franklin & Mewborn, 2008) as below:

:No	Prediction	Anticipation
1	**If students appear confused or silent to solve problems the**	teacher gives a *probabing question* "What should you do to solve this problem?
2	**If the student presents with a point diagram (plot) the**	teacher gives a *probabing question* "are we presenting the data correctly to the teacher?

3	**If students make the presentation of data with blockplots the**	teacher gives a *probabing question* "does this data presentation make it easier to read data?
4	**If students make a pigtogram (diagram with pictures) the**	teacher gives a *probabing question* "can your diagram be changed to be more easily understood?
5	**If students make the Plot Block the**	teacher gives a probabing question, Is using the picture the most appropriate way to present data?

Picture 7: HLT for presenting data

When students use Statistics ten, then the teacher guides students with questions, as below.

Teacher : *Are you having problems?*
Student : *I am not presenting data.*
Teacher : *You have seen the data. What i the presentation of the data?*
Student : *There is a column, there is a ba diagram, there is aline diagram*
teacher : *Can you determine th presentation form that is suitabl for your data?*
Student : *Yes bu*
Teacher : *Now discuss with your gro friends.*

Finally, students can present data, but there are still students who have not been able to explain the reasons for choosing the data in their chosen form.

4th day. Reading Data

Students read the data that has been presented, students read the data and write down the information obtained such as the highest data, the lowest and compare between data.

Based on the activities and findings of student answers, it can be described the form of changes in the answers of students who initially know the meaning of data, followed by data collection, presentation and reading data. The main results of this study indicate that through the activity of resolving contextual problems in each learning flow, students can use statistics to solve problems in everyday life. With the three main principles of RME which are the basis of learning activities, the practicality of learning that is carried out shows very practical criteria with a value of 85%. Meanwhile, product effectiveness has a positive impact on students' problem solving abilities. This is reviewed from the results of the evaluation at the end of each meeting which shows 85% of students have problem solving skills with very good criteria.

5. CONCLUSION

Local Instruction Theories developed on the topic of Statistics with realistic mathematics education in elementary school students in elementary school meet the criteria of valid, practical, and effective. Valid criteria are reflected from the results of validation assessed by experts. The practical criteria reflected in the assessment of the learning process carried out through observation sheets and questionnaires, and students can work in accordance with the hypothesized. Meanwhile, effective criteria are reflected by being able to improve the mathematical problem solving abilities of elementary school students in elementary school.

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