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Learning Obstacle to Ontogeny of Mathematics Teacher Candidates on Number Theory

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ABSTRAK

Calon guru matematika harus memiliki ciri-ciri ilmu matematika yaitu sistematis, logis, dan kritis. Penelitian ini bertujuan mengungkap analisis hambatan belajar yang dialami calon guru matematika pada mata kuliah teori bilangan dengan sub materi relasi pembagian, FPB dan KPK. Penelitian ini menggunakan metode pendekatan kualitatif dalam bentuk deskriptif. Penelitian ini dilakukan dengan pengumpulan data melalui kuesioner dan wawancara serta divalidasi dengan menggunakan metode triangulasi. Kajian dibatasi pada analisis hambatan pembelajaran ontogenik menurut Brosseasu. Hasil penelitian ini adalah 4 dari 6 subjek penelitian mengalami terjadinya hambatan ontogenik pembelajaran dengan rincian 37,5% calon guru mahasiswa mengalami hambatan ontogenik psikologis dan hambatan ontogenik instrumental, kemudian 25% mengalami hambatan ontogenik didaktik. Hal ini mengindikasikan bahwa kesiapan mahasiswa untuk mengikuti mata kuliah teori bilangan masih lemah. Mahasiswa lemah dalam hal kesiapan psikologis, lemah dalam kesiapan untuk menguasai secara tuntas materi terkait yang dipelajari sebelumnya dan lemah dalam hal mengikuti proses berpikir yang diperlukan dalam mata kuliah ini.

ABSTRACT

Prospective mathematics teachers must have the characteristics of mathematical science, namely systematic, logical, and critical. This study aims to reveal the analysis of learning obstacles experienced by prospective mathematics teachers in number theory lectures with sub-material of division relations, FPB and KPK. This research uses a qualitative approach method in descriptive form. This research was conducted by collecting data through questionnaires and interviews and validated using the triangulation method. The study was limited to the analysis of ontogenic learning obstacles according to Brosseasu. The results of this study were that 4 out of 6 research subjects experienced the occurrence of ontogenic learning obstacles with details of 37.5% of prospective teacher students experiencing psychological ontogenic obstacles and instrumental ontogenic obstacles, then 25% experiencing didactic ontogenic obstacles. This indicates that students' readiness to take part in number theory courses is still weak. Students are weak in terms of psychological readiness, weak in readiness for complete mastery of related material previously studied and weak in terms of following the thought process needed in this course.

1. INTRODUCTION

Educating students is intended to guide the younger generation to become intelligent and good ethics. Many psychological theories, learning is a continuous change in improving skills as human resources (Nurjanah et al., 2017; Suryadi et al., 2021). Furthermore, previous study added that continuous change can contain one of abilities, attitudes, beliefs, knowledge, and skills (Kuo, 2008). Educators take a big role in the implementation of good education. Students of prospective mathematics teachers are people who are prepared to become one of the educators in the school (Kinach, 2002; Rohmah et al., 2022). Therefore, prospective mathematics teacher students must first become intelligent and ethical before trying to make students experience the meaning of education (Alenezi, 2020; Baker et al., 2020; Keefe, 2020). Not only are the ability of teachers there many factors that affect the quality of an education. Previous study states that it is very difficult to determine measurement systems or criteria to evaluate educational outcomes (García-Ceberino et al., 2020). However, we must continuously make efforts to improve the quality of education, as much as possible if it depends on us, strive for it (Brooks, 2021; Damayanti & Jumiyati, 2020; Lavoué et al., 2019). Efforts to improve the quality of education through mathematics must certainly be based on the purpose of teaching mathematics. The purpose of teaching

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mathematics is to make students able to express opinions based on mathematical patterns and properties, describe generalizations, draw conclusions using inference rules to prove and clarify statements, mathematics, in addition to improving self-confidence, appreciating the beauty, regularity of mathematics, to be objective and open, to be curious, to show interest and pay attention to learning mathematics (Agustini et al., 2020; Machaba, 2018). Prospective mathematics teachers are one of the efforts that can be done. Prospective mathematics teachers must have the characteristics of mathematical science, namely systematic, logical, and critical (Bosica et al., 2021; Puspita et al., 2022). This characteristic is the ability to think. This is in line with previous study explaining that mathematics can be seen as a human activity that can present the solution of situations dividing problems socially, besides that mathematical activities create symbolic language that expresses situations and solutions of problems (Hernández et al., 2020; Putra et al., 2017). Mathematical activities have the aim of logically constructing conceptual systems. Previous study states the six mathematical characteristics are 1). Have an abstract object of study, 2). Rest on agreement, 3). Deductive mindset, 4). Has empty symbols and meanings, 5). Pay attention to the universe of speech (universal) and the 6). Consistent in its system (Trisnawati et al., 2018). Furthermore, other study suggests that the character of modern mathematics consists of 1). Applicable and effective, 2). Abstract and general, 3). Simple, 4) (Fuadi et al., 2017; Rahmawati & Anwar, 2020).

In the Number Theory course, students learn about abstract theories of integer systems and specifically about prime numbers. Students prospective mathematics teachers must master the number proof theorem because it is an important capital in solving mathematical problems (Bleiler et al., 2014; Zhampeissova et al., 2020). These theorems are also important in shaping the cognitive thinking process of the prospective mathematics teacher student. This is in line with what previous study said that the number theory course is a course that generally trains logical, critical, systematic and innovative thinking skills because it studies material about mathematical proofs, integer systems, principles of division and congruence of a number (Lampropoulos et al., 2019). However, in the reality of learning number theory courses, many prospective teacher students experience obstacles so that the topics of this material are often not completely studied. For this reason, it is important to find the learning obstacles experienced by students in taking number theory courses. The implementation of analysis and evaluation of prior learning are the best predictors of subsequent learning (ai et al., 2020; Strømme & Mork, 2021). So, it is expected to overcome obstacles and improve the quality of the next mathematics teacher candidate.

Previous study mentions a number of obstacles such as cognitive obstacles, genetic and psychological obstacles, didactic obstacles, and epistemological obstacles can occur in learning (Perdana et al., 2018). However, other study mentions types of obstacles based on their origins, namely divided into obstacles derived from ontogenic, didactic and epistemological (Susanto et al., 2020). Furthermore, ontogenic obstacles are divided into 3 types, namely psychological ontogenic obstacles, instrumental ontogenic obstacles and conceptual ontogenic obstacles (Li, Y., Ouyang & Zhang, 2022; Wahyuningrum et al., 2023). Didactic obstacles are divided into 3 types, namely didactic obstacles to structural structure related to concepts and functional didactic obstacles related to the sustainability of thinking stages. In this study, a review of learning obstacles was carried out, namely and limited on ontogenic obstacles in all three types. Furthermore, in more depth, the following is the definition of ontogenic obstacles. Based on the explanation above, it can be concluded that ontogenic obstacles are obstacles that originate from within students, occur from the factors of readiness and maturity of student cognition, this can be seen from the distance between the needs that should be owned and the circumstances that occur in students. Therefore, this obstacle is divided into three parts, namely ontogenic psychological obstacles, namely related to student interest and learning motivation or referred to as ontogenic psychology, then about students not fully understanding the concept of prerequisites related to the material being taught, namely instrumental ontogenics and the last about the incompatibility of cognitive abilities / thinking processes of students with the conditions needed in learning. This study aims to reveal the analysis of learning obstacles experienced by prospective mathematics teachers in number theory lectures with sub-material of division relations, FPB and KPK.

2. METHODS

The research method used in this study uses a qualitative approach using a descriptive type of analysis conducted in the number theory class course on prospective teacher students of Mathematics Education FKIP UKI. According to previous study, the qualitative approach is the process of collecting data in a scientific setting that aims to interpret the phenomena formed, with researchers as key instruments, samples of data sources or respondents are taken based on purposive or snowball, collection through triangulation techniques, data is analyzed inductively, and the emphasis of research results emphasizes meaning rather than generalization (Sugiyono, 2018). The results of qualitative research are not obtained

through statistical steps or other quantification methods, but are expressed in descriptive form. Descriptive analysis of a data for a variable, namely describing the results through the mean, standard deviation and range of the values studied (Cresswell & Cresswell, 2018). This research originated from 6 research subjects determined based on the ability category in the previous value, namely the high, medium and low ability categories. However, it is estimated that 2 students in the high category do not experience learning obstacles, so the research subjects discussed come from the medium and low categories. This still meets the criteria of research subjects needed in interviews. Data collection was carried out through two ways, namely, diagnostic tests of learning obstacles and interviews. The test is given to see the location of learning obstacles experienced by prospective teacher students. The test consists of 10 questions with 3 categories, namely easy, medium and difficult. After that, the answers are analyzed and dug through interviews. The interview questions are arranged following a semi-structured form, which has a reference but can be developed as needed during the interview process and is an open question. Data analysis in this study follows the technique where data is continuously analysed continuously and stops when it comes to the saturation point of answers exported by respondents related to the phenomenon studied (Miles et al., 2014). The stage of data analysis is data reduction, namely selecting data from all collected data, selecting as needed to answer research questions. The second stage is the presentation of data, where researchers try to show the truth of the data revealed in the study, and the last is conclusions, which is the process where when the data has been validated and accepted scientifically to draw conclusions as answers to research questions.

3. RESULT AND DISCUSSION

Results

Based on the results of diagnostic tests, it was found that the data collection of the scores of the four research subjects was concerning, while their scores were seen in Table 1.

Table 1. Diagnostic Test Results of Research Subjects

No.	Research Subjects	Category	Value	Questions that are not done
1.	S1	Low	25.36	6, 7, 9 and 10
2.	S2		18.06	2, 3, 5, 6, 7, 9 and 10
3.	S3	Keep	46.04	3 and 4
4.	S4		60.71	9 and 10

Based on diagnostic tests can also be analyzed material mastery scheme based on **Figure 1**.

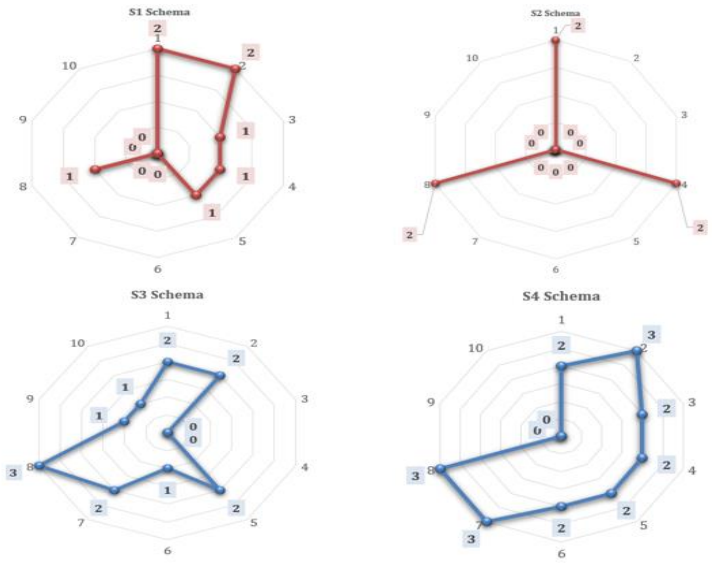

Figure 1. Comparison of Material Mastery Schemes

The material mastery scheme is made based on a comparison of the achievement of the value of the research subject with the maximum value obtained. Based on the picture, it appears that S4 has a wider area of material mastery than the other three research subjects. This is because S4 gets the most maximum value from the questions done. Furthermore, an analysis of learning obstacles was carried out from the four research subjects. Based on the results of the questionnaire of two questions about likes and learning motivation, the results were found as show in Figure 2 and Figure 3.

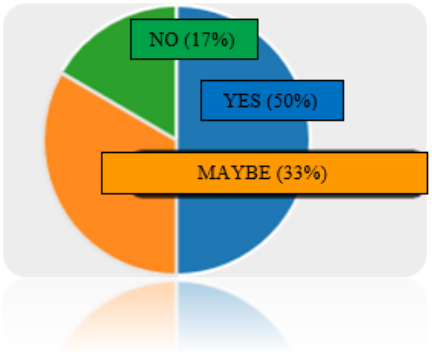

Figure 2. Percentage of Category Likes

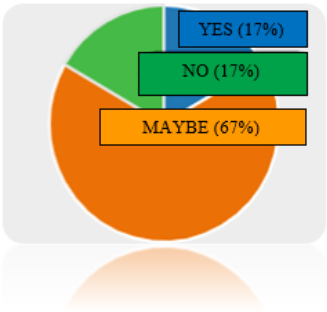

Figure 3. Percentage of Motivated Categories

Base on Figure 2 and Figure 3, it appears that there are 17% of prospective mathematics teacher students who do not like the Number Theory course and 33% who are hesitant, that is, sometimes like sometimes not. Next on the next question about whether they were motivated, again 17% answered no and increased to 67% who were sometimes motivated sometimes not. The answer was confirmed in an interview with the following excerpt of the interview as show in Table 2.

Table 2. Interview Result

Subject	Excerpt
P	*Do you like and are motivated by Number Theory?* *Can you explain more about the deck?*
S1	*"Actually, I am neutral, miss just doesn't like the proof part, just miss makes you confused because there are many letters, the letters look more complicated, miss the same use of theorems too, sometimes it makes you confused about when to use it."* *"So there is no feeling like like like or dislike like like Miss, it's just said to be motivated because it's confusing and takes a lot of practice like Miss"*

Based on the interview as show in **Table 2**, it appears that S1 is not motivated in learning number theory even though he does not have a dislike for this course, but S1 is not motivated to study this course more deeply, this is in line with S4 who sometimes likes, sometimes not, when he finds a deadlock S4 admits to not liking and not motivated in studying this course. Next interview with S2 who clearly chose dislike and not motivated. The conversation is show in Table 3.

Table 3. Interview Result

Subject	Excerpt
P	*Do you like and are motivated by Number Theory?* *Why can it happen deck?*
S1	*"Honestly Miss I don't like it, because it's too hard for me to play with proof and with letters instead of numbers. So I often get stuck doing it."* *"Maybe it's because I'm also weak at Miss's basics."*

Based on the interview as show in Table 3, S2 expressed his dislike and despair in doing questions from the Number Theory course, for that S2 is also included in the category of teacher candidates who have ontogenic learning obstacles in psychology. Based on the overall interview results, data on students who experience ontogenic psychological obstacles are S1, S2, and S4 and can be concluded through the chart as show in Figure 4.

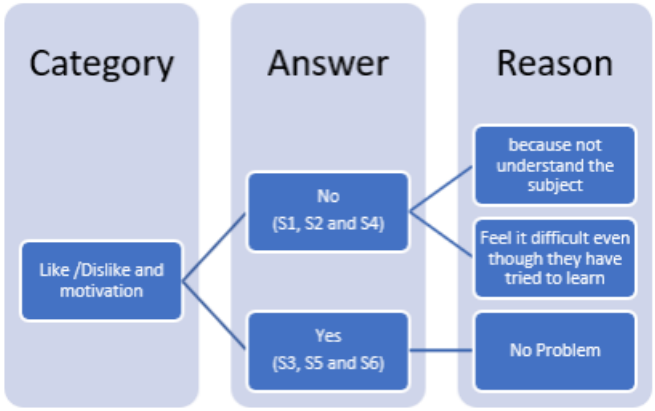

Figure 4. Classification of Psychological Ontogenic Interview Answers

Furthermore, instrumental ontogenic, namely the weakness of students in mastering the previous material that has been studied, can be seen from the answer sheet of the S1 research subject as show in Figure 5.

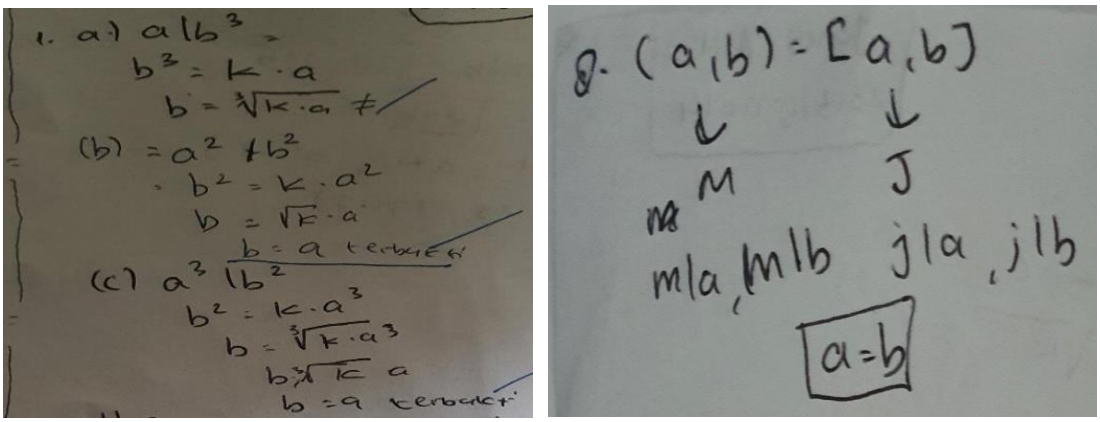

Figure 5. S1 Questions and Answers on Questions No. 1 and 8

Base on **Figure 5** the answer sheet, it appears that S1 has weaknesses in understanding the meaning of mathematical equations, in the context of the same problem there are several different b values. The same thing happened in the work on question no. 8, namely when two equations are called the same, the example value should also be the same, but S1 makes it a different value, namely m and j. S2 does not answer question no. 7 which asks how many FPBs of the two numbers above, a similar case when researchers find on S2 scribble paper, errors in finding KPK from two numbers. S2 mistakenly searched for KPK from 8 and 10, it appears that S2 looked for KPK using factor trees. So this is an obstacle for S2 in

understanding Number Theory, especially in the material of division relation theory, FPB and KPK. Conceptual ontogenic obstacles are onthegenic obstacles that occur because the thinking ability of students is not in accordance with the thinking skills needed in learning. When confirmed in the interview, S2 admitted that it was difficult to prove the theory or abstract. The same thing is also experienced by S1, the ability to think at the stage of students who take number theory courses should be able to prove using theories on numbers symbolized by letters. So that the conclusions obtained Prospective mathematics teachers who experience conceptual learning obstacles are S1 and S2. The conclusions obtained from the results of the above discussion are show in Table 4.

Table 4. Percentages on Each Learning Obstacle

SP	Category	Psychology	Instrumental	Conceptual
S1	Low	√	√	√
S2	Low	√	√	√
S3	Keep	×	√	×
S4	Keep	√	×	×
S5	Tall	×	×	×
S6	Tall	×	×	×
Total		**50%**	**50%**	**33.33%**
Overall Percentage		**37.5%**	**37.5%**	**25%**

Table 4 states the percentage on each of the ontogenic learning obstacles. There are 4 out of 6 students who experience ontogenic obstacles, which is 66.67%. Furthermore, the overall conclusions of the study are described in Figure 10.

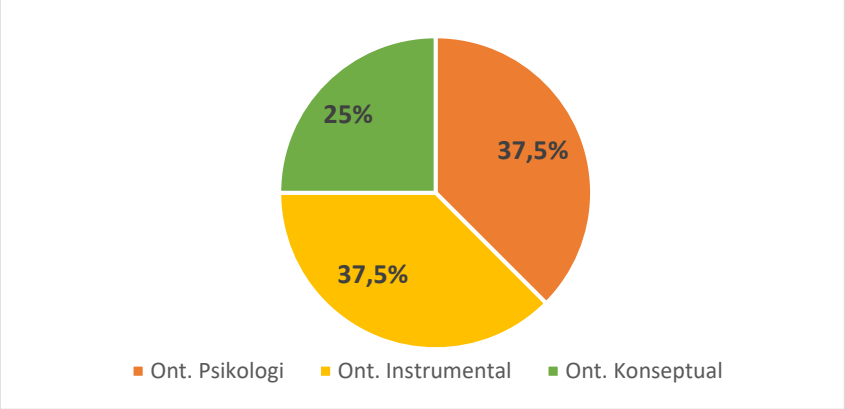

Figure 10. Percentage of Learning Obstacles for Prospective Teacher Students

Based on Figure 10, it appears that the learning obstacles experienced by prospective mathematics teacher students who experience ontogenic obstacles are 33%. After the conclusions were found some interesting things, the six research subjects came from the same learning class, but not all of the research subjects experienced didactic obstacles.

Discussion

Ontogenic obstacles are obstacles that come from students, namely related to student interest and motivation or referred to as ontogenic psychology, then about the lack of understanding of students towards the prerequisite material of the material being learned, namely instrumental ontogenics and the last about the incompatibility of students' brain abilities with normal conditions or generally can be higher can be lower this type of ontogenic, called conceptual ontogenic (Pramitasari et al., 2019; Wahyuningrum et al., 2023). Next, we will see whether this type of ontogenics is experienced by prospective mathematics teacher students in number theory courses. In addition, there is an interesting phenomenon when conducting research, all research subjects say the reason they cannot answer questions is because of lack of independent exercises, and based on observations researchers also see that S4 has increased understanding since diligently doing independent question work exercises. During the

interview, the sentence that was said was repeated by each SP, namely multiply the exercise. SP believes that training is the key to mastering this material.

Based on the results of this study, some suggestions that need to be considered in the next number theory lecture are that teachers should pay attention to the learning maturity of students (ontogenic). This is in line with previous study which states that mathematics learning needs to be designed by presenting situations that are able to lead students to mental aspects such as axioms, concepts, theorems and problem solving and others (Ekawati et al., 2020). This needs to pay attention to the readiness of students psychologically, a qualified initial scheme to learn the material taught and pay attention to the cognitive of students (Ferreira & Morais, 2020; Hossain et al., 2021). This can be done by conducting perceptions, diagnostic tests for prerequisite materials. The findings from this study can assist in identifying areas that need improvement in the training of future mathematics teachers. Teacher training programs can be adapted to address the specific constraints identified in the research. Then the results of this research can be the basis for developing learning materials that are more effective and in accordance with the needs of prospective mathematics teachers. Materials that are more interactive, visual, and focus on identified learning barriers can be designed. This study also has limitations, this study only involved prospective mathematics teachers from one particular institution or region, so the results may not be widely generalizable to prospective mathematics teachers from different backgrounds. Institutional factors such as the learning environment and teaching methods used in certain institutions can also influence learning barriers. This may not fully reflect the situation elsewhere.

4. CONCLUSION

According to the study's findings, 4 out of 6 research participants had trouble learning because of ontogenic barriers, including psychological and instrumental barriers. These barriers were experienced by prospective teacher students. This suggests that students are still not sufficiently prepared to participate in number theory classes. Students lack the necessary psychological readiness, complete mastery of previously studied related material, and the ability to follow the thought processes required for this course.

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