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Pre-service Mathematics Teachers' Professional Competency Development Through Analysis of Learning Obstacles

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It is the role of teachers to increase the quality of learning. When the instructor wants to increase the quality of learning, reflective practice is an option. However, instructors' current practice of learning reflection is based only on classroom action research and is primarily concerned with enhancing learning models rather than paying attention to student replies. As a result, prospective mathematics teachers must be able to engage in reflection techniques based on didactical design research that emphasizes student reactions. This study employs a descriptive qualitative technique, with the subjects being Mathematics Education students at the University of Majalengka who are enrolled in the Kapita Selekta Mathematics course. Students experience translating scientific, mathematical knowledge into mathematics ready to be taught in schools based on the study findings. Every step in the process of becoming a mathematics teacher has an impact on pedagogical content understanding.

K e y w o r d s :
Professional competency development; Learning Obstacle; Pre-Service Mathematics Teachers

INTRODUCTION

Education has a critical role in enhancing the quality of better-educated human resources (Ayu & Zanthy, 2020). The educational process is anticipated to meet the needs of every human being and prepare them to face the challenges and quick changes of the current era (Kim, 2020; Salmiwati, 2019). According to the Law of the Republic of Indonesia Number 20 of 2003, the objective of national education is to build capacities and shape the character of a dignified nation's culture to educate the nation's life. Teacher competence is critical for maximizing the educational process and meeting objectives (Baumert & Kunter, 2013). Improving the quality of education at all levels is the first step toward strengthening a nation's human resources in the age of globalization, with the assistance of instructors with high professional competence.

Mathematics teacher competence entails the development of various facets of knowledge and abilities (Blömeke et al., 2020), and mathematics are two of the most critical components of human cognitive ability (Ernest, 2015). Mathematics with simple to complicated, systematic, logical, and hierarchical concepts in order for mathematics to contribute to the development of critical thinking skills (Jatisunda & Nahdi, 2020). In essence, mathematics education aims to grasp mathematical principles and engage students in active mathematical thinking (Suryadi, 2015b). As a result, teachers who are well-versed in the mathematical subject must assist students in this endeavour. A strong foundation in mathematics material knowledge is a critical component for math teachers (Güler et al., 2020).

Teaching is a difficult task (Maher et al., 2018). Subject Matter Content Knowledge, Curriculum Knowledge, and Pedagogical Content Knowledge are three categories of content teachers must-have for effective teaching (Shulman, 1986). According to the findings, pedagogical content knowledge is the essential determinant of teacher learning success (Gudmundsdottir & Shulman, 1987). Pedagogical Content Knowledge encompasses both content and pedagogic knowledge. As a result, it is critical to adequately prepare potential mathematics instructors who possess strong Pedagogical Content Knowledge skills. Prospective mathematics teachers are prepared to become professional teachers in college, both in terms of content knowledge and teaching abilities.

The development of Pedagogical Content Knowledge for aspiring mathematics teachers is aligned with the mathematics teacher professional development process in this study. Teachers' professional competency includes pedagogical content knowledge. Professional development can be gained from natural experiences and organized activities that help improve learning quality (Davies, 2000; Melesse & Gulie, 2019). According to the literature on quality education, there is a strong link between teacher professional development and the quality of education in schools (UNESCO, 2006). One of the keywords for teacher professional development is a reflection on the learning process. In order to foster innovation and a learning revolution in the classroom, it is necessary to reflect on the learning process (Loughran, 2002).

Until now, aspiring mathematics teachers or mathematics teachers have generally used Class Action Research or lesson study to reflect on their practice. Practical techniques to reflecting mathematics teachers include action research, lesson analysis, and design research (Holmqvist, 2017). Reflection can increase one's emotional self-awareness and

help one find a better solution (Rahman, 2014). Teachers have used Classroom Action Research to carry out learning reflection practices (Ilfiandra et al., 2016). Learning reflection study based on Classroom Action Research has improved learning quality, increased teacher professionalism, and increased teacher competency (Fitria et al., 2019). Classroom Action Research also allows teachers to assess the interaction of the learning process (Chairunnisa et al., 2020). Lesson Study is the basis for yet another learning reflection. The study's findings linked to a lesson study conducted on prospective mathematics teachers, with the outcome that prospective mathematics teachers' competency in drafting lesson plans grew, as did their learning habits (Vitantri & Asriningsih, 2016). The teacher then demonstrates how lesson study practice improves reflective thinking skills (Hidajat, 2020; Subanji, 2015).

However, due to the lack of internal and external validity, students encounter many challenges when doing classroom action research, including a lack of scientific discipline (Maulana et al., 2020). Teacher saturation, the fact that not all teachers can follow a series of lesson studies, the lack of preparation of model instructors in dealing with lesson studies, and a lack of funding for lesson study activities are some of the challenges in implementing lesson study. As a result, other professional qualities must be developed as well. Design research is one of them, and it focuses on the development of professional competence through didactical design research, which is a type of design research. Professor Didi Suryadi of the Indonesian University of Education introduced the Indonesian version of Didactical Design Research in 2010(Fauzi & Suryadi, 2020).

Didactical Design Research is a theoretical, conceptual, and methodological framework in implementing teacher reflection practice (Rudi et al., 2020). The three stages of Didactical Design Research are (1) analysis of the didactic situation prior to learning in the form of a Hypothetical Didactic Design, (2) metapedadidactive analysis, and (3) retrospective analysis, which is an analysis that links the hypothesis didactic situation analysis with the results, a metapedadidactic examination (Suryadi, 2019). The execution of professional competence development is focused on stage 1 in this study. The activity's unique implementation is in the examination of learning obstacles (Suryadi, 2010).

Learning obstacles analysis gives a snapshot of students' knowledge and mental processes (Suryadi, 2013). An essential aspect of preparing for a learning setting is analyzing learning objects (Lestarai, 2019). When a learning hurdle is not addressed with analysis, it is typical for another learning obstacle to arise during the learning process (Perbowo & Anjarwati, 2017). Learning obstacles must be discovered to change the current learning circumstances and develop new learning situations that address the identified epistemic barriers (Clément, 2003). Another goal of the learning obstacles analysis is to establish a didactic situation where the relationship between students and teaching materials can produce an optimum learning environment (Carvalho et al., 2004) because the learning environment is essentially made up of three relationships: those between teachers, students, and materials (Kansanen & Meri, 1999). There are three different types of learning obstacles: *ontogenic obstacle, didactical obstacle,* and *epistemological obstacle* (Brousseau, 2006). As a result, the goal of this study is to characterize the process of prospective mathematics instructors analyzing learning items to increase professional competence.

METHODS

Population and Sample

In qualitative research, the object of investigation is frequently casuistic. Generalizations are not a worry for researchers. As a result, the sample was chosen with care, and the research sample does not need to reflect the entire population. The evaluation of sample research is not based on the sample's population representation. The ability of the sample (informants) to supply researchers with as much information as possible is increasingly important. In terms of the study, one student following the Praktek Pengenalan Lapangan (PKL) is the research participant.

Research Design

Qualitative techniques are concerned with how humans perceive, describe, and comprehend specific phenomena (Creswel, 2009) by giving the phenomenon a meaning; as a result, the goal of these methodologies is to create a detailed account of a particular aspect of human experience (Qutoshi, 2018). Phenomenological research was used in this study to better comprehend the significance of the participants' learning experiences. Phenomenology investigations, rather than proving a hypothesis, rely on participants' knowledge in the field of their own lived experience to provide specialized insight into the phenomenon under investigation (Smith, 1996).

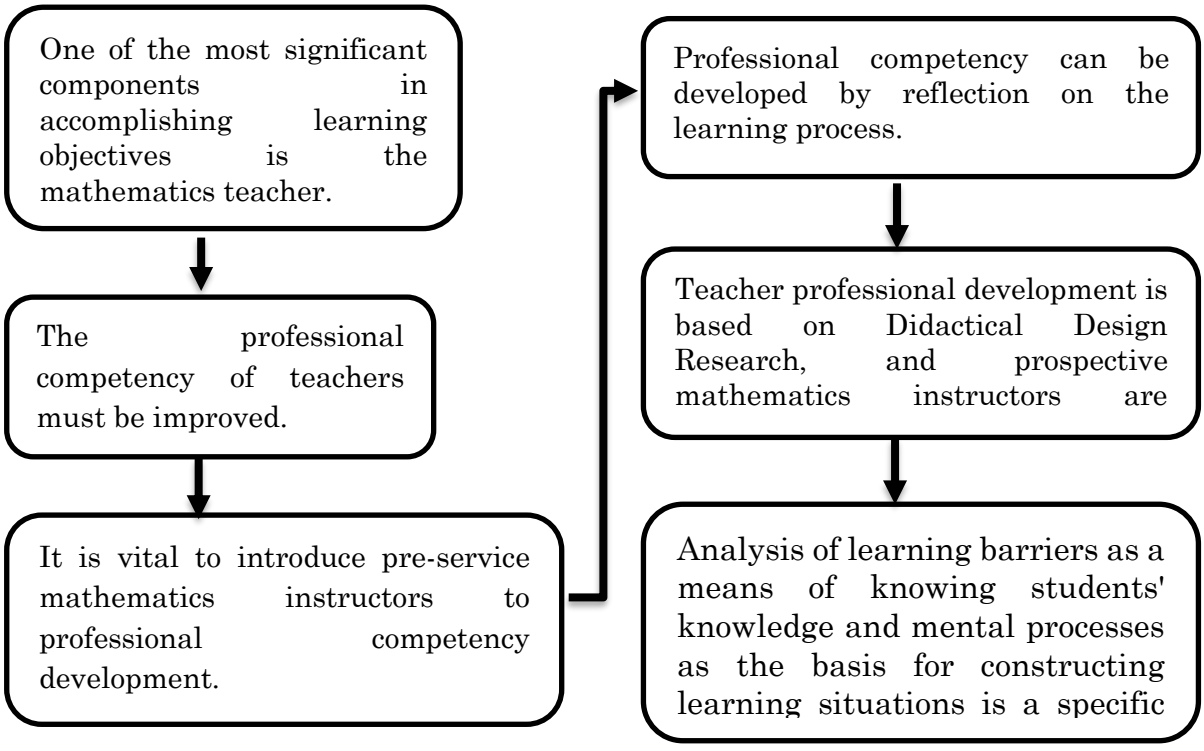

Figure 1
Framework

Data Collection and Analysis

Participant observation, interviews, and focus group discussions (Creswel, 2009) were utilized to collect data. Participant observation is a form of data collecting involving persons participating in and being observed for a period (Moser & Korstjens, 2018). The qualitative research interview aims to describe the significance of essential themes in the participants' activity. The interview is semi-structured, intending to help increase the accuracy of the overall picture of the learning barrier analysis process. The extent to which participants communicated and shared their ideas and experiences in assessing learning obstacles was investigated via focus group discussions.

Interpretative Phenomenological Analysis (IPA) is a growingly popular technique for qualitative research that aims to understand how people feel and make sense of their experiences. Qualitative analysis is generally not used to find data in terms of frequency but is used to analyze the meaning of data that appears on the surface-interpretative phenomenological analysis as written by (Smith, 1996). The stages of interpretative phenomenological analysis are as follows: 1) reading and re-reading; repeated reading also allows the analyst to construct a model of the overall interview structure and understand how narratives can connect different sections of an interview. 2) initial noting; descriptive comments focused on describing the content of what the participant has said, the subject of the talk within the transcript (standard text), linguistic comments focused upon exploring the specific use of language by the participant (italic),

conceptual comments focused on engaging at a more interrogative and conceptual level (underlined). 3) developing emergent themes; 4) searching for connections across emergent themes; 5) moving the following case, and 6) looking for patterns across cases.

RESULT AND DISCUSSION

Pre-service mathematics teachers' learning reflection is a Didactic Design Research emphasizing the identification of learning obstacles. They create a respondent's ability test that will be presented to class IX pupils by geometry transformation of the material to analyze potential mathematics teachers' learning obstacles. In addition, based on the results of the analysis of student responses and student interviews linked to the learning obstacle analysis conducted by the participants, the following are the learning difficulties encountered by students in the idea of transformation geometry:

Tabel 1. Material on Transformation Geometry Learning Obstacle

Test	Learning Obstacle
1	Sketching and modifying sketches appropriately is difficult.
2	Algebraic operations, algebra equations, and matrices multiplication operations are difficult to solve.
3	Finding the projected point's location on the line and in the plane is difficult.
4	The shape of a plane that contains points and line segments in the resulting plane of dilatation is difficult to determine and make.
5	Using the Pythagorean theorem makes it difficult to figure out what data to answer the problem.

These problems serve as the foundation for creating new learning circumstances. In contrast to the prospective mathematics teacher who was given related information when experiencing the learning process, the two prospective mathematics teachers were given related information when experiencing the learning process without categorizing every difficulty encountered when faced with answering the respondent's ability test questions. Based on their research, the participants' findings were grouped into three kinds of learning barriers in the quadratic equation content. The first category is ontogenic barriers, which include instrumental ontogenic barriers. This difficulty arises because students are not prepared to learn. After all, the concepts related to student equations have not been mastered, and the material related to shifting mindsets from arithmetic to algebra has not been mastered. Then, to determine the conceptual barriers, the difficulty of students not truly understanding the concept of the actual quadratic equation is in a formal definition or too high in conceptual thinking: ontogenetic psychological hurdles, notable challenges in motivating students to understand transformation geometry.

The epistemological obstacle is the second type of difficulty students face, and it manifests itself when they are confronted with complex questions in various situations—the difficulty of operating algebraic form as a didactic impediment. Prospective mathematics teachers are supposed to interpret the actuality of the meaning written by pupils throughout the learning barrier analysis process. A hermeneutic study method involves prospective instructors analyzing student learning difficulties. The three types of learning hurdles are used to interpret each student's challenges. As a result, every variation in student learning challenges is a reaction for teachers to prepare anticipation to aid students in learning. However, prospective mathematics teachers will face a significant problem in preparing this response when the learning obstacle analysis is completed.

There will be three primary theoretical pillar studies when a prospective mathematics teacher does a didactic study: didactic situation theory based on Brousseau, conceptual field theory based on Vergnaud, and didactic anthropology theory based on Chevallard's didactic transposition theory (Artigue & Winsløw, 2010). Theoretically, there are three main pillars. When completing the learning hurdle process, aspiring mathematics teachers must pass this. The didactic transposition is one of them. The didactic transposition process involves the transformation of a scientific knowledge item as a result of the research process. Then it is reassembled in a social context to become part of the knowledge that needs to be taught, such as part of the official curriculum. Then it becomes accurate information that is passed down through the generations. Finally, pupils receive the information they have learned. Depersonalization and re-contextualization, re-depersonalization and re-decontextualization are all processes that prospective mathematics teachers go through (Suryadi, 2015a)

When prospective mathematics teachers analyze the learning obstacle, they are going through a didactic transposition process. They work as mathematicians exploring the concept of transformational geometry based on college books, and they also work on analyzing school books. The following is an example of student activities when they explore transformation geometry using the didactic and specific transposition process using the anthropology theory of didactic (ATD), then using praxeology consisting of four tuples (T, τ, θ, Θ), namely practical blocks (praxis) consists of the types of tasks (T) and

techniques (τ) to complete (T). Theoretical blocks (logos) include technology (θ), which explains and justifies techniques, and theory (Θ), which justify and explain technology in general. General and formal. At the university level, where the knowledge to be taught is generated, the tasks studied by mathematicians may involve abstract definitions and certainly more comprehensive illustrations. On the other hand, assignments given to students are more focused on techniques to complete assignments and are contextual.

An illustration of didactic transitions, one example of which is in the Geometry of transformation material, the definition of transformation in a book by Frank M. Eccles which is commonly used in universities, reads, "A transformation of the plane is a one-to-one function from the plane onto the plane." Another illustration is related to the definition of transformation according to John E. Gilbert in his book Modern Geometry: a Dynamic Approach "Let $\mathcal{G}_1 = (\mathcal{P}_1, \mathcal{L}_1)$and $\mathcal{G}_2 = (\mathcal{P}_2, \mathcal{L}_{2)}$ *be two abstract geometries, and let* $f: \mathcal{P}_1 \longrightarrow \mathcal{P}_2$ *a bijective function. Then we say that it is a geometric transformation if f also maps* $\mathcal{L}_1$ *onto* $\mathcal{L}_2$". Based on the illustration above, books at universities introduce the concept of Geometric Transformation through the concept of onto functions.

Based on another university study book by Richard S. Millman and George D. Parker with the title Geometry A Metric Approach with Models, it states that transformation is a collineation "If $\delta = \{\mathcal{L}, \ell\}$ *and* $\delta' = \{\mathcal{L}', \ell'\}$ *are* ***incidence geometries****, then* φ: $\delta \rightarrow \delta'$ *preserves line if for every line* l *of* $\mathcal{L}$, $\varphi(l)$ *is a line of* $\mathcal{L}'$*; that is,* $\varphi(l) \in \ell'$*If* $l \in \ell$. φ *is a* ***collineation*** *if* φ *is a bijection which preserves line* is a collineation is a bijection which preserves lines. Likewise, based on George E. Martin with the book title Transformation Geometry An Introduction to Symmetry, he stated that the definition of transformation is "A transformation on the plane is a one-to-one correspondence from the set of points in the plane onto itself." The explanation for the definition is, for example, given the transformation f; means that for every point P there is a unique point Q so that f (P) = Q and, conversely, for every point R, there is a unique point S so that it applies f (S) = R. A transformation f with this property is called a collineation (Martin, 2012).

The study of Geometric Transformation at the school level begins at the IX grade of Junior High School, the material for geometric transformation is studied as a prerequisite for studying congruence and congruence. In the 2013 Curriculum package before and after the revision, the definition or understanding of transformation was not discussed but directly studied the concepts of reflection, translation, rotation, and dilation. Unlike the 2013 Curriculum textbook printed by the government, the Grade IX Mathematics textbook written by Ved Dudeja and V. Madhavi defines transformation as changing every point coordinate (points of a shape) into other coordinates on a plane with one particular rule, with a general form. $P\,(x, y) \overset{T}{\rightarrow} P'(x', y')$ If viewed from a praxeological perspective, to explain the two definitions, of course, they will be different in terms of practical blocks consisting of types of tasks (T) and techniques (τ) to complete (T). This means that the task given to a prospective mathematics teacher will be much more comprehensive related to the concept of Geometric Transformation. Of course, they also are interested in thinking about how to teach the concept of Geometric Transformation.

A process of generating mathematical knowledge at the university level is in-depth research undertaken by prospective mathematics teachers. In order to reach the ultimate goal of attaining pedagogical content knowledge criteria.

The following activities are based on the concept of learning obstacles study activities to increase pedagogical topic knowledge:

1. Representation of mathematical concepts.
2. Answering "why" queries from students.
3. Trying to come up with examples to illustrate a mathematical idea.
4. Understand the implications of utilizing certain representations.
5. Establishing connections between representations and underlying ideas and other representations.
6. Make connections between the topics taught this year and past years' topics, and 6. Change the work to make it simpler or more difficult.
7. Explain the reasoning behind student explanations (often rapidly).
8. Giving or evaluating mathematical explanations is number eight on the list.
9. Please make a list of applicable definitions and write them down.
10. Criticize the use of mathematical symbols and language.
11. Pose practical math questions.
12. Choosing a symbol for a particular purpose.

CONCLUSION AND IMPLICATION

Mathematics teacher's professional competency is a combination of mathematical content knowledge and pedagogical abilities. Shulman refined the concept with Pedagogical Content Knowledge (PCK), a teacher's knowledge and views about pedagogy, students, subject matter, and curriculum. Didactical design research, a type of design research, is used to implement the research during the reflection process. The process of reflective practice for prospective mathematics teachers is the topic of this research's analysis, which is carried out in the first stage of didactical design research, namely "Analysis of the didactic situation before learning," in which learning obstacles are analyzed. Every aspiring mathematics instructor has analyzed every challenge that students confront during the learning process. The learning obstacle analysis demonstrates that aspiring mathematics teachers go through a didactic transposition process, which involves changing scholarly knowledge (college knowledge) into knowledge that can be taught in schools (knowledge to be thought). Prospective mathematics teachers develop didactic and pedagogical talents due to the learning process, which aid in the improvement of pedagogical content knowledge.

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