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ARE INDONESIAN PROSPECTIVE MATHEMATICS TEACHERS READY? DIAGNOSTIC INSIGHTS INTO BASIC MATHEMATICAL COMPETENCE

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Abstract

Basic mathematical skills constitute a crucial foundation for prospective mathematics teachers, as weaknesses in this competence may hinder conceptual understanding, the development of Pedagogical Content Knowledge (PCK), and readiness to teach effectively. Therefore, an early diagnostic assessment of prospective teachers' mathematical competence is important to provide empirical evidence for curriculum improvement in mathematics teacher education programs. This study aims to identify the profile of prospective teachers' basic mathematical skills and formulate curriculum implications based on diagnostic findings. A quantitative descriptive approach was employed involving 85 third-semester students of the Mathematics Education Program at one of the teacher education institutions (LPTK) in North Sumatra Province, Indonesia, selected through random sampling. The research instrument consisted of a written test containing 40 multiple-choice items covering five junior secondary mathematics content domains: number, algebra, measurement, geometry, and data analysis and probability. Data were analyzed using descriptive statistical techniques to determine achievement percentages across domains and identify patterns of students' weaknesses. The findings reveal that 91.76% of students were categorized as having low mathematical ability, with an average score of 29.86 on a 100-point scale. Domain-based analysis showed that algebra achieved the highest percentage (38.55%), followed by data analysis and probability (37.84%), geometry (28.24%), number (24.00%), and measurement (20.67%) as the weakest domain. These findings indicate the need for curriculum interventions, including matriculation programs, redesigning junior secondary mathematics courses through Hypothetical Learning Trajectory (HLT), implementing Realistic Mathematics Education (RME), and conducting periodic diagnostic assessments to strengthen prospective teachers' mathematical foundations.

Keywords*: Assessment of Mathematical Ability, Pedagogical Content Knowledge, Prospective Teachers*

Abstrak

Kemampuan matematika dasar merupakan fondasi penting bagi calon guru matematika, karena kelemahan dalam kompetensi ini dapat menghambat pemahaman konseptual, pengembangan Pedagogical Content Knowledge (PCK), dan kesiapan untuk mengajar secara efektif. Oleh karena itu, asesmen diagnostik dini terhadap kompetensi matematika calon guru penting dilakukan untuk memberikan bukti empiris bagi perbaikan kurikulum pada program pendidikan guru matematika. Penelitian ini bertujuan untuk mengidentifikasi profil kemampuan matematika dasar calon guru serta merumuskan implikasi kurikulum berdasarkan temuan diagnostik. Pendekatan deskriptif kuantitatif digunakan dengan melibatkan 85 mahasiswa semester tiga Program Studi Pendidikan Matematika di salah satu Lembaga Pendidikan Tenaga Kependidikan (LPTK) di Provinsi Sumatera Utara, Indonesia, yang dipilih melalui sampel acak. Instrumen penelitian berupa tes tertulis yang terdiri atas 40 butir soal pilihan ganda yang mencakup lima domain konten matematika sekolah menengah pertama, yaitu bilangan, aljabar, pengukuran, geometri, serta analisis data dan peluang. Data dianalisis menggunakan teknik statistik deskriptif untuk menentukan persentase capaian pada setiap domain dan mengidentifikasi pola kelemahan mahasiswa. Hasil penelitian menunjukkan bahwa 91,76% mahasiswa tergolong memiliki kemampuan matematika rendah, dengan rata-rata skor sebesar 29,86 pada skala 100. Analisis berdasarkan domain menunjukkan bahwa aljabar memperoleh persentase tertinggi (38,55%), diikuti oleh analisis data dan peluang (37,84%), geometri (28,24%), bilangan (24,00%), dan pengukuran (20,67%) sebagai domain yang paling lemah. Temuan ini mengindikasikan perlunya intervensi kurikulum, antara lain program matrikulasi, perancangan ulang mata kuliah matematika sekolah menengah pertama melalui Hypothetical Learning Trajectory (HLT), penerapan Realistic Mathematics Education (RME), serta pelaksanaan asesmen diagnostik secara berkala untuk memperkuat fondasi matematika calon guru.

Kata Kunci: Asesmen Kemampuan Matematika, *Pedagogical Content Knowledge, Calon Guru*

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INTRODUCTION

The competency of teachers in mastering mathematical content and pedagogical skills primarily determines the quality of mathematics education in Indonesia. However, various studies have shown that prospective mathematics teachers continue to face significant challenges in understanding basic mathematical concepts (Khairudin, 2020; Jannah et al., 2021). This condition presents a paradox, as educators expect prospective teachers not only to master advanced university-level material but also to possess a deep understanding of school mathematics that they will later teach. Ball et al. (2008) emphasize, through the theory of Mathematical Knowledge for Teaching (MKT), that a profound understanding of school mathematics content is an essential foundation for mathematics teachers. MKT encompasses not only Common Content Knowledge (CCK), which anyone using mathematics must possess, but also Specialized Content Knowledge (SCK), which is specific to teachers, such as the ability to analyze students' errors, select appropriate representations, and anticipate conceptual difficulties. In this context, insufficient mastery of foundational mathematics may hinder prospective teachers from constructing meaningful conceptual explanations and making appropriate pedagogical decisions in classroom practice. Difficulties in understanding school-level mathematics can also weaken their ability to connect concepts across topics, identify misconceptions, and adapt instruction to students' needs. Consequently, teacher education institutions need to ensure that prospective mathematics teachers possess strong basic mathematical competencies before engaging in more advanced disciplinary and pedagogical coursework, making diagnostic evaluation of foundational knowledge an important component of curriculum development and quality assurance.

The basic mathematical abilities of prospective teachers play a crucial role in two main aspects. First, they serve as prerequisites for advanced courses such as Real Analysis, Abstract Algebra, and Statistics, which require strong conceptual understanding (Sucipto & Mauliddin, 2017; Mardianto et al., 2024; Lestari et al., 2026). Second, they constitute the foundation for the development of Pedagogical Content Knowledge (PCK), namely the ability to transform mathematical knowledge into effective instruction (Ayuningtyas & Apriandi, 2019). Research has shown that strong mastery of basic mathematics correlates with higher-order thinking skills and the ability to comprehend abstract concepts (Aprillia & Sutiarso, 2023). In line with the concept of profound understanding of fundamental mathematics proposed by Ma (1999), mathematics teachers need to possess deep, interconnected, and flexibly represented knowledge. Such understanding enables teachers to explain concepts from multiple perspectives, justify mathematical procedures, and respond appropriately to students' misconceptions and learning difficulties in classroom contexts. Therefore, basic mathematical ability serves as a key indicator of both academic and professional success for prospective teachers.

However, field realities reveal a concerning gap between expectations and actual conditions. Data from the Minimum Competency Assessment (AKM) indicate that Indonesian students' numeracy skills remain below international standards (Kemendikbudristek, 2021), which in turn affects the quality of incoming students in mathematics education programs. Studies show that prospective teachers enter university with low initial competency, particularly in the domains of algebra, geometry, trigonometry, and functions (Khairudin, 2020; Setiawan et al., 2022). These conceptual weaknesses often originate as early as the secondary school level (Khusna et al., 2023). This situation raises a critical question: how can prospective teachers teach mathematics effectively if their mastery of fundamental concepts is still limited? Moreover, inadequate foundational understanding may create cumulative learning difficulties in university coursework, reducing prospective teachers' confidence, limiting conceptual connections across topics, and affecting their capacity to facilitate meaningful mathematical learning experiences for future students.

At the Mathematics Education Study Program of Universitas Islam Negeri Sumatera Utara (UINSU), lecturers have also identified this phenomenon through informal observations and instructional records. Students taking advanced mathematics courses, such as Real Analysis, Abstract Algebra, and Linear Algebra, often exhibit conceptual difficulties rooted in a weak mastery of basic mathematical concepts at the secondary school level. These weaknesses not only affect academic performance but also hinder the development of professional competencies as future teachers (Hasanah & Siregar, 2022). Research conducted at various teacher education institutions indicates that this issue is systemic and requires data-driven interventions (Kasim et al., 2023; Jannah et al., 2021; Oktariani & Puspaningtyas, 2024). Therefore, the program needs to conduct an initial assessment of students' basic mathematical abilities before they undertake the Junior Secondary Mathematics Studies course, so that instructional interventions can be more targeted and effective. Such an assessment may also provide valuable information regarding patterns of conceptual misunderstanding, students' readiness for higher-level learning, and priority areas requiring curricular reinforcement. The resulting evidence can support lecturers in designing remedial instruction, adjusting learning trajectories, and improving the alignment between prerequisite competencies and course expectations.

Several studies have examined the mathematical abilities of prospective teachers from different perspectives. Khairudin (2020) examined students’ initial mathematical abilities with a particular focus on algebra, while Setiawan et al (2022) investigated the numeracy literacy of prospective mathematics teachers. Kasim et al. (2023) analyzed students’ initial mathematical abilities, whereas Khusna et al. (2023) focused on algebra and geometry. Reflina (2020) examined prospective mathematics teachers’ difficulties in solving geometry problems, and Septianingsih & Zakiyah (2026) emphasized the importance of mapping students’ initial mathematical competencies as a basis for adaptive learning. Although these studies provide important evidence regarding prospective teachers’ mathematical competence, their diagnostic scope is generally limited to particular mathematical topics or broad measures of mathematical ability. Consequently, they provide less evidence on how weaknesses are distributed across the major domains of junior secondary mathematics and how such domain-specific evidence can be translated into curriculum decisions in mathematics teacher education. The present study advances previous diagnostic research in three ways. First, it provides an empirical diagnostic profile based on students’ performance across five junior secondary mathematics content domains—number, algebra, measurement, geometry, and data analysis and probability—thereby enabling the identification of domain-specific strengths and priority areas for intervention. Second, the empirical findings are interpreted in relation to Mathematical Knowledge for Teaching (MKT) and the notion of profound understanding, allowing the observed weaknesses in foundational content knowledge to be considered in terms of their potential implications for prospective teachers’ future capacity to explain concepts, address misconceptions, and use appropriate mathematical representations. Third, the study translates the diagnostic evidence into specific curriculum and instructional implications rather than treating assessment results as an endpoint. In particular, the findings are used to justify diagnostic-remedial matriculation, the redesign of the Junior Secondary Mathematics Studies course, the use of Hypothetical Learning Trajectory (HLT) to organize progressive conceptual development, the integration of Realistic Mathematics Education (RME) to strengthen contextual application and numeracy, and periodic diagnostic assessment. Thus, the unique contribution of this study to mathematics teacher education research lies in connecting comprehensive empirical diagnosis with a theory-informed interpretation of teacher knowledge and concrete curriculum responses, providing an evidence-based pathway from identifying foundational weaknesses to strengthening the preparation of prospective mathematics teachers at UINSU.

This study addresses the aforementioned gap through three main contributions. First, it presents a comprehensive diagnostic profile covering all junior secondary mathematics content domains, namely number, algebra, geometry, measurement, and data analysis and probability, using standardized instruments with a representative sample. Second, it analyzes item-level achievement and links the findings to the theoretical frameworks of Mathematical Knowledge for Teaching (MKT) and profound understanding, aiming to reveal gaps between students' actual abilities and professional teacher competency standards. Third, it offers concrete, theory-based recommendations for curriculum development. Specifically, the study aims to (1) map the level of mastery of prospective teachers at UINSU across each junior secondary mathematics content domain, and (2) formulate practical implications for curriculum development and instructional strategies in the Mathematics Education Program. The findings aim to provide empirical contributions to improving the quality of prospective mathematics teachers, particularly within the context of State Islamic Higher Education institutions. In addition, the study is expected to support evidence-based decision making in curriculum planning, strengthen alignment between prerequisite competencies and course demands, and provide a reference for designing diagnostic-based instructional interventions to address students' conceptual weaknesses systematically and sustainably.

METHODS

This study employs a quantitative descriptive approach with a diagnostic design to depict the profile of prospective teachers' basic mathematical abilities. The researchers chose this approach because it aligns with the research objectives of systematically identifying and mapping students' mastery of school-level mathematical concepts using numerical data (Creswell & Creswell, 2018). Diagnostic research enables the identification of specific weaknesses within each mathematics content domain, providing actionable information for curriculum and instructional improvements (Desjardins & Bulut, 2018). The researchers collected data through a written test and subsequently analyzed it using descriptive statistics to provide an overview of students' ability distribution across high, medium, and low categories within each junior secondary mathematics content domain.

The participants were 85 third-semester students (65.9% of the population of 129 students) from the Mathematics Education Study Program at UINSU during the 2024/2025 academic year. The participants were selected using simple random sampling. Practically, the sampling procedure was conducted by assigning a number to each of the 129 eligible students and selecting 85 students through a random-number drawing, giving each student an equal opportunity to be included in the sample. Third-semester students were selected because they had completed introductory mathematics courses but had not yet taken the Junior Secondary Mathematics Studies course.

The research instrument was a basic mathematics proficiency test developed to assess foundational junior secondary mathematics competencies. The instrument was developed with reference to the competency standards of the Merdeka Curriculum and adapted from the format of the former Indonesian National Examination (Ujian Nasional/UN). The test consisted of 40 multiple-choice items with four response options (A–D), covering five content domains: number (10 items), algebra (13 items), measurement (7 items), geometry (4 items), and data analysis and probability (6 items). Correct answers were scored as one and incorrect answers as zero, and the total score was converted to a 100-point scale. The items assessed foundational competencies involving numerical representation and operations, algebraic manipulation and problem solving, measurement and geometric properties, and data interpretation and probability. The complete test blueprint, including the indicators and item distribution across the five content domains, is presented in Table 1. The instrument underwent a pilot test prior to the main administration. Its content validity was assessed by three mathematics education experts, resulting in a content validity index of 0.89. Following the main administration, the internal consistency of the 40-item test was assessed using the Kuder–Richardson 20 (KR-20) coefficient, which yielded a value of 0.82, indicating high internal consistency.

Table 1. Blueprint of the Basic Mathematics Proficiency Test

Mathematical domain	Indicators assessed	Item numbers	Cognitive demand
Number	Comparing and ordering fractions, decimals, and percentages; performing numerical operations; applying number concepts to mathematical and contextual problems	1–10	Understanding and applying

Algebra	Identifying patterns and relationships; simplifying algebraic expressions; working with sets and algebraic representations; solving equations and systems; applying algebraic concepts to problems	11-23	Understanding and applying
Measurement	Applying measurement concepts and formulas to determine quantities such as area, volume, and related measures	24-30	Understanding and applying
Geometry	Applying properties of plane and solid figures; determining lengths, angles, areas, volumes, and spatial relationships	31-34	Understanding and applying
Data analysis and probability	Determining and interpreting measures of central tendency; reading and interpreting data representations; determining probabilities of events	35-40	Understanding and applying
Total		**40 items**	

Data were analyzed descriptively based on the percentage of achievement in each content domain. The results were used to identify students' relative strengths and weaknesses and to classify their overall basic mathematical ability into high, medium, and low categories. The classification criteria were adapted from the assessment criteria of the Ministry of Education and Culture (Kemendikbud, 2017), as presented in Table 2.

Table 2. Score Intervals and Categories of Basic Mathematical Ability

Score Interval (out of 100)	Ability Category
80 – 100	High
60 – 79	Medium
0 – 59	Low

RESULTS AND DISCUSSION

General Profile of Prospective Teachers' Basic Mathematical Abilities

The diagnostic results reveal a substantial gap in the foundational mathematical competence of the prospective mathematics teachers examined in this study. The 40-item test produced a mean score of 29.86 out of 100 (SD = 12.43), with scores ranging from 7.5 to 62.5. Thus, in Table 3, none of the 85 participants reached the high-ability category, while only seven students (8.24%) reached the medium category and 78 students (91.76%) remained in the low category. This distribution indicates that the students entered their third semester of mathematics teacher education with considerable variation but generally limited mastery of foundational junior secondary mathematics. The finding is consistent with recent concerns about the mathematical readiness of prospective teachers; for example, Arhin et al. (2025) specifically emphasized the importance of examining the mathematics readiness of pre-service teachers at the beginning of their university education.

Table 3. Distribution of Students Based on Basic Mathematical Ability Categories

Ability Category	Score Interval	Number of Students	Percentage
High	80 – 100	0	0,00%
Medium	60 – 79	7	8,24%
Low	0 – 59	78	91,76%
Total		85	100%

The low overall performance should not be interpreted simply as a lack of isolated procedural skills. Foundational mathematical knowledge provides an important basis for prospective teachers to connect mathematical ideas, interpret students’ reasoning, and engage successfully with more advanced university mathematics. Sugeng (2022), for instance, demonstrated that prospective mathematics teachers’ ability to make mathematical connections when solving advanced problems is related to their prior mathematical knowledge. Similarly, Wulan et al. (2024) showed that prospective mathematics teachers’ performance on mathematically demanding tasks can differ according to their prior knowledge. From this perspective, the low scores observed in the present study may signal gaps in prerequisite knowledge that could subsequently constrain students’ engagement with higher-level mathematical learning.

This issue is particularly important in mathematics teacher education because prospective teachers are expected not only to solve mathematical problems themselves but also to use mathematical knowledge in ways that support students’ learning. A recent review by Zlatkin-Troitschanskaia et al. (2025) highlights the complexity of modelling and assessing mathematics teachers’ competence, suggesting that teacher competence involves multiple interconnected dimensions rather than mathematical performance alone. Therefore, the diagnostic results in the present study should be viewed as an early indication of areas requiring targeted support rather than as a direct measure of future teaching competence. Strengthening foundational mathematical knowledge at the beginning of teacher preparation may provide a necessary basis for the subsequent development of more sophisticated professional and pedagogical competencies.

The findings also have implications for the organization of mathematics teacher preparation. Rather than assuming that prospective teachers enter university with sufficiently consolidated school mathematics knowledge, teacher education programs may benefit from systematic diagnostic screening at the beginning of the program. Such screening can help identify specific areas requiring remediation or enrichment before students encounter more advanced mathematical and pedagogical content. This recommendation is consistent with recent research emphasizing the development of prospective teachers’ diagnostic competencies and the need for structured support within university teacher education (Schons et al., 2022; Walter et al., 2025). In this sense, diagnostic assessment can function not merely as a mechanism for classifying students but as a basis for designing responsive learning opportunities.

At the national level, the present findings should be interpreted cautiously because the participants were drawn from a single mathematics education program at UINSU. Nevertheless, they point to a potentially important issue for mathematics teacher education: foundational mathematical competence should be explicitly monitored as part of prospective teachers’ academic development rather than being assumed to have been fully acquired before entering university. Further studies involving multiple teacher education institutions are needed to determine whether similar patterns occur across different regions and institutional contexts in Indonesia. Such evidence would provide a stronger basis for designing nationally informed strategies to strengthen the mathematical foundations of future mathematics teachers.

Domain-Specific Profile of Prospective Teachers' Basic Mathematical Abilities

The domain-specific results reveal a clear hierarchy of students’ mathematical performance, although achievement remained low across all five domains. In Table 4, algebra recorded the highest achievement (38.55%), followed by data analysis and probability (37.84%), geometry (28.24%), number (24.00%), and measurement (20.67%). The approximately 18-percentage-point difference between the highest and lowest domains suggests that students’ foundational knowledge is not uniformly weak; rather, particular areas require more immediate attention. This pattern is important for teacher preparation because a single overall score does not adequately identify the specific mathematical knowledge that prospective teachers need to strengthen.

Algebra emerged as the relatively strongest domain, although the overall achievement remained within the low category. Students performed comparatively well on arithmetic sequences (62.35%) and basic algebraic operations (64.71%), while performance was substantially lower on sets (11.76%), linear equations in one variable (21.18%), and geometric sequences (24.71%). Students’ performance on systems of two linear equations also remained limited, ranging from 32.94% to 42.35%. This contrast suggests that students may be more familiar with some routine algebraic procedures than with tasks requiring flexible application and relational understanding. Sucipto & Mauliddin (2017) & Mardianto et al. (2024) similarly reported that weaknesses in prerequisite mathematical concepts can create difficulties when students encounter more advanced mathematics. Thus, the relatively higher algebra score should not be interpreted as evidence of strong algebraic understanding; rather, it may indicate that some procedural aspects of algebra are more familiar to students than more conceptually demanding forms of reasoning.

The data analysis and probability domain showed the second-highest achievement (37.84%), although performance varied considerably across the assessed competencies. Students demonstrated relatively strong performance on mode (70.59%), whereas achievement was lower on mean (35.29% and 24.71%), interpreting pie charts (32.94%), and probability-related tasks (30.59%–32.94%). This variation suggests that students may be more comfortable identifying a familiar statistical concept than working flexibly with quantitative information and probability. Such a pattern is important because mathematical competence in data and probability requires more than recalling formulas; it also involves interpreting representations, connecting quantities, and making reasoned judgments from data. Utomo (2023) similarly emphasized the importance of numeracy competence for prospective mathematics teachers, particularly in applying mathematical knowledge beyond routine procedures. Therefore, teacher preparation should provide opportunities for prospective teachers to work with authentic data, interpret multiple representations, and justify statistical and probabilistic conclusions rather than relying primarily on formula-based exercises.

Geometry achievement was lower, at 28.24%, with performance across items ranging from 17.65% to 40.00%. The weakest results were found in similarity and congruence (17.65%–18.82%), whereas the highest performance was observed in another similarity and congruence item (40.00%) and angle relationships (36.47%). These results suggest considerable variation in students’ understanding of geometric relationships rather than uniformly weak performance across all geometry tasks. Geometry often requires learners to coordinate visual representations, properties, spatial relationships, and symbolic reasoning simultaneously. The variation observed in this study may therefore indicate a need for learning experiences that explicitly connect diagrams, spatial representations, and formal mathematical reasoning. This interpretation is consistent with Reflina (2020), who reported difficulties among prospective mathematics teachers in solving geometry problems. For teacher preparation, strengthening such connections is particularly important because future teachers need to explain geometric relationships through multiple representations rather than rely exclusively on formulas.

The number domain produced an even lower achievement percentage (24.00%). Students’ weakest performance occurred on radical numbers (8.24%), integers (14.12%), and ratio (12.94%). Other difficulties were observed in inverse proportion (18.82%) and integer-related tasks (20.00%). These results suggest that students’ difficulties extend from basic numerical concepts to the flexible use of numbers in comparative and contextual situations. Khairudin (2020) similarly reported difficulties among mathematics education students in dealing with basic mathematical concepts, indicating that gaps in school-level knowledge can persist into university study. The low performance in the number domain is particularly important because numerical ideas serve as prerequisites for learning across many other areas of mathematics. From a teacher-education perspective, remediation should therefore focus not only on computational accuracy but also on representations of numbers, relationships among number forms, estimation, and the interpretation of numerical quantities in context.

Measurement was the weakest domain, with an achievement percentage of only 20.67%. Performance varied substantially across the assessed topics, from 9.41% on arc length to 38.82% on the volume of a cylinder. Students also showed low achievement on area (12.94%–20.00%), the volume of a pyramid (17.65%), the space diagonal of a cuboid (21.18%), and combined surface area (24.71%). The particularly low performance on arc length and area suggests difficulties across both geometric measurement and the application of measurement relationships. A possible explanation is that measurement tasks require students to integrate several forms of mathematical knowledge, including numerical operations, geometric properties, spatial reasoning, proportional relationships, units, and contextual interpretation. Consequently, the weakness observed in measurement may reflect difficulties in connecting these components rather than a simple inability to recall formulas. This interpretation supports the need for stronger integration between conceptual understanding and application in teacher education, particularly because prospective teachers must later help school students make sense of measurement quantities rather than merely apply formulas.

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The contrast between algebra and measurement also provides an important curriculum implication. The higher performance in algebra may partly reflect greater familiarity with symbolic procedures, whereas the lower performance in measurement may indicate greater demands for coordination among representations, spatial relationships, units, and contextual meaning. However, because the present study was descriptive, these explanations should be treated as plausible interpretations rather than established causal factors. Further research involving classroom observations, interviews, or analysis of students' written responses would be needed to determine whether differences in curriculum exposure, instructional practices, prior educational experiences, or conceptual understanding explain the observed domain differences. The present diagnostic profile nevertheless provides useful evidence for identifying where such follow-up investigation and instructional support should be directed.

Overall, the domain-level findings indicate that prospective teachers need differentiated support rather than a uniform remedial program. Algebra requires a shift from routine procedures toward generalization, structural reasoning, and contextual application; data analysis and probability require stronger interpretation and reasoning with data and uncertainty; geometry requires greater coordination of visual, spatial, and formal representations; number requires reinforcement of foundational concepts and flexible numerical reasoning; and measurement requires integrated work with quantities, units, spatial relationships, and contextual applications. Such differentiation is consistent with the broader argument for using diagnostic evidence to inform mathematics teacher preparation rather than treating prospective teachers as a homogeneous group. The findings therefore support the implementation of targeted diagnostic-remedial activities and structured learning trajectories within teacher education, with particular priority given to the number and measurement domains.

Table 4. Students' Ability Profile Based on Mathematics Content Domains

Content Element	Achievement Percentage	Category
Algebra	38,55%	Low
Data Analysis and Probability	37,84%	Low
Geometry	28,24%	Low
Number	24,00%	Low
Measurement	20,67%	Very Low

Implications of Findings for Curriculum Development in the Study Program

The findings have important implications for curriculum development in the Mathematics Education Program at UINSU. With 91.76% of students classified in the low-ability category and no students reaching the high category, the results indicate substantial gaps in foundational mathematical knowledge. Similar concerns have been reported regarding the mathematical readiness and prior knowledge of prospective mathematics teachers (Arhin et al., 2025; Sugeng, 2022). Therefore, curriculum development should respond to students’ specific mathematical needs rather than assume that prerequisite knowledge has been fully established.

First, a diagnostic-remedial bridging program could be implemented for students with substantial gaps in prerequisite knowledge. This is particularly important for the measurement (20.67%) and number (24.00%) domains, including very low achievement in arc length (9.41%), radical numbers (8.24%), and area (12.94%). Rather than simply reviewing procedures, remediation should target conceptual understanding through diagnostic assessment, targeted intervention, and follow-up assessment. Such an approach is consistent with the importance of diagnostic processes in developing prospective teachers’ professional competence (Schons et al., 2022; Walter et al., 2025).

Second, the Junior Secondary Mathematics Studies course should emphasize conceptual connections rather than procedural review alone. Although algebra was the strongest domain (38.55%), achievement varied substantially across topics, from 11.76% on sets to 64.71% on algebraic operations. This variation suggests that relatively strong performance on routine procedures does not necessarily reflect comprehensive conceptual mastery. Therefore, learning activities should require students to explain, represent, justify, and apply mathematical ideas. This is consistent with the MKT perspective (Ball et al., 2008) and recent findings on the integration of mathematical and pedagogical knowledge among prospective teachers (Ayuningtyas & Apriandi, 2019; Setiawan et al., 2025).

Third, the measurement domain should receive particular attention because it showed the lowest achievement (20.67%). Students’ low performance on arc length (9.41%), area (12.94%–20.00%), and pyramid volume (17.65%) suggests difficulties in connecting formulas with quantities and geometric representations. A Hypothetical Learning Trajectory (HLT) could be used to organize learning progressively from exploration and visual representation toward formalization (Simon, 1995). Previous research also indicates the potential of HLT to support prospective teachers’ professional learning (Ivars et al., 2019).

Fourth, the curriculum should provide more opportunities to connect mathematical concepts with meaningful contexts. Difficulties in ratio (12.94%), inverse proportion (18.82%), and measurement-related tasks indicate the need to strengthen students’ ability to apply mathematics beyond routine procedures. Numeracy among prospective teachers also requires the ability to use mathematical knowledge meaningfully in different situations (Ayuningtyas & Sukriyah, 2020). RME could therefore be considered as one approach for integrating contextual problems, mathematization, and formal mathematical concepts, although its effectiveness was not directly examined in the present study.

Finally, diagnostic assessment should be conducted periodically to monitor students’ development and inform instructional decisions. The differences across domains demonstrate that overall scores alone do not adequately represent students’ specific learning needs. Integrating diagnostic assessment into the curriculum could help lecturers identify priority areas, provide targeted support, and monitor progress. Overall, the findings support a more responsive teacher education curriculum that strengthens foundational knowledge while connecting school mathematics with conceptual, contextual, and pedagogical learning.

Implications of Findings for the Development of Pedagogical Content Knowledge (PCK)

The low mastery of basic mathematics identified in this study has important implications for the development of prospective teachers’ Pedagogical Content Knowledge (PCK). Within the MKT framework, Ball et al. (2008) distinguish Common Content Knowledge (CCK) from Specialized Content Knowledge (SCK), with the latter requiring teachers to understand mathematical content in ways that support teaching, including explaining concepts, interpreting students’ strategies, and selecting appropriate representations. The low achievement observed in the present study, particularly in number (24.00%) and measurement (20.67%), suggests that strengthening foundational content knowledge should be an important component of teacher preparation before expecting prospective teachers to develop more specialized pedagogical uses of mathematics.

This implication is particularly relevant because PCK requires prospective teachers to connect mathematical knowledge with decisions about how mathematics should be represented and explained to learners. Previous studies have emphasized the relationship between prospective teachers’ content knowledge and pedagogical knowledge (Ayuningtyas & Apriandi, 2019; Setiawan et al., 2025). Njiku (2025) further highlights the role of teaching practicum in developing prospective teachers’ mathematics pedagogical content knowledge, suggesting that content knowledge needs to be connected with opportunities to interpret and enact mathematical knowledge in teaching situations. In the present study, difficulties in applying mathematical concepts, interpreting relationships, and working beyond routine procedures may limit opportunities for prospective teachers to develop such connections. Therefore, teacher education should provide learning experiences that require students not only to solve mathematical problems but also to explain their reasoning, compare representations, anticipate possible difficulties, and justify instructional choices.

Accordingly, the recommended curricular interventions should address both mathematical understanding and the development of reflective awareness. Diagnostic-remedial programs can strengthen prerequisite knowledge, while HLT-based activities can help prospective teachers connect mathematical concepts with learning processes (Simon, 1995; Ivars et al., 2019). Similarly, contextual approaches such as RME can provide opportunities to examine how mathematical ideas are connected to meaningful situations. Through these experiences, prospective teachers can reflect on how mathematical understanding is constructed and how learners may experience difficulties in developing that understanding. Thus, strengthening basic mathematics should be viewed not merely as remediation, but as a foundation for developing the integrated mathematical and pedagogical knowledge required for effective mathematics teaching.

However, the findings should be interpreted within the institutional context of UINSU, as the participants were drawn from a single mathematics education program; therefore, the results cannot be generalized to all prospective mathematics teachers in Indonesia.

CONCLUSIONS AND SUGGESTIONS

Conclusions

This study revealed that the basic mathematics ability of prospective teachers in the Mathematics Education Program at UINSU remains low. Of the 85 students, 91.76% were classified in the low-ability category, with a mean score of 29.86 out of 100. Across content domains, algebra showed the highest achievement (38.55%), followed by data analysis and probability (37.84%), geometry (28.24%), number (24.00%), and measurement (20.67%). The results indicate substantial gaps in foundational mathematical knowledge, particularly in measurement and number, as well as difficulties in applying mathematical concepts beyond routine procedures. These conditions have important implications for the development of prospective teachers’ mathematical and pedagogical knowledge.

Suggestions

Based on these findings, several practical actions are recommended. First, a diagnostic-remedial matriculation program could be implemented during the first 4–6 weeks of the semester. The program should begin with diagnostic assessment, followed by targeted instruction on students’ weakest domains, and conclude with a post-assessment. The program should involve lecturers in mathematics education and is expected to improve students’ mastery of prerequisite concepts, with success indicated by achieving the minimum competency criterion established by the study program. Second, the Junior Secondary Mathematics Studies course should be redesigned over one semester to emphasize conceptual understanding and mathematical connections. Lecturers should incorporate tasks requiring explanation, representation, justification, and application, supported by Hypothetical Learning Trajectories (HLT). The expected outcome is improved ability to connect mathematical procedures with underlying concepts and teaching situations, with progress evaluated through domain-level achievement and students’ performance on conceptual tasks. Third, Realistic Mathematics Education (RME) can be integrated into relevant mathematics education courses throughout the semester to strengthen contextual mathematical reasoning and numeracy. Lecturers should use realistic problems, mathematization activities, and applications in new contexts. Success can be monitored through students’ ability to interpret and solve contextual problems rather than rely solely on procedural calculations.

The findings should nevertheless be interpreted within several limitations. The study involved prospective mathematics teachers from a single institution and therefore cannot be generalized to all Indonesian prospective mathematics teachers. In addition, the cross-sectional and descriptive design provides a snapshot of students’ mathematical abilities but does not establish changes over time or causal relationships. The study also relied primarily on quantitative test data and did not include qualitative investigation of students’ reasoning or misconceptions. Future studies should therefore involve multiple institutions, longitudinal or intervention-based designs, and qualitative analyses to obtain a more comprehensive understanding of prospective teachers’ mathematical learning and development.

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