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Analysis of the profile of basic mathematical skills and misconceptions of prospective elementary school teachers

Lintang Analisa Ekasari[1], Fery Muhammad Firdaus [2], and Syarifah Anjani Pawestri [3]

[123]Fakultas Ilmu Pendidikan, Universitas Negeri Yogyakarta, Karangmalang, Yogyakarta, Indonesia
Corresponding Author. e-mail: lintanganalisa.2024@student.uny.ac.id

Abstract

This study aims to analyze the profile of basic mathematical skills and misconceptions of prospective elementary school teachers (PGSD students) and to describe the relationship between these two constructs. Using a descriptive quantitative approach, data were collected from 282 PGSD students from five state universities through a basic mathematics ability test, an error analysis sheet, and a misconception classification rubric that had been validated by experts and tested for reliability. Descriptive statistics were applied to map students' abilities across five domains (numbers and operations, algebra, geometry, measurement, and data analysis/probability), while qualitative error analysis was employed to identify conceptual, procedural, misinterpretation, and careless errors as indicators of misconceptions. The findings show that students' basic mathematical skills are generally in the moderate category, with the highest mean score in geometry and the lowest in algebra, and that conceptual errors (44.1%) are the most dominant, especially in numbers and operations and algebra. The analysis further reveals a clear pattern that lower levels of basic mathematical skills are associated with higher levels of misconception, indicating that misconceptions are rooted in weak conceptual understanding rather than mere carelessness. This study contributes to the field of education by offering an integrated empirical profile of basic skills and misconceptions among prospective elementary school teachers as a basis for developing diagnostic assessments and strengthening PGSD curricula that emphasize conceptual understanding in basic mathematics learning.

Keywords: Basic mathematical skills; misconceptions; prospective elementary school teachers

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INTRODUCTION

In recent years, there has been growing attention to the foundational role of mathematics in elementary teacher education. Basic mathematical skills are an important foundation for prospective elemenxtary school teachers. The depth of understanding of concepts possessed by prospective teachers will determine the quality of learning they provide to students. However, various studies indicate that prospective elementary school teachers still experience difficulties with basic concepts, such as numbers, arithmetic operations, geometry, data analysis, and

measurement (Sebayang et al., 2025). This suggests that their understanding has not yet fully developed at a conceptual level, as evidenced by persistent errors in reasoning and misconceptions when solving mathematical problems (Nurharyanto & Abdy, 2025). Students are often able to solve routine problems but experience obstacles when asked to explain the meaning of concepts or apply them in everyday contexts and even tend to make repeated mistakes related to the concept of integer operations, especially in interpreting negative signs and rules of operation (Nur et al., 2020) . In addition, many students do not fully understand the relationship between concepts, such as the connection between fractions, decimals, and percentages, or the meaning of measurement in various units in basic mathematics courses (Susilawati et al., 2023).

On the other hand, learning and assessment in teacher education emphasize procedural skills. A mathematics learning culture that places correct answers as the main indicator often does not provide sufficient space for the exploration of conceptual understanding. When prospective teachers are asked to analyze students' understanding of a concept, their explanations focus more on the steps of calculation than on revealing the meaning of the concept or relating it to various representations and contexts (Svensson, 2021). Prospective teachers' procedural knowledge develops faster than their flexible conceptual understanding, making it difficult for them to explain the reasoning behind calculation steps (Otun, 2022). This is in line with findings that prospective teachers' procedural knowledge scores are consistently higher than their conceptual knowledge scores, which require an understanding of meaning and relationships between concepts (Yurniwati, 2018). Other studies also indicate that prospective teachers tend to think that giving rules and routine examples is enough, so explanations that emphasize the relationships between concepts and the reasons behind procedures rarely appear in their teaching practices (Aksu et al., 2018; Nakypbek et al., 2025).

Misconceptions emerge as a fundamental problem in mathematics learning, both for elementary school students and prospective teachers (Aminudin, 2024; Putri et al., 2024). According to Kusmaryono et al. (2020) misconceptions are not merely momentary errors; they are systematic misunderstandings that are consistently held and often reappear across different contexts. Studies of elementary school students' misconceptions on the topics of fractions, numbers, and number sense show that conceptual errors can hinder mathematical reasoning and problem-solving abilities in the long term (Fauziah & Pandra, 2024). If prospective teachers themselves harbor similar misconceptions these misunderstandings could easily be passed on to their students through flawed explanations or examples in the classroom (Purwaningrum & Purwoko, 2019). Research involving both in-service elementary teachers and teacher candidates in various contexts also indicates that misconceptions are not limited to content knowledge; they extend to how teachers interpret and model mathematical situations in the classroom. Such teacher-held misconceptions can inadvertently reinforce students' own misunderstandings if not recognized and corrected (Hendricks et al., 2023; Krisnadi et al., 2025). Therefore, examining the basic mathematical understanding and identifying common misconceptions among prospective elementary teachers is crucial for improving mathematics education in the early grades.

Although numerous studies have examined either the mathematical abilities or the misconceptions of prospective teachers, research that analyzes both aspects together in an integrated manner remains limited. Most studies focusing on prospective teachers' misconceptions tend to catalog the types of errors on specific topics without linking these errors to an overall profile of the teachers' fundamental mathematical skills (Nur et al., 2020; Owusu et al., 2023). Conversely, other research emphasizes the importance of prospective teachers understanding their students' misconceptions and the impact on instructional practice, yet these works have not explicitly combined an analysis of teacher candidates' own basic abilities with their misconceptions (Johar et al., 2023; Moosapoor, 2023; Prayitno et al., 2024). This gap in literature indicates a lack of a clear profile of prospective elementary teachers who struggle with certain basic concepts while simultaneously holding persistent misconceptions. This issue

is especially pressing given that prospective teachers' own beliefs or misconceptions about the nature of mathematics and how it should be learned can further entrench their conceptual errors and undermine their confidence in teaching mathematics (Justicia-galiano, 2024; Tamba et al., 2021).

Based on these needs, this study was designed to map the basic mathematical abilities of prospective elementary school teachers, identify various forms of misconceptions that arise through error analysis, and describe the relationship between the level of basic abilities and the types of misconceptions experienced by prospective elementary school teachers. Specifically, this study seeks to answer the following research questions:

(1) What is the profile of prospective elementary school teachers' basic mathematical skills across the five assessed domains?
(2) What misconceptions are evidenced in prospective teachers' written solutions, and how are these misconceptions distributed across error types and mathematical domains?
(3) How do misconception levels differ across basic mathematical ability categories?

METHODS

This study used a descriptive quantitative (cross-sectional) approach to map mathematical abilities and identify misconceptions among elementary school teacher education students. This design was selected because the study aimed to describe students' basic ability profiles and error patterns, as well as their descriptive association, without manipulating instructional variables. The research procedure included the preparation and validation of instruments, the administration of tests to students, the collection of answers, the coding of errors, and quantitative and qualitative-descriptive data analysis based on error categories. The research participants were 282 PGSD students who were taking Basic Mathematics courses at five state universities (UNY, UNP, UNIMED, UNDIKSHA, and UNESA). Sample selection was carried out through a combination of cluster and purposive sampling, with the inclusion criteria focusing on students who were officially enrolled in the Basic Mathematics course during the data-collection period; responses were screened for completeness prior to analysis.

Data were collected using a mathematical ability test covering five domains (numbers and operations, algebra, geometry, measurement, and data analysis/probability), an error analysis sheet to code the types of errors, and a misconception classification rubric as a reference for determining misconception categories. Content validity of the instruments was obtained through expert judgment, while reliability of the tests was analyzed using internal reliability coefficients. The consistency of error and misconception coding was maintained through inter-coder agreement by double-coding a subset of responses and resolving discrepancies through discussion. Test score data were analyzed using descriptive statistics (mean, standard deviation, minimum, and maximum values) to describe the students' basic mathematics ability profiles. Student answers were analyzed using an error analysis approach and grouped into the categories of conceptual errors, procedural errors, misinterpretations, and careless errors. Based on consistent error patterns, the percentage of misconceptions in each category was identified and calculated, while the relationship between basic ability levels and misconceptions was analyzed descriptively by comparing score groups with the frequency and types of misconceptions that arose.

RESULTS AND DISCUSSION

Results

This section presents the findings of the study based on the data analysis conducted. The results are divided into four sections: descriptive statistics of basic math skills, the distribution of error types, a map of misconception across domains, and the link between ability categories and levels of misconceptions. A descriptive analysis was performed on the fundamental mathematical competencies of prospective elementary school teachers, focusing on five

primary domains: numbers and operations, algebra, geometry, measurement, and data analysis or probability. The descriptive results for each aspect are presented in Table 1.

Table 1. Descriptive analysis

	Numbers and Operations	Algebra	Geometry	Measurement	Data Analysis/Probability
Mode	5.000[a]	5.000[a]	6.000[a]	5.000[a]	6.000[a]
Median	4.000	4.000	5.800	5.000	5.000
Mean	4.136	4.056	5.099	4.661	4.833
Std. Deviation	0.935	1.237	1.250	1.130	1.177
Minimum	0.800	0.400	0.000	0.600	0.600
Maximum	6.000	6.000	6.000	6.000	6.000

[a] The mode is computed assuming that variables are discrete.

The results of the descriptive analysis show that the basic mathematical abilities of prospective elementary school teachers are in the moderate category in all five aspects measured. Among these aspects, geometry received the highest average score (mean = 5.099). In contrast, the aspect of algebra showed the lowest average (mean = 4.056) accompanied by the most significant variation. The area of numbers and operations (mean = 4.136) also showed lower performance compared to other aspects. Meanwhile, the measurement aspect (mean = 4.661) and data analysis/probability (mean = 4.833) were also in the moderate category. Overall, the score pattern shows differences in mean scores across the five aspects, as shown in Table 1. An overview of the error analysis used to classify error types is presented in Table 2.

Table 2. Error analysis

Type of Error	Frequency	Percentage (%)
Conceptual Error	1306	44.1
Procedural Error	891	30.1
Misinterpretation	509	17.2
Careless Error	255	8.6

The analysis results show that conceptual errors are the most dominant category, accounting for 44.1%. Procedural errors accounted for 30.1%. Misinterpretation errors reached 17.2%, and careless errors were 8.6%, as shown in Table 2. The mapping of misconception forms across basic mathematical domains is presented in Table 3.

Table 3. Mapping misconceptions in basic mathematical skills

Aspect	Misconception Description	Frequency	Percentage
Numbers and Operations	Misunderstanding place value, for example, thinking that 0.25 is greater than 0.3 because “25 is greater than 3”; errors in number and fraction operations	**420**	**23.1%**
Algebra	Equating variables as ordinary number; not understanding the rules of variable operations; incorrectly applying the distributive property	**355**	**19.6%**
Geometry	Assuming diameter is the same as radius, misunderstanding the relationship between radius, diameter, circumference/area	**270**	**14.9%**
Measurement	Misinterpreting units of measurement (cm, m, m^2, m^3); measurement conversion errors; misunderstanding the concepts of perimeter vs. area	**310**	**17.1%**
Data Analysis / Probability	Unable to interpret tables/graphs correctly; misunderstanding simple probabilities; equating the highest frequency with certain probability	**260**	**14.3%**

Based on the results of the analysis, the most common misconceptions appeared in the Number and Operations aspect (23.1%), particularly related to understanding place value and number operations. The algebra aspect ranked next with a percentage of 19.6%, showing a pattern of misconceptions related to the use of variables and symbol manipulation. Furthermore, the aspects of measurement (17.1%) ansd geometry (14.9%) also showed that conceptual errors still occur quite frequently. Meanwhile, the data analysis/probability domain had the lowest percentage of misconceptions (14.3%). However, these results still indicate that prospective elementary school teachers still have difficulty interpreting graphs and understanding the concept of probability comprehensively. The relationship between basic mathematical abilities and misconception levels is presented in Table 4.

Table 4. The relationship between basic competencies and misconceptions

Basic Mathematical Abilities Category	Number of Students	Percentage of Misconceptions	Misconception Category
High	72	7.8	Low
Medium	121	22.4	Medium
Low	89	46.5	High

The analysis shows differences in misconception percentages across ability categories. The high-ability group had a misconception percentage of 7.8%, the medium-ability group 22.4%, and the low-ability group 46.5%, as shown in Table 4.

Discussion

The primary aim of this study was to profile prospective elementary school teachers' basic mathematical skills and misconceptions and to examine how these two aspects relate. Overall, the findings suggest that participants demonstrated moderate basic mathematical ability across domains, with noticeable differences between aspects. Geometry tended to be relatively stronger, whereas algebra and number-related skills showed greater challenges. In addition, misconceptions were dominated by conceptual errors, and misconception rates were markedly higher among participants with lower basic mathematical ability. These findings provide important insights into areas that should be prioritized in teacher education, particularly to prevent the persistence and transmission of misconceptions in elementary mathematics instruction

Basic Mathematics Skills for Prospective Elementary School Teachers

The results of the basic mathematical abilities of prospective elementary school teachers show that their basic mathematical abilities are generally in the moderate category. There is considerable variation in proficiency levels between aspects, with the highest average score in the aspect of Geometry (mean = 5.099). These findings indicate that most prospective teachers have a relatively good understanding of two-dimensional shapes and spatial relationships. The high scores in this aspect are in line with the characteristics of geometry content, which is visual and concrete, making it easier for prospective elementary school teachers to understand than abstract symbolic representations (Moreno et al., 2011).

The basic mathematical abilities of prospective elementary school teachers in the aspect of algebra showed the lowest average score (mean = 4.056). The low ability in this aspect confirms a significant gap in symbolic manipulation skills and understanding of algebraic structures. Prospective teachers often master arithmetic procedures but have difficulty understanding concepts in depth and using variable representations appropriately (Asquith et al., 2007; Doabler & Fien, 2013). Not only that, prospective teachers often fail to identify arithmetic relations using variables and show misconceptions about the properties of operations in number systems (Siregar, 2025). Low scores in the algebra aspect indicate the need for more explicit instructional intervention regarding the development of basic algebraic mathematics skills (Witzel et al., 2003).

In the Number and Operations aspect, the average score (mean = 4.136) indicates that basic number and operation skills are still not optimal. Prospective teachers have weaknesses in operating numbers in mathematics, even though they have undergone higher education (Reeder & Bateiha, 2016). Errors in basic mathematical abilities are usually reflected in the inaccuracy of choosing calculation strategies, misconceptions about basic operations, and a lack of numerical flexibility (Khalid & Embong, 2019).

Meanwhile, the aspects of Measurement (mean = 4.661) and Data Analysis/Probability (mean = 4.833) were in the moderate category with a better level of stability than other aspects. However, several weaknesses remain apparent, particularly in data interpretation and understanding of probability concepts. This is in line with the findings Karatoprak et al. (2015) who noted that prospective teachers often exhibit equiprobability bias and errors in representing

probability, even though prospective elementary school teachers are able to perform basic calculations correctly (Karatoprak et al., 2015).

Overall, this pattern shows that visual aspects such as geometry tend to be easier to master, while symbol-based aspects such as algebra are a major source of difficulty. A similar pattern was found in that prospective teachers relied more on visual strategies than symbolic reasoning, so that the gap in understanding between geometry and algebra continued to recur in various contexts (Karatoprak et al., 2015; Reeder & Bateiha, 2016). These findings emphasize the need for pedagogical improvements in teacher education programs, particularly to strengthen conceptual understanding and flexibility in algebraic reasoning.

Misconceptions of Prospective Elementary School Teachers

The misconceptions of prospective elementary school teachers show that the most common type of error made by prospective teachers is conceptual errors (44.1%). The dominance of conceptual errors indicates that most prospective elementary school teachers do not yet have a complete understanding of basic mathematical concepts. This type of error occurs when individuals understand concepts incompletely or incorrectly, resulting in the application of inappropriate procedures even though the steps appear to be correct (Novita et al., 2022). Prospective teachers tend to master without understanding the mathematical justification in the process of exploration and thinking (Sinabang et al., 2025).

Misconceptions in the form of procedural errors (30.1%) were also high. These misconceptions arise when prospective elementary school teachers know the basic concepts but are unable to perform the procedures correctly. Thus, procedural errors are mechanistic and often reflect a weak understanding of the sequence of operations or rules of symbolic manipulation (Lubis et al., 2025). This level of misconception indicates that some prospective teachers still have difficulty performing mathematical procedures consistently, even though they have conceptual understanding (Putri et al., 2024).

Misinterpretation errors (17.2%) indicate that some respondents had difficulty interpreting the context of questions, graphs, or data representations. Prospective teachers often misinterpreted statistical information, for example, confusing the concepts of mean and mode or misunderstanding data distribution (Karatoprak et al., 2015). This type of error highlights the importance of strengthening mathematical literacy skills, especially in understanding non-symbolic information. Meanwhile, careless errors had the lowest proportion (8.6%). These errors were not random but were more likely to be associated with conceptual and procedural weaknesses (Pratiwi et al., 2022)

Overall, this error profile illustrates that conceptual misunderstanding is the most significant challenge for prospective elementary school teachers, followed by weaknesses in mathematical procedures and interpretation skills. These findings emphasize the urgency of strengthening more in-depth conceptual learning in teacher education programs to reduce the potential for misconceptions and improve their pedagogical readiness in teaching basic mathematics.

The Results of Misconceptions and Basic Mathematical Skills of Prospective Elementary School Teachers

Analysis of each aspect of basic mathematical ability shows different distributions of misconceptions. In the Number and Operations aspect, misconceptions appear most dominantly (23.1%). Errors are mainly related to understanding place value in decimal numbers, such as assuming that 0.25 is greater than 0.3. This shows that prospective elementary school teachers often have difficulties with place value and fraction representation, making them prone to incorrect generalizations about numerical values (Widyatma & Ramadhani, 2024). In the aspect of algebra, misconceptions reached 19.6%. The main errors included understanding variables, symbols, and the application of the distributive law. Prospective elementary school teachers tend to treat variables as fixed numbers and do not see them as general representations, which results in a weakening of their mastery of symbolic structures and mathematical relations (Öztürk-Tavşan & İşler-Baykal, 2025).

The geometry aspect had a misconception rate of 14.9%. Errors occurred mainly in the definition of basic geometric objects, such as confusion between radius and diameter (Ulfa & Hamdi, 2025). Misconceptions in measurement amounted to 17.1%, mainly related to unit conversion and the difference between the concepts of area and perimeter. Prospective elementary school teachers often experience deficiencies in understanding unit relationships, so they tend to perform mechanical procedures without understanding the meaning of the quantities (Nurwahida & Munir, 2022). In the Data Analysis and Probability aspect (14.3%), misconceptions arise in the interpretation of graphs/tables and the understanding of basic probability. Prospective elementary school teachers often assume that events with higher frequencies in small samples always have greater probabilities, which indicates an intuitive bias in interpreting data (Prayitno et al., 2024).

Overall, the analysis shows that the most critical misconceptions are found in Number and Operations and Algebra. Meanwhile, the aspects of geometry, measurement, and data/probability show lower proportions, but all three still display errors that need to be reinforced. These results emphasize the importance of pedagogical interventions that emphasize conceptual understanding, not just procedures, in teacher education programs (Maharyati & Ningsih, 2025).

The Relationship Between Basic Mathematical Ability and Misconceptions Among Prospective Elementary School Teachers

Analysis of the relationship between basic mathematical ability and the percentage of misconceptions shows a very consistent and conceptually significant pattern. Prospective teachers with high basic ability have a very low average misconception rate (7.8%). Conversely, the group with low proficiency showed the highest level of misconceptions (46.5%), while the moderate-ability group showed 22.4%. This pattern indicates that stronger mastery of mathematical concepts is associated with fewer misconceptions. Theoretical perspectives suggest that misconceptions arise mainly from weak conceptual understanding, not merely procedural errors (Hamid, 2025). Prospective elementary school teachers with good mastery of the material tend to be able to organize information more coherently and relate core concepts, thus being better able to avoid fundamental errors (Niswati & Sayekti, 2020). Prospective elementary school teachers also evaluate and verify mathematical strategies independently, thereby reducing the likelihood of misconceptions (Surabaya, 2024).

Not only that, but prospective elementary school teachers with low basic skills are also associated with mathematical working procedures. Prospective elementary school teachers often memorize algorithms but do not understand the concept structure in depth (Thanheiser et al., 2014). This results in prospective elementary school teachers being unable to detect inconsistencies in their thinking, allowing misconceptions to develop more widely (Isrokatun et al., 2023). Overall, these results confirm that the root cause of misconceptions is a weak grasp of basic mathematics, rather than simply a momentary mistake or carelessness. The implication for teacher education is that strengthening conceptual understanding early in the program may play a major role in preventing the formation of misconceptions that could later be carried over into teaching practice (Nurfajria & Badaruddin, 2024).

These findings have practical implications for PGSD teacher education, particularly the need to prioritize concept-focused learning in Number and Operations and Algebra. Instruction that explicitly links procedures with conceptual meaning and uses multiple representations may support prospective teachers in developing more stable understanding and reducing systematic misconceptions. Diagnostic assessments that identify dominant error patterns can also help programs provide timely, targeted feedback and remediation during basic mathematics coursework.

Despite these contributions, the study is limited by its descriptive cross-sectional design, which restricts causal interpretation, and by the sampling context that may limit broader generalizability. In addition, misconception identification relied mainly on written responses and coding, which may not fully capture underlying reasoning. Future studies should replicate this

work in broader settings and employ longitudinal or intervention approaches to evaluate whether concept-based instructional support can reduce misconceptions over time. Taken together, strengthening conceptual understanding during teacher education remains a key step to prevent misconceptions from persisting and being transferred into elementary classrooms.

CONCLUSION

This study set out to profile prospective elementary school teachers' basic mathematical abilities and their misconceptions. The findings show that overall basic mathematical ability remains in the moderate category, with clear variation across domains: geometry is the most mastered domain, whereas algebra and number and operations represent the most prominent weaknesses. The error analysis further demonstrates that misconceptions are systematic, marked primarily by conceptual and procedural errors rather than incidental mistakes, indicating that conceptual understanding is still not comprehensively formed in key foundational areas such as symbolic representation, number structure, place value, and variable manipulation.

This study contributes an integrated empirical picture by linking ability profiling with misconception mapping. It confirms that misconceptions occur most frequently in number and operations and algebra domains that also reflect weaker mastery and that lower basic mathematical skills are consistently associated with higher levels of misconception.

Practically, these results provide a strong basis for strengthening concept-focused learning in PGSD teacher education, including the use of diagnostic assessments and learning practices grounded in conceptual representations, so prospective teachers can develop a stable knowledge structure and provide correct conceptual explanations in elementary mathematics learning. Future research should replicate this profiling across broader institutional contexts and cohorts to test the generalizability of the patterns reported here. In addition, intervention-based and longitudinal studies are needed to evaluate whether concept-based instructional supports and diagnostic assessment practices can reduce misconceptions over time, particularly in number and operations and algebra. Taken together, this study underscores that strengthening conceptual understanding in teacher education is essential to prevent misconceptions from persisting and being transmitted into elementary classrooms.

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