

# Using Learning Trajectory Real Function Based on Realistic Mathematics Education to Increase High Order Thinking Skills of The Students' at SMAN 10 Padang

1<sup>st</sup> Arnellis  
*mathematics department*  
*State University of Padang*  
Padang, Indonesia  
arnellis\_math@fmipa.unp.ac.id

2<sup>nd</sup> Ahmad Fauzan  
*mathematics department*  
*State University of Padang*  
Padang, Indonesia  
fauzan\_math@fmipa.unp.ac.id

3<sup>rd</sup> Made Arnawa  
*mathematics department*  
*Universitas Andalas*  
Padang, Indonesia  
arnawa1963@gmail.com

**Abstract**— This research aim are to produce Learning Trajectories of material in real function based Realistic Mathematics Education and to describes the potential impact of its use in learning mathematics toward students at SMA 10 Padang on High Order Thinking Skills. The method is design research, which three stages: preparing for the experiment, conducting, and the retrospective. The first, teaching and learning plan was design after reviewing related literature. The second, tests were held in 32 students of eleventh grade of SMA 10 Padang. The data were obtained through video recording, field note, and posttest. In the end of the study, we evaluated whether the designed LT is running as expected. From the results of this study has been designed Learning Trajectory real function material based on Realistic Mathematics Education. The results show that the designed LT can work well. We obtained that there was an improvement of the students' in their high order thinking skills after attending the class by using the Realistic Mathematics Education on real function. The percentage of learning score was 85.32%

**Keywords**— *learning trajectory, real function, realistic mathematics*

## I. INTRODUCTION

Increasing the ability of high-level thinking has become one of the priorities in school math learning. In the regular 21 in 2016 on standards of content it is noted that the subjects of mathematics are given to all students to equip them with logical, analytical, systematic, critical and creative thinking skills, as well as the ability to cooperate [1]. The High Order Thinking Skills (HOTS) has appeared in national exams in Indonesia despite the new high-level thinking skills included in the 2013 curriculum that are currently being refined-. In this new curriculum, the teaching of mathematics includes a mission to build students' competence from elementary school level to senior high school in improving their ability.

Learning Trajectory can explore students' experiences with realistic mathematics education. Teacher facilities are tailored to the characteristics and stages of student thinking development in which students directly study at the formal

stage. Learning Trajectory adjust the characteristics of students in providing student learning facilities. The fundamental changes in the role of students as knowledge developers, preparation of teachers in designing Learning trajectory based on real mathematics education and real estate learning aspects that emphasizes the development of high-level thinking skills of students, the study focuses on Learning trajectory of real functions based on real mathematics education is expected to improve students' high-order thinking skills. The objective of the research is to produce the practically, and effective Learning Trajectory (LT) based on Realistic Mathematic Education so that it can be used to build students' high thinking ability in understanding relation and function.

Learning Trajectory is a science that studies how students learn as well as how students think that is applied in learning Innovative teachers build Learning Trajectory by studying how students think and learn through various references and facilitate student learning by linking the material before, the material of the real function is taught, and the material after learning real functions [2]. Learning Trajectory on how students learn and how students think that has implications on HOTS. Learning Trajectory can be applied by teachers by facilitating student learning in learning tools and learning process that is held in accordance with the 2013 curriculum using scientific approach and authentic assessment. The teacher adjusts the way of thinking and learning of high school students. There are three main components from the *learning trajectory*, [3] namely: learning aims (*learning goals*), learning activities (*learning activities*) and learning process hypothesis (*hypothetical student learning process*) who anticipate how to develop mathematical thinking process high level students.

Realistic Mathematics Education (RME) is the approach in learning in mathematics education. Freudenthal [4] who said that mathematics closed to contextual [5]. This effort is made through exploring various situations in day life. The principle of rediscovery can be inspired by informal solving procedures, while the process uses the concept of mathematization.

Higher-order thinking skills are defined as follows: "With HOTS students will be able to learn more deeply, knowledge is thick, Activities that can develop students' HOTS skills are seen in answering innovative questions: [6] Is there another way? (What's another way?), What if ...? (What if ...?), Which wrong? (What's wrong?), and What will be done? (What would you do?). HOTS development investigated by concluding that teachers' are preparation in teaching materials. In preparing the lesson, teachers need to make predictions about how students might learn mathematics in particular, a prediction of how thinking ability will develop in learning activities designed by teachers. A learning trajectory (LT) is provided by the teacher with a rationale for selecting a learning path so that the teacher can make design decisions in best estimates.

## II. METHODS

Based on the objectives to be achieved, the type of research that will be conducted is Design Research (DR) [7]. According to Gravemeijer, there are three step of design, namely preparing for the experiment, conducting, and retrospective analysis. First, the purpose of preparing phases is to formulate an alleged learning path that can be expanded / described and improved upon experimental design [7]. To make a functional LT perform a literature review and divide several stages from the preparing phase as follows: Specify End Points, Determining Starting Points.. LT Early Design. Conducting the Experiment. Second, the experiment, this phase is to test refine alleged learning path that has been developed in the preparation and design phase, as well as see how LT works. At this stage, LT design is used as a guide (Guideline) implementation of learning activities.

**The Retrospective Analysis.** The third stage is the retrospective analysis. The purpose of retrospective analysis would depend on the theory and design of the study [7]. In the retrospective analysis phase, an analysis of the validity and effectiveness of the learning flow is performed. Validity of data in this research is done by triangulation of data. As mentioned before, data collection is done by video recording, field notes, documentation, and tests. Furthermore, to see the effectiveness of the real function LT is done an analysis of post-test results related to the ability of high-level mathematical thinking of students. The analysis is done by percentage technique.

## III. RESULT AND DISCUSSION

In LT designing this function follows the following steps: Objective: Finding the Function Concept, What hypothesis will occur about how students learn and think high level (HOTS) Possible answers from student, Provide Anticipation by preparing the Alternative Solution of the above questions, and Probing Question (question of investigating) of student's answers.

For LT operational, the Learning Implementation Plan (RPP) is designed which contains three components in the learning path, ie learning objectives, set of activities or steps to be taken for the purpose, and hypotheses about how students learn and think high level (HOTS) by preparing an alternative solution to the question, probing question of the

student's answer. Findings of LT analysis results that have been designed and tested in cycle 1 is in small groups associated with the concept of functionality is generally inhibition epistemologis students belonging to 4 types. Type 1 deals with the concept of student image. This happens because students tend to have difficulty recognizing the form of functions both presented in cartesius charts as well as set of consecutive pairs. Type 2 deals with students' thinking ability in presenting functions into three forms (arrow diagrams, set of consecutive pairs, and cartesian coordinates). Type 3 deals with the naming rule of the function and type 4 relates to the application of the function. Problems that arise during the test are limited to small groups; is that students can not give a reason for the situation in function or not function.

After the LT that has been made in this research is implemented to some students of class XI found that students are able to overcome this problem. Similar to the student's answer during the initial test, almost all students illustrate this situation into the arrow diagram. This means that the arrow diagram is the easiest diagram for students to distinguish relationships that are functions or not functions. The next student difficulty in solving the problem is to apply the concept of algebra they have learned in junior high. Therefore, in the process of learning the material rules of function, apperception of the concept of algebra must be emphasized. The results of this student's answer indicate that there are still students who are mistaken in the concept of algebra. However, the concept of rules of function is enough they understand.

LT that have been designed and tested in cycle 1 are validated by mathematicians. LT validation results say LT is valid and fit to be used to teach real function topics. LT that has been validated by experts is tested in the second cycle of learning through a large group. After learning by applying the LT real function with RME approach, positive attitude of learners start to be seen. They began to be passionate and active in learning. Learners begin to be motivated with the LT that has been designed.

Based on the experimental results of the learning flow in both cycles, at meeting 1 there is no contextual problem that requires the learner to solve the problem. All activities at meeting 1 aim to introduce the basic concept of function to the learners. Then at the 2nd meeting the learner began to solve the contextual problem in their own way. This is a situational stage and learners perform a process of horizontal mathematization [5]. Contextual problems are given in accordance with the learning objectives. The thinking of real functions is developed through activities that involve relations in context and problem-based situations that vary without reference to rules and formulas. At the beginning of activity 1, learners are asked to draw an arrow diagram of how many hours their average learning time is in a day. Then they are asked to determine a relation that you might think describes the length of time that the five companions learned. Learners develop symbolic models informally on the given problem. Then the learning runs interactively, ie the learners explain and give reasons for the answers given, understand the answers of friends, find alternative answers, and reflect on each step taken on the results obtained. After being able to develop models

informally (horizontal mathematization), then learners are directed to think formally (vertical mathematization).

After the relationship is obtained further learners are told that the special relationship is called a function. Learners are asked to define what is meant by the function and write the function formula in the mathematical language. In activity 2, the learner again was given a contextual problem that determines presenting the function into three forms (arrow diagram, set of consecutive pairs, and cartesian coordinates). In the activity of 2 students have done vertical mathematization and learners already familiar with the concept of function. In vertical mathematization, learning also begins with real problems, devise specific procedures that can be used to solve without the help of context. Learners directly solve problems using the concept of the function they have gained on activity 1.

At the 3rd meeting, learners do the horizontal mathematization because the issues discussed have shifted to the naming rules of function and application functions. The designed learning activities will stimulate the mindset of learners for higher-order thinking, where problems are using the concept of naming rules and where problems are using application functions.



Fig. 1. The activity of student learning at XI MIA SMAN 10 Padang

Learners understand the concept of function through activity 1 that is determining the relationship length of study time of five friends, while in activity 2, learners directed to understand the concept of presenting the functions into three forms through akvititas determine the relationship of many fifth friend of the friend. Learners will find that the problem on activity 1 is a problem related to the relation and the problem on activity 2 is a problem related to the function.

The emergence of RME characteristics as described, encouraging learners to always interact well between learners with students and learners with teachers. In class discussions, all the interesting strategies found by learners are discussed that enable learners to know the truth of a concept. Thus, the process of interaction continues not only between learners in one group but with other groups in the classroom. It can be said that LT real function based on RME can develop and improve the ability of high-level mathematical thinking of students.

The description of students' activity showed that the number of worksheet which student have done right in each meeting as diagram following below

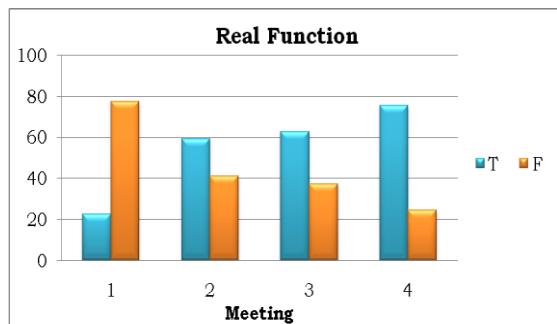


Fig. 1. The number of completed worksheets by students

Based on diagram, it can conclude there was increasing to do worksheet in every meeting. Student completeness percentage reach 85.32% with Minimum Exhaustiveness Criterion (KKM) is 80. In other words, developed LT is effectively used in studying material of real function, especially to develop student's high level mathematical thinking ability. In addition, the results of the study show that the resulting LT can improve the process and student learning outcomes.

#### IV. CONCLUSION

Practical LT based real-time LT design has been developed and can improve the mathematical thinking ability of high grade students of grade XII SMAN 10 Padang. LT developed effectively used in studying the material of real function, especially to develop the ability of mathematical thinking of high level of student. It is shown that the percentage of students' learning mastery reaches 85.32% with Minimum Exhaustiveness Criteria (KKM) is 80

#### ACKNOWLEDGMENT

We thank for headmaster of SMA 10 Padang, mathematics teachers and State University of Padang had been supported by facilities and expertise that greatly assisted in this research.

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