Analysis of mathematical didactic situation constructed by prospective teachers based on learning trajectory

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Abstract. The key to the success of a prospective teacher in conducting teaching practices is the didactic situation that is built. If the first step is successful, then the learning process will go well. This study aims was to analyse the mathematical didactic situation built by prospective teacher based on its learning trajectories. This research was a descriptive qualitative study, with the subject of the study being 3 prospective teacher students who have been practicing teaching in class in PPL activities or taking data for their final project. Data was generated from learning documents, Teacher's books, and interviews with subjects. The results of the study indicate that there were criteria's for the resulting didactical mathematics situations, as well as the presence of obstacles in lectures. It was recommended to conduct research to build meaning and build new designs that encourage prospective teacher students to build constructive mathematical didactic situations.

1. Introduction

To learn mathematical concepts a student can build in his mind based on a high-level pedagogical concept. To find out how far the mathematical concepts are understood, assessment is one of the tools [1]. One that drives the building process in his mind is the ability of students in theoretical analysis In APOS theory (Actions, Processes, and Objects as well as organizing them in the Schema), mathematical knowledge is essentially a tendency it has to respond to mathematical problem situations faced through reflection on problems and their solutions in a social context. The reflection is done through the construction of actions, processes, and mathematical objects and organizing them in a scheme that can be used in relation to the problem situation at hand [1,2].

In another opinion, mathematical knowledge is obtained from the practice and the process of doing that is based on activities related to mathematics [3]. The activity is obtained from a learning activity that encourages students to do, observe, measure, draw, and end with a conclusion [4]. The student activity is a form of mental action of students who are doing the learning process. Regardless of how students learn, mathematics education emphasizes the active involvement of students in building their own knowledge [5,6].

Activities generated in learning will develop students' thought processes [7]. In each rung of his cognitive process, he was assisted by problems that encourage him to actively learn and build his own knowledge. This then builds a learning trajectory [7,8]. Thus, the key to successful learning lies at the beginning of each step in the learning trajectory. When the teacher succeeds in developing a didactic
situation that encourages student mental action, which was indicated by learning activities related to mathematics, the student's knowledge was strongly expected to be achieved.

Teacher actions in class were very influential in mastering students' mathematical concepts. In the didactic triangle, the mastery of mathematical concepts by students was a form of students' knowledge (Way of understanding, WoU) facilitated by the teacher in building thought processes in thought processes. The way the teacher facilitates students was a form of knowledge that was apparent from WoU Teachers. If the steps in mental action were fail, however effective the pedagogical activities that were designed at the WoT stage, it would not build good knowledge. This shows that teacher learning planning has not succeeded in building student knowledge.

The study of prospective teachers was always interesting. In previous research prospective teachers attracted the attention of researchers to see aspects of their ability to recognize evidence of students' understanding of concepts [9]. The way a prospective teacher asks, based on their experience and implementation in the curriculum, and has also been studied before [10]. In essence, the teaching process in the classroom by prospective teacher was actually the transformation of prospective teachers, from learning to teaching [11]. What distinguishes it from previous research was that it examines the didactic situation developed by prospective teachers that was more general. This certainly became more interesting to be studied.

If students were not able to receive the initial information built by the teacher, the first step, which was to encourage student mental action, was not going well. What happened then was, the teacher re-explained the meaning of the problem and the situation that was built. Students actually no longer need to transfer information from the teacher, but rather look at the mathematical knowledge that was in life [12]. That was what underlies the birth of constructivist mathematics. Therefore, the study of the teacher's ability to construct mathematical didactic situations, mathematical learning environments, or problems, in accordance with student learning networks becomes important to do.

2. Method

This research was a descriptive study with a qualitative approach, to describe phenomena [13]. Specifically, this study intends to describe the phenomenon of didactic mathematical situations or mathematical problems presented by prospective teacher students at the beginning of a step of learning trajectory (furthermore in the context of this research, the intended teacher was a prospective teacher).

The phenomenon was then described based on: 1) The ability to build a mathematical situation by looking at what students are mastering first; 2) The ability to build mathematical situations by observing the learning footprint; and 3) Ability to build constructive mathematical situations. The stages of this research are: 1) determining the research problem (in which it is implied about determining the location of research and the literature used); 2) determine the research subject; 3) collecting data; 4) analyzing data, including reducing data; 5) verify data; and 6) writing qualitative narratives [13,14,15].

The subjects of this research were 4 prospective teacher students with codes S1, S2, S3, and S4. S1 has done learning in junior high school for the thesis data retrieval process, S2 is in the process of mentoring with lecturers and tutors for teaching in schools in the framework of thesis preparation, while S3 and S4 are students who have finished carrying out PPL assignments in junior high. S1 and S2 pack the ICT-assisted mathematics learning in the form of an android application that utilizes augmented reality, while S3 and S4 package mathematics learning with the help of the slide presentation application. To strengthen the results of the descriptive analysis, the researcher made observations on the teacher, the Learning Tools (Lesson Plan, Student Worksheet, and Media) used, the Teacher's Book.
3. Result and Discussion

3.1. Research Result

3.1.1. Data Reduction. Of the four research subjects, after deeper exploration, we found only three subjects that were suitable as sources of data and information for this research. We could not continue the S2 subject as a source of information because the subject could not convey the description of learning properly.

3.1.2. Learning Tool Analysis Result. There were three things that became the focus of researchers in analyzing the learning tools of the three research subjects, namely: 1) Seeing how the prospective teacher analyzes Basic Competence (we usually called with KD), so that it raises indicators, both supporting and key; 2) Analyze the lesson plan document (we usually called with RPP), especially in the core activities, whether this activity reflects the achievement of supporting indicators, up to the key indicators; and 3) Analyzing Student worksheet (we usually called with LK), whether it has created a constructive mathematical situation.

Of the three research subjects, we found the fact that all subjects had obtained the same subjects as their basis for teaching practice in schools. However, each understanding of KD was not the same. S1 also explained that he did not check the achievement of these indicators individually. He said that his belief was based on answers in the group. This is actually in accordance with the concept of social constructivist, that communication, interaction, and other verbal languages were needed to solve problems [12,16]. However, in the concept of radical constructivism, what S1 did was a contradiction. In learning, one must be able to find out for themselves what was learned. In learning, students must be able to construct what was obtained from the teacher. So, the examination should whether students learn or not, was personal [3,12].

From the interview, it was found that the three subjects have understood how to describe KD as an indicator. If we look more closely in KD, there were two operational verbs, namely “to distinguish” and “determine”. In the foregoing, the indicators compiled were only describing the operational verbs, “determine”. The operational verb “distinguishes” that the supporting indicators have not yet been compiled. When we compared Teacher’s Books [17] and lesson plan, compiled by S1, it was showed that there were different steps in implementing learning. S1 need to add recalling the element of cube because he wants his students started learning from what they were good at. This was in line with Vygotsky’s, that to achieve mastery of concepts, one must start from the known [18].

However, S3 stated that the mastery of student prerequisites was very lacking. At least, half of the students in their class didn’t know, didn’t understand, how to read Cartesian coordinates. This became problematic, because the mathematics problems built by S3 became meaningless. Mastery of this prerequisite material was needed because to understand the higher structure a comprehensive understanding of the previous structure was needed [19,20]. In practice, S3 repeated how to read the Cartesian diagram, before entering into the core material, the locus.

The next analysis was focused at the worksheet (LK), see Figure 1.

![Translated from the original. From figure above, point position can be determined. Point A has 6 units distance from X-axis and 3 units distance from Y-axis. Point B has ... units distance from X-axis and ... units distance from Y-axis. Point C has ... units distance from X-axis and ... units distance from Y-axis. Point D has ... units distance from X-axis and ... units distance from Y-axis. Point E has ... units distance from X-axis and ... units distance from Y-axis. Figure 1. Excerpt of LK, made by S3](file://C:/Users/username/Downloads/LK.png)
In Figure 1, it was clear that the worksheet that was compiled still contained a line of information and missing lines that the students would fill out. If you look at the characteristics of the worksheet, S3 actually wants students to duplicate what was in the example. He tries to give students experience in the information in the first part, with the hope that students will gain knowledge after working repeatedly. This brief habituation was suitable with the theory of behavioristic, which states that student behavior changes, based on experience, was the sign that the student have been learned [21].

3.1.3. Didactical Mathematics Situation Analysis. The didactical mathematics situation was the teacher's action as a first step to encourage students' mental actions on each learning trajectory. The learning trajectory was defined as a teaching process that based on the student learning trajectory as a basis for decision making [8]. Furthermore, the learning trajectory was marked by a series of tasks to activate mental activities [7]. The didactical mathematics situation that was built by S1, was in form of a sequence of teacher instructions followed by students using LKPD and augmented reality applications, built by S1 itself.

While compiling the lesson plan, S3 did not use the theory of learning trajectory. He compiled by describing the sequence of problem-based learning, namely: providing stimuli, identification of problems, data collection, data processing, and proof. At each stage, he describes the activities carried out by students. Questions in LKPD as listed in the above snippet can be seen in Figure 3 as follows.

3.2. Discussion
From the explanation above, several findings in this study can be conveyed. First, the things that encourage the research subjects to produce works as in the above findings were: (1) Practical. The time for implementing teaching practices was quite short.; (2) Ewuh pakewuh. In Javanese terms, ewuh pakewuh was quite dominant in the concept of daily communication, including in the academic atmosphere at school. Ewuh pakewuh was a condition of respecting others because they were older, or because they were more experienced. In their previous teaching practice experience, prospective teacher students did not yet have strong authority in classroom management, so they tend to follow existing traditions. To be able to teach well, teachers were required to know many other things, for example, about students' learning styles, about the economic, social, and cultural conditions of their students, and about the cultural, social, and political context in which they work [23].
The explanation above actually showed that there was a learning obstacle in the lecture process. These obstacles seem to tend to be external, namely cultural obstacle. It is difficult to find the kind of obstacle. There were three kinds of obstacle, namely: ontogeny obstacle, didactical obstacle, and epistemological obstacle [24]. However, if explored further, there were an epistemological obstacles experienced by the three subjects. Epistemological obstacle of the above problem because of lack of understanding of its functional needs [25,26]. These obstacles were leaps from what was known to what was needed. This was similar to the findings in previous research, but different in the object of study [27,28]. Didactic triangle of the problem of understanding and obstacles was suitable with the theory of learning mathematics [29].

**Second**, that the didactical mathematics situation that was built, was not based on the learning trajectory. All three subjects have tried earnestly to translate KD into supporting and core indicators, but the elaboration of these indicators had not yet illustrated the learning trajectory to reach the concepts. The three subjects tended to carry out different activities, different problems, but with the same and repeated student mental actions.

**Third**, that from the search to the teaching kit, teaching materials, media, and interviews with research subjects, criteria for the subject emerge, which were seen based on the ability to build didactical mathematics situations. **Criteria 1.** Subject based on the ability to build a didactical mathematics situation by analyzing what students have mastered. S1 subjects did this, which starts the material by reminding students about the elements of space shape. What S1 was done in the learning, accordance with the order of students' cognitive processes 18 and previous research [30]. S1 brings the distance between concepts that have not been mastered with knowledge that has been well mastered. S3 and S4 didn’t do this.

**Criteria 2.** Subject description based on the ability to build didactical mathematics situations by observing the learning trajectory. Building a problem situation based on an analysis of learning trajectory was in line with previous research related, that the ultimate goal of learning was actually to accommodate students' learning trajectories [8,31].

**Criteria 3.** Subject description based on the ability to build constructive didactical mathematics situations. From the analysis of the teaching aid and confirming through interviews, the fact was that the three subjects were still developing persuasive mathematical situations. In concept building activities, students must be involved in experiencing activities [4], hunting, representing, exploring, manipulating the patterns, and suspecting patterns [32]. The instruction techniques used by the three subjects tended to be the same, namely explaining, giving questions in LK or Learning Media, and concluding. Student knowledge construction was more dominant when the teacher explains, so the concept of finding their own knowledge did not occur. This was in contradiction with previous research which states that knowledge was acquired in its own way, although to master that knowledge, students need to verify and confirm with friends or teachers [3,12,16]. Mastering mathematical material independently through an active thought process will be able to improve students' self-efficacy [33]. In the end, if student had high self-efficacy, they will see a problem to be solved and faced, not to be avoided [34,35].

4. **Conclusion**

Based on the results of the study and discussion it was concluded that there were three criteria for the subjects based on their didactical mathematics situation built by prospective teacher students. These criteria indicated the existence of obstacle in lectures to prepare prospective teacher students. Based on the research findings, to strengthen the meaning of the research results it was recommended to conduct further research related to the results of the analysis, especially the obstacles that lead to the understanding of student prospective teacher. Furthermore, larger research, to build lecture designs that produce perspective teacher who were able to build constructive didactical mathematics situations, needs to be done.
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