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Didactic trajectory of research in mathematics education using research-based learning

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Abstract. This study aims to describe the role of research-based learning in design a learning trajectory of research in mathematics education to enhance research and academic writing skills for pre-service mathematics teachers. The method used is a design research with three stages, namely the preliminary design, teaching experiment, and retrospective analysis. The research subjects are pre-service mathematics teacher class of 2012 from one higher education institution in Tangerang - Indonesia. The use of research-based learning in designing learning trajectory of research in mathematics education plays a crucial role as a trigger to enhancing math department preservice teachers research and academic writing skills. Also, this study also describes the design principles and **7** characteristics of the learning trajectory namely didactic trajectory generated by the role of research-based learning syntax.

Keywords: Design Research, Research-based Learning, Research Skill, Academic Writing Skill, Didactic Trajectory

1. Introduction

Indonesian Directorate of Higher Education Institution to encourage more research and publications by students including undergraduate students issued a policy [1]. Furthermore, the National Standard Qualification [2] requires students to publish their studies in a reputable national journal (acknowledged by KKN level 6). On the other hand, some researchers have documented the success of research-based learning to enhance students' skills in conducting research [3, 4, 5], but most of them still focused on the students who come from the non-education department. Therefore, this study develops learning trajectory of research that focused on mathematics education.

2. Literature Review and Research Question

Research skills represent a set of abilities which are required to do a research, including the strategies and instruments to gather and evaluate information which consists of observing, formulating research question, building a hypothesis, conducting experiment, analyzing data, and drawing a conclusion [6, 7]. In accordance to that, Majelis Profesor Riset Lembaga Ilmu Pengetahuan Indonesia (The Council of Research Professor of Indonesian Institute of Science) [8] stated that research skills are the skills to conduct scientific study in attempt to find truth with the implementation of scientific methods which are based on tested scientific reasoning. Furthermore, these **25** are important for preservice teachers since developing such skills would help them building a **strong intellectual and practical** connection **between research and their own**

learning process [3, 9]. Thus, when students possess these skills, it would be easier for them to do a research.

Willison & O'Regan [5] developed six research skill indicators that classified into five levels of research. Furthermore, Dowse and Howie [10], conducted within the framework of design research, sought to design and develop an academic research writing intervention. Prahmana & Kusumah [11] identified that the learning process at the university did not offer enough support for students to develop their academic writing skills. Therefore, this study aims to develop a learning trajectory of research in mathematics education using design research methodology to enhance research and academic writing skills for pre-service mathematics teachers.

Based on the problems mentioned, the success of the learning activities to improve pre-service teachers skills is investigated in research question as follows, *"To what extent do the didactic trajectory on research in mathematics education in assisting pre-service mathematics teachers to enhance their research and academic writing skills?"*

3. Research Method

This study uses a design research as the research method, which is an appropriate way to answer the research questions and achieve the research objectives that start from preliminary design, teaching experiments, and retrospective analysis [12]. Design research is a methodology that has five characteristics, namely interventionist nature, process oriented, the reflective component, cyclic character, and theory-driven [13]. Design research is a cyclical process of thought experiment and instruction experiment to implementation [14]. According to Freudenthal [15], students given the opportunity to build and develop their ideas and thoughts when constructing mathematics. Teachers can select appropriate learning activities as a basis to stimulate students to think and act when creating mathematics.

The 35 pre-service mathematics teachers during eight months period from one higher education institution in Tangerang - Indonesia was collected. Initial data analysis of 35 pre-service teachers research and academic writing skills conducted in six stages and the learning trajectories on this topic were identified [11]. This study consists of three steps repeatedly done until the discovery of a didactic trajectory that a revision of the theory of learning tested.

4. Research Results and Analysis

The design principles are statements heuristics (heuristic statements) based on the input or suggestions based on research to solve a problem [16]. The statement should always develop in certain situations, so it does not guarantee success in another situation. However, the report is getting better, when validated in various situations. Therefore, all activities that are designed and implemented in this study documented and analyzed retrospectively to generate design principles in local instruction theory (LIT) on research in mathematics education (one set of procedures and conditions that lead to the achievement of learning targets) as shown in Fig. 1. Further, the characteristics of LIT on research in mathematics education provides a quirk in the design principles that produced.

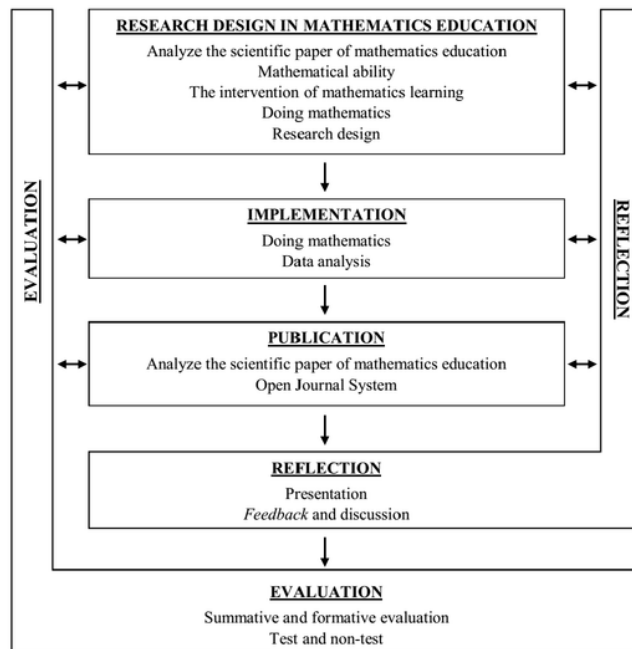


Figure 1. Didactic trajectory of research in mathematics education

The design principles of the learning trajectory of research in mathematics education namely didactic trajectory in mathematics education research is the research-based learning activities were carried out in 16 meetings in Research Methodology course. The activities were divided into two major parts of the learning activities in the classroom (Mathematics Education Research Design, Publication, Reflection, and Evaluation) and data collection in schools (Implementation). During the learning activities in the classroom, students are given the opportunity to learn about how to examine the scientific article mathematics education research, formulate research problems of mathematics education that consist of facts, procedures, principles, and mathematical concepts. Students study some mathematical ability and its indicators, such as the ability of mathematical understanding, mathematical problem solving, and the mathematical representation. Lastly, students conduct research data processing, making inferences, writing scientific articles based on research data that collected, and submitting scientific articles in national journals indexed Google Scholar using the Open Journal System. Activities reflection carried out at each learning activities in the classroom to provide feedback and understanding of the material that is being studied in the form of discussions and presentations, while the evaluation activities carried out on all activities to see achievement in each learning activity.

The didactic trajectory on research in mathematics education was developed based on the principles of research-based learning to cultivate the students' skills in conducting research and writing scientific papers. Those principles are: (1) teaching material enriched by the faculty research that can be used as a reference in conducting research for students; (2) a number of the findings of recent studies on mathematics education research trends, use and find the history of inventions; (3) learning activities enriched with contemporary research issues in the world of mathematics education; (4) the material taught mathematics education

research methods in the early learning process; (5) learning activities enriched with mathematics education research activities on a small scale is done in groups; (6) enriched learning activities with the involvement of students in mathematics education research activities that carry the name of the institution (Student Creativity Program Research [20](#)); (7) enriched learning activities by encouraging students to become part of the culture of research in Mathematics Education courses; and (8) the learning activities enriched with values that must be owned by a researcher [see e.g. [4, 5, 7, 11, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27]].

In addition to the principles above, there are some characteristics of the didactic trajectory that has been developed to cultivate the skills of researching and writing scientific papers. These characteristics are (1) the student as a center of learning; (2) the role of a facilitator of learning is held fully by the lecturer; (3) the student has a project on the study of mathematics education; (4) the results of the research are integrated with learning materials; (5) The student is required to play an active role in the implementation of the mathematics education research; (6) the research instruments used during the learning process; (7) the research context developed inclusively (the students learn the procedures and results of research to understand the intricacies of synthesis); and (8) the results disseminated in scientific forums or scientific journals of mathematics education by students, facilitated by lecturers [11].

The whole subject of research succeeded in doing mathematics education research and publish the results of their studies in the form of scientific articles. These results show that the didactic trajectory in mathematics education research that consists of 7 activity [23, 28] has provided knowledge about the various problems faced by the students about their ability to solve mathematically and measures formulated in the form of mathematics education research. Students also gain experience teaching activities (provide treatment) in the classroom to resolving the problems that hypothesized. Lastly, students gain experience in research data processing until the conclusion of the results of research and then write it in the form of scientific articles. Students feel their skills in doing research and writing scientific papers grew and developed after completion of all activities in the learning trajectory of research in mathematics education that has been in the design.

5. Conclusion

This study develops a learning trajectory of research in mathematics education using design research methodology to enhance research and academic writing skills for pre-service mathematics teachers. The product of development is didactic trajectory on research in mathematics education that gives real contribution to improving their skills. Initial data analysis of 35 pre-service teachers research and academic writing skills conducted in six stages and the learning trajectories on this topic identified. The 35 pre-service teachers were divided into ten groups and did research independently to produce ten scientific articles that published in ten different Nasional Journal. The retrospective analysis occurred in the teaching experiment showed that these pre-service teachers were on the level 3 (20%) and 4 (80%), based on research skill indicators developed by Willison & O'Regan [5]. The academic writing skill category of these pre-service teachers was excellent (30%) and good (70%), based on academic writing skill indicators developed by Supriyadi [28].

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