Assessing didactic mathematical knowledge for teaching geometry transformation

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Abstract. The purpose of this study is to assess the pre-service teacher's mathematical knowledge for teaching geometry transformation material. Teacher content knowledge is a critical focus of educational research in light of the potential impact of teacher knowledge on process teaching and learning. There are learning obstacles for students in learning mathematics including ontogenic obstacles, epistemological obstacles, and didactic obstacles. This research is qualitative research with a hermeneutic phenomenology approach. That is used to find out more deeply about the phenomena. The results of the study revealed that pre-service mathematics teachers rely on their past experiences as math students and also their work experience compiling a learning obstacle. The next result shows that the level of knowledge of transformation geometry content is still low, this can hinder the teaching process of the subjects. The last concluded pre-service teacher mathematics need developing the required professional knowledge and skills requires to exercise analyzing the learning obstacle continuity

1. Introduction

The mathematics classroom should not be a closed and self-reproducing system developing its concept meanings, rather, the meanings that are to be constituted in the classroom should be related to practices and meanings outside school [1]. Researchers have worked on the concept of teachers’ didactic competence as a substantial element of pedagogical competence [2]. Mathematical competence is fundamental support for a good quality teaching of mathematics and a mathematics teacher should know the mathematics at the educational level he/she teaches, but he/she must also be able to articulate this knowledge with those corresponding to some higher-level [3]. For the learning process to run effectively the teacher must know and understand in depth the mathematical concepts they teach and be able to utilize knowledge in their teaching assignments.
Consequently, pre-service teachers’ education should take into account developing didactic mathematical knowledge and competence regarding mathematics concepts. Mathematical knowledge models for learning developed so far have categories that are too general and unrelated, so it would be more useful if the knowledge model can be analyzed so that it is more effective if used in learning mathematics [4]. The teachers’ knowledge is not only “knowing things” (facts, properties, if-then relationships…), but also knowing how to identify and solve professional problems, and, in more general terms [5]. System for analyzing mathematical teacher knowledge models, called "Didactic Mathematical Knowledge (DMK)", the DMK model places didactic mathematics as a scientific discipline that systematically articulates various aspects implicit in the learning process teaching mathematics [6].

Teacher knowledge can be built from the analysis and description of activities needed for planning, managing, and evaluating mathematics lessons [7]. Thus, the problem of teacher knowledge can be considered as an integration of knowledge, abilities, and attitudes to action. Learning obstacles experienced by the students lead to the level of mathematical ability they have [8]. Learning obstacle analysis becomes one of the alternative activities to increase the didactic competence and pedagogical competence of pre-service mathematics teachers. Learning obstacles in three types comprising: 1) ontological obstacle (due to limited learning development); 2) didactical obstacle (due to the learning system) and 3) epistemological obstacle (due to students’ knowledge is limited to certain contexts) [9].

Mathematics teachers have difficulty in identifying students' misconceptions and predicting students' thinking processes [10]. Then the other research aims to find out whether the mathematics teacher can identify and handle students' misconceptions related to material angles in geometry [11]. Then the research aims to test and highlight the extent to which the ability of mathematics teachers to identify students' geometric misconceptions at junior high school level [12]. Student difficulties can be used as a means to increase teacher knowledge [13]. Likewise, vice versa teacher knowledge plays a role in overcoming student difficulties [14]. Based on the explanation above, this study aims to see the pre-service activities of mathematic teachers in analyzing learning obstacles viewed from didactic mathematical knowledge (DMK).

2. Method

2.1 Design
Phenomenology as a philosophy and a method of inquiry is not limited to an approach to knowing, it is rather an intellectual engagement in interpretations and meaning-making that is used to understand the lived world of human beings at a conscious level [15]. A phenomenological research design is a study that attempts to understand people’s perceptions, perspectives, and understanding of a particular phenomenon [16]. Design phenomenology used to exploration the experienced pre-service mathematics teacher when analyzing learning obstacles.

2.2 Approach
The research is framed within a qualitative approach. Inquiry into meaning says researchers try to understand how others make sense of their experience [17]. focuses on reports of experience or on data that cannot be adequately expressed numerically [18], which is reflected in analyzing learning obstacle, to understand their impact on reality, these orientations are the starting point for defining key elements within the characterization of the didactic mathematical knowledge.

2.3 Scenario
The setting where the research was developed to achieve the objective, was department mathematics education FKIP Universitas Majalengka located in Majalengka.

2.4 Data collection techniques
Didactic and pedagogical conceptions of mathematics teachers as opposed to the training process by competencies, the technique of in-depth interviews was applied. The interview made use of the script of questions.

2.5 The dimension of didactic mathematical knowledge.

A short description of the facets of the model is given below for a more complete description: 1. Epistemic facet: The intended and implemented institutional meaning for a given mathematical or statistical content, that is, the set of problems, procedures, concepts, properties, language, and arguments included in the teaching and its distribution over the teaching time. 2. Cognitive facet: Students’ levels of development and understanding of the topic, and students’ strategies, difficulties, and errors as regards the intended content (personal meaning). 3. Affective facet: Students’ attitudes, emotions, and motivations regarding the content and the study process. 4. Media facet: Didactic and technological resources available for teaching and the possible ways to use and distribute these resources over time. 5. Interactional facet: Possible organizations of the classroom discourse and the interactions between the teacher and the students that help solve the students’ difficulties and conflicts. 6. Ecological facet: Relationships of the topic with the official curriculum, other mathematical or statistical themes and with the social, political and economic settings that support and condition the teaching and learning [19].

3. Result and Discussion

Generally, students can read or understand the questions given by one of the pre-service mathematics teachers, but students cannot understand every relationship of every concept of geometry transformation. Figure 1. below is a question designed by a pre-service mathematics teacher and the answer to see the learning obstacles experienced by students.

![Figure 1. Question and answer for the student](image-url)
Researcher: In your opinion, what abilities do you want to measure through these questions?
Pre-service mathematics teacher: To find out students' knowledge about the definition of transformation geometry.
Researcher: Based on student answers, what are the main difficulties students have in solving problems?
Pre-service mathematics teacher: if we look at each student's writing it seems that there is no difficulty, but after an in-depth interview, it turns out the student who answers it does not know the relationship of each concept within the scope of transformation geometry. Based on the analysis of the package book, to introduce the concept of geometry transformation begins by providing a Cartesian diagram concept, it turns out that participants do not understand the relationship between the two concepts.
Researcher: Why do you think students have difficulty in solving these problems?
Pre-service mathematics teacher: if we see from the understanding that they wrote related to the concept of geometry transformation it does not look difficult. Based on interviews with students because we realized that students did not answer in full from the notion of transformation they could not answer it, only could exemplify that the transformation included reflection, dilation, translation, and rotation.
Researcher: What knowledge or concepts play a role in solving these problems?
Pre-service mathematics teacher: To know the concept of geometry transformation students must know the concept of one of them the concept of Cartesian coordinates, although in fact to strengthen the understanding of the concept of transformation geometry students must know the concept of mapping.
Researcher: Are the questions above suitable for class IX students and why?
Pre-service mathematics teacher: Suitable given because the problem is only to see student knowledge.
Researcher: How the students' thinking flow to solve the problem appropriately?
Pre-service mathematics teacher: Based on students 'answers the students' thinking lines still do not fit into the material hierarchy, they answer based on their memories without understanding the interrelationship of the material.
Researcher: What is the design of the learning situation that you use to overcome student difficulties based on the student's thinking flow?
Pre-service mathematics teacher: Of course, the strengthening of the Cartesian coordinate concept also with the concept of mapping becomes the initial focus of making learning situations.
Researcher: What strategies will you use to integrate social attitudes in learning, so students can answer questions well?
Pre-service mathematics teacher: Discussion between students becomes a strategy for teaching social attitudes to students.
Researcher: What strategies will you use to integrate spiritual attitudes in learning, so students can solve these problems?.
Pre-service mathematics teacher: Based on the concept of reflection, I can talk to students that reflection can be applied in everyday life, reflection or reflection is the way adults learn, with us reflecting on what we do becomes the basis for further action, if the reflection turns out to be good This becomes our capital to improve the quality of our lives, whereas if on the contrary, we need to evaluate how to do good so that what we do something wrong can be corrected.
Researcher: What media needs to be used to overcome student obstacle learning?
Pre-service mathematics teacher: explore and teach through computer assistance, especially the use of GeoGebra to be an alternative that needs to be carried out so that every existing building space can be simulated well on the computer.

The interview transcript above shows a positive response to students towards the proposed. They enjoy a challenging learning process and at the same time help them understand the concept well.

4. Conclusion

To conclude, we suggest the need to improve the model for didactic knowledge needed to teach transformation geometry. Much pre-service mathematics teacher in Godino experience having difficulty in analyzing different components for pedagogical knowledge and in assessing the didactic suitability of the teaching process [20]. These results make sense, given the limited time to prepare teachers who take part in experiences and understand pedagogical knowledge. However, this activity proved useful for introducing reflection on various aspects that influence and enhance statistical learning. In addition, the responses by the most advanced teacher candidates also show some underlying concepts about the discussion and learning of mathematics which must be made explicitly and confronted. It also provides obtained from analysis to gather information about the dimensions requested by the statistical teaching and learning process requested in the previous section.

5. References.

[1] Rolf Biehler. 2005 Reconstruction Of Meaning As A Didactical Task: The Concept Of Function As An Example.

[2] Nijolė Cibulskaitė. 2016 The Development of Didactic Competence of Pre-service Mathematics Teachers Through Teaching Practice at School. ICEEPSY 2016: 7th International Conference in Education and Educational Psychology.

[3] Teresa B. Neto. Luis Kamuela, and Maria de Natividade. 2019 Assessing didactic and mathematical knowledge. African Mathematical Union and Springer-Verlag GmbH Deutschland, ein Teil von Springer Nature. https://doi.org/10.1007/s13370-019-00747-3

[4] Godino, J. D. 2009 Categorías de análisis de los conocimientos del profesor de matemáticas [Categories to analyze the mathematics teacher’s knowledge]. Unión, Revista Iberoamericana de Educación Matemática, 20, 13-31.

[5] Da Ponte, João Pedro, and Olive Chapman. "Mathematics teachers’ knowledge and practices." Handbook of research on the psychology of mathematics education. Brill Sense, 2006. 461-494.

[6] Godino, J.D., Ortiz, J.J., Roa, R. & Wilhelmi, R. (2011). Models for statistical pedagogical knowledge. In C. Batanero, G. Burril & C. Reading (Eds.), Teaching Statistics in School Mathematics-Challenges for Teaching and Teacher Education: A Joint ICMI/IASE Study (pp. 271-282). Berlin: Springer.

[7] Pedro, Gomez, Maria José González. 2009 Conceptualizing and exploring mathematics future teachers' learning of didactic notions. Indivisa, 12: 223-235.

[8] Redo M. Ruli, Nanang Priatna, Suyyani P., and Endang M., "Analysis Learning Obstacle on Quadratic Function Topic," International Journal of Information and Education Technology vol. 8, no. 9, pp. 681-684, 2018.

[9] Brousseau, G. 2002 Theory of Didactical Situations in Mathematics. New York: Kluwer Academic Publishers.

[10] Asquith, P., Stephens, A., Knuth, E., & Alibali, M. (2007). Middle school teachers” understanding of core algebraic concepts: Equal sign and variable. Mathematical Thinking and Learning, 9(3), 249-272.

[11] Zuya, E. H., & Kwalat, S. K. 2015 Teacher’s Knowledge of Students about Geometry. International Journal of Learning, Teaching and Educational Research, 13(3).

[12] Al-Khateeb, M. A. (2016). The Extent of Mathematics Teacher's Awareness of Their Students'
Misconceptions in Learning Geometrical Concepts in the Intermediate Education Stage.  
*European Scientific Journal, ESJ, 12*(31).

[13] Brodie 2010 Teaching Mathematical Reasoning in Secondary School Classroom. New York: Springer

[14] Zuya, E. H., & Kwalat, S. K. 2015 Teacher’s Knowledge of Students about Geometry.  
*International Journal of Learning, Teaching and Educational Research, 13*(3).

[15] Sadruddin Bahadur. 2018 Phenomenology: A philosophy and method of inquiry. *Journal of Education and Educational Development, 5*.1: 215-222.

[16] Vinay Chandra Pathak. 2017 Phenomenological Research: A Study of Lived Experiences. Vol-3 Issue-1 2017 Ijarie-Issn(O)-2395-4396

[17] Sonia Ospina. 2004 Article Qualitative Research. *Encyclopedia Of Leadership*

[18] Beverle Hancock, Elizabeth Ockleford, Kate Windridge. 2001 *An Introduction To Qualitative Research*. Trent Focus Group,

[19] Pino Fan, L. R., Assis, A., & Castro Gordillo, W. F. 2015 Towards a methodology for the characterization of teachers’ Didactic-Mathematical knowledge.

[20] Godino, J. D., Batanero, C., Roa, R., & Wilhelmi, M. R. 2008 Assessing and developing pedagogical content and statistical knowledge of primary school teachers through project work. In C. Batanero, G. Burrill, C. Reading, & A. Rossman