Innovation of learning line on research in mathematics education to support students in conducting research

Denny Haris¹, Chairunisah²
Dept. of Mathematics Education, Universitas Negeri Medan, Medan Indonesia
Dept. of Mathematics, Universitas Negeri Medan, Medan Indonesia

E-mail: dennyharis08@gmail.com

Abstract. Learning of research method required effective instruction to help students developed research and academic writing skills. Various approaches had been offered to overcome this obstacle. However, these approaches do not have a special treatment to produce a model of instructional activity in generating research and academic writing well. This paper aims to describe the activities structure of a developed learning line to support research and academic writing skills for students in the mathematics education department. The design research method containing preliminary design, teaching experiment and retrospective analysis was applied. The research described how developed learning line on research contributed to 30 students in mathematics education department in Universitas Negeri Medan. Explicitly, the developed learning line on research was successful in promoting understanding of a research process.

Keywords: Learning Trajectory, Research Skills, Writing Skills, Design Research

1. Introduction
Indonesian research publications are now first ranking in ASEAN [1]. Various attempts were made by the government under the Ministry of Research and Technology of Higher Education to achieve this position, ranging from strengthening research funds to providing rewards for those who made it into Scopus indexed international publications. To maintain the quality of these achievements the government also requires and involves students in writing scientific articles [2]. The work done is strengthening students in conducting research and writing research reports in theses. These activities are expected and expected to produce a quality scientific article or journal that is ready to be published in national and international journals. Similar to most universities in Indonesia, there is a spirit of mathematics education students to conduct and write the results of their research in international journals. In reality, students have little experience in developing studies related to research and academic writing skills [3]. Therefore, students require an essential and effective strategy to help them to develop research skills.

Kumar [4] developed three phases of research developed into the research journey. Prahmana & Kusumah [5] developed a learning trajectory in mathematics education research. At the university level, the learning process is connected to research [6]. Consequently, learning research in university demands essential support to develop research skills. This study aims to create the students' worksheet based on learning trajectory developed to improve the skills of conducting and writing basic research.
on mathematics education students. An overview of the students' worksheets based on the learning trajectory to improve the skills in researching mathematics education was investigated in research question as follow, “How can research-based students’ worksheets in mathematics education be used to support prospective mathematics teachers to conduct research?”

2. Research Method

This study used design research as a tool to answer the research question so that research objectives were achieved. Design research is a research method that aims to develop a local instructional theory through collaboration between researchers and teachers to improve the quality of learning [7]. This research developed the students' research-based worksheet. It involved 30 students of the mathematics education department in Universitas Negeri Medan. Research activities consist of three phases that were distributed to students by designing research-based worksheets. The research activities implied as follows:

- Phase I is the preliminary design. At this stage, literature reviews were carried out on a research-based worksheet so that the conjecture of the student's initial thinking strategy can be organised about the research and its methods. Then, this stage identifies the problem of why a research-based worksheet is needed. The development of research-based worksheets also pays attention to curriculum analysis, design of learning plans to be carried out, and preliminary observations to determine the students' initial abilities. This student's initial ability in research knowledge is the basis to the design of learning trajectory and hypothetical learning trajectory. Conjecture of the local instructional theory is formulated into research learning objectives, research learning activities, and tools to assist the research learning process.

- Phases II is a teaching experiment. This second stage is trying out a research-based worksheet designed in the first stage. This trial aims to explore and hypothesize students' strategies and thoughts regarding research skills during the learning process. During the learning process, the conjecture can be modified as a revision of local instructional theory for the next activities. Researchers focus on observing each activity and significant moments during the teaching experiment. At this stage, a series of learning activities are carried out. The researcher observes and analyzes what happens during the trial process of the research-based participant worksheet. It aims to evaluate the conjectures contained in research learning activities.

- Phase III is a retrospective analysis. After the trial, data obtained from research learning activities are analyzed. The results of this analysis are used to plan activities or to develop designs for subsequent learning activities. The purpose of retrospective analysis, in general, is to develop local instructional theory. At this stage, HLT compared with actual student learning and the comparisons become the basis for the answer to the problem formulation.

The three stages of this research were carried out repeatedly (see figure. 1)
3. Research Result and Discussion
In the preliminary design, the initial idea of developing students' worksheets based on the learning trajectory developed was implemented by reviewing the literature, analyzing learners, and studying teaching materials in mathematics education research. At this stage, an analysis of the initial abilities of students is also carried out by observing mathematics education students at Medan State University. Some of this data analysis forms the basis for designing HLT. The recent research produced HLT which consists of learning objectives, learning plans, and learning process conjectures. Simon [8] pointed out that the learning process conjecture aims to anticipate the development of student understanding in learning activities.

This research aimed to develop a research-based worksheet. Constructed activities refer to the hypothetical learning trajectory (HLT). The design learning activities requires HLT that was developed in each learning activity of research methods [5]. Learning trajectory that contained a learning plan is designed to foster student skills in conducting research. The activities designed are then applied to the learning of research methods. This study divided nine activities that were completed in one semester (16 meetings). All activities designed in this study were tested. The data collected is documented and analyzed retrospectively. It resulted in a local instructional theory that being the principle and direction of designing student worksheets in mathematics education research.

Figure 1. Design Research Phase for Research-Based Worksheet
Plomp [9] stated that a statement that develops based on suggestions was needed to solve a research problem. Therefore this research provided the learning trajectory (a procedure built to produce targets to be achieved) (see figure 2).

![Learning trajectory developed of research in mathematics education](image)

**Figure 2.** Learning trajectory developed of research in mathematics education

On the path of constructing the research idea, students conduct activities analyzing scientific articles. The dominant research article analyzed was mathematics education research. The purpose of this activity was to strengthen students regarding the types of research methods used in mathematics education research. This activity also motivated students to explore information about the latest research trends. The end of this activity was students presented the results of their analysis.

In planning the research activities, students were trained to observe mathematical education research problems in class. Next, they compiled the research instrument as a research data collection tool. At this stage also determined the research sample. The end of this activity was students designed mathematical education research and link it with relevant research. This activity objected to select references that can be used to support their research. At the stage of conducting the research, students carried out research based on research designed. Students also validated the research instruments developed. The result of this activity was students collecting all research data through documentation and research instruments. Furthermore, students compiled a research report in the thesis.

All activities developed through student worksheets have a good impact on students in constructing research and writing in the form of a thesis. The results showed that the learning trajectory used as a guide to designing worksheets provided knowledge about the steps in formulating the problem, determining the right method, and conducting research. Finally, students earn experience and skills in conducting research based on procedures built into learning trajectory.
4. Conclusion
Implementation of learning trajectory designed to become a guide for developing student worksheets in research methods courses. The results concluded that student worksheets developed based on research could foster student skills in conducting research and writing them into the thesis. Each research subject had a different level of achievement in conducting research.

References
[1] Hutapea E 2019 Publikasi Riset Indonesia Kini Peringkat Pertama di ASEAN, www.kompas.com. [Online]. Available: https://edukasi.kompas.com/read/2019/10/16/08511601/publikasi-riset-indonesia-kini-peringkat-pertama-di-asean?page=all
[2] Peraturan Menteri Pendidikan dan Kebudayaan (PERMENDIKBUD) Republik Indonesia Nomor 49 Tahun 2014 Tentang Standar Nasional Pendidikan Tinggi
[3] Prahmana R C I and Kusumah Y S 2016 The hypothetical learning trajectory on research in mathematics education using research-based learning Pedagogika 123 p 42
[4] Kumar R 2011 Research Methodology: A Step-by-Step Guide for Beginners (SAGE Publications)
[5] Prahmana R C I, Kusumah Y S and Darhim 2017 Didactic trajectory of research in mathematics education using research-based learning Journal of Physics: Conference Series 893 1 p. 12001
[6] Camacho Rivadeneira, M H, Valcke M and Chiluiza Garcia K 2017 The effect of research based learning activities’ on students’ intention to do research in graduate courses 9th International Conference on Education and New Learning Technologies, EDULEARN 17 p. 6571–6579
[7] Gravemeijer K and Eerde D V 2009 Design research as a means for building a knowledge base for teachers and teaching in mathematics education The Elementary School Journal 109 5 p. 510–524
[8] Simon M A and Tzur R 2004 Explicating the Role of Mathematical Tasks in Conceptual Learning: An Elaboration of the Hypothetical Learning Trajectory Mathematical thinking and learning 6 2 p. 91–104
[9] Plomp T 2013 Educational design research: An introduction Educational Design Research eds T Plomp and N Nieveen (Enschede: SLO) pp. 10–51