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Researching on the Knowledge of Teachers Who Teach Math for Secondary Level Student Understanding

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Abstract

Although mathematics teachers' expertise in understanding subject matter is widely believed to have a direct impact on students' comprehension and academic achievements, there remains limited empirical research that specifically examines how teachers' content knowledge contributes to student learning outcomes. This study aims to assess the importance of mathematics teachers' competence in the content knowledge required for teaching secondary school mathematics. The research involved 55 secondary mathematics teachers who specialize in SS-level subjects for grades 10–12. Participants were selected through a combination of purposive and convenience sampling, considering their subject expertise and availability. Data were collected using a validated 25-question mathematics subject knowledge test, administered over 60 minutes via EduSuite computer-assisted instruction (CAI) software. The test was designed to evaluate teachers' understanding of essential mathematics topics taught in schools. Data analysis involved descriptive statistics, frequency distributions, and one-way ANOVA to assess the variation in mathematics knowledge and classify achievement levels based on established benchmarks. The findings provide a comprehensive overview of teachers' proficiency in key areas, including algebraic patterns, functions and relationships, space, geometric shapes, measurement, operations, trigonometry, and geometry. These results underscore the significance of strengthening mathematics content knowledge as part of teacher professional development. This study provides a solid foundation for designing targeted training and education programs aimed at improving the quality of mathematics instruction at the secondary level. Future research is recommended to explore the effectiveness of such training programs in enhancing teacher competency and improving student outcomes across different educational settings.

Keywords: Assesing; Knowledge; Teacher; Mathematics.

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Abstrak

Meskipun keahlian guru matematika dalam memahami materi pelajaran secara umum diyakini memiliki dampak langsung terhadap pemahaman dan pencapaian akademik siswa, namun masih terdapat keterbatasan penelitian empiris yang secara khusus mengeksplorasi sejauh mana pengetahuan konten guru berkontribusi terhadap hasil belajar siswa. Studi ini bertujuan untuk menilai pentingnya kompetensi guru matematika dalam penguasaan pengetahuan konten yang diperlukan untuk mengajar di tingkat sekolah menengah. Penelitian ini melibatkan 55 guru matematika sekolah menengah yang mengampu mata pelajaran tingkat Secondary School (SS) untuk kelas 10 hingga 12. Para peserta dipilih melalui kombinasi metode purposive dan convenience sampling, dengan mempertimbangkan keahlian dan ketersediaan mereka. Data dikumpulkan menggunakan tes pengetahuan konten matematika yang telah divalidasi, terdiri atas 25 butir soal, dan dilaksanakan selama 60 menit melalui perangkat lunak Computer-Assisted Instruction (CAI) EduSuite. Tes ini dirancang untuk mengukur pemahaman guru terhadap topik-topik esensial dalam kurikulum matematika sekolah menengah. Analisis data dilakukan menggunakan statistik deskriptif, distribusi frekuensi, dan analisis varians satu arah (ANOVA) untuk mengevaluasi variasi dalam tingkat pengetahuan serta mengklasifikasikan pencapaian berdasarkan tolok ukur yang telah ditetapkan. Temuan studi ini memberikan gambaran menyeluruh mengenai tingkat kecakapan guru dalam bidang-bidang utama seperti pola aljabar, fungsi dan relasi, ruang, bentuk geometris, pengukuran, operasi, trigonometri, dan geometri. Hasil tersebut menegaskan pentingnya penguatan pengetahuan konten matematika sebagai bagian integral dari pengembangan profesional guru. Studi ini menjadi landasan strategis untuk merancang program pelatihan dan pendidikan yang terfokus dalam rangka meningkatkan kualitas pembelajaran matematika di tingkat sekolah menengah. Penelitian lanjutan disarankan untuk mengevaluasi efektivitas program pelatihan tersebut dalam meningkatkan kompetensi guru dan mendukung pencapaian hasil belajar siswa di berbagai konteks pendidikan.

INTRODUCTION

In both developed and developing countries, the correlation between teacher knowledge in mathematics and student achievement has been proven. A deep understanding of mathematical concepts allows teachers to effectively convey complex material, implement innovative teaching strategies, and overcome challenges in the teaching process (Al Malki et al., 2023). Teacher proficiency in mathematics not only facilitates effective teaching but also significantly influences student participation and engagement in the learning process (Stewart & Ball, 2023). A strong understanding of mathematical concepts allows teachers to create an engaging learning environment, encouraging student motivation and interest in the subject (Sidekerskienė & Damaševičius, 2023). The positive impact is improving student achievement and increasing their interest in mathematics as a subject (Bhatia et al., 2024).

Beyond assessing teacher knowledge, it is important to explore students' understanding of mathematics. Research conducted by shows a positive correlation between students' overall mathematics knowledge and their teachers' expertise (Bhatia et al., 2024; Ortega-Barba et al., 2024). When teachers have a strong understanding of mathematics content, they can transfer that knowledge more effectively to students to better master the material (Braund, 2021).

A strong foundation in mathematics is especially important during the primary and secondary education levels, forming the basis of a student's understanding. Learning mathematics at the Secondary Education level aims to provide students with various experiences in mathematics, which will help them build mathematical reasoning skills and creativity (Naidoo & Reddy, 2023). This is an important step in preparing them to understand more complex mathematical concepts at the higher education level (Stewart & Ball, 2023). Teachers at the secondary school level must ensure that students can develop critical and analytical thinking through solving various mathematical

problems (Altynbekov et al., 2023; Stewart & Ball, 2023). In this way, students will be better prepared to face more complex mathematical challenges in the future (English, 2023).

In the context of primary and secondary education, teachers' mathematics content knowledge is very crucial. This stage is the foundation for forming students' understanding of mathematics (El Abbadi & Alaoui, 2023; Hoffstein-Rahmey et al., 2024). Secondary education plays an important role in shaping students' abilities and preparing them for future challenges (Barker et al., 2025). This is the phase where students not only acquire academic skills but also develop important non-academic skills such as teamwork, time management, and effective communication skills (Kostyrya et al., 2022).The secondary education stage offers students diverse course options, allowing them to explore their interests and talents deeply (Hernández et al., 2024). This exploration serves as a crucial foundation for further education, enabling students to carve a path toward a fulfilling and meaningful career aligned with their visions and dreams (Kay & Buxton, 2023).

Teachers specializing in secondary education play a pivotal role in this process, utilizing effective teaching methods to instill a deep understanding of mathematical concepts in students. This understanding is fundamental for applying mathematical concepts in real-life scenarios and positively contributing to society (Kay & Buxton, 2023). Beside that, the readiness of students to comprehend mathematics at the tertiary level is heavily influenced by the quality of their preparation in secondary education (Sutama et al., 2022). Teachers at the secondary education level must possess in-depth knowledge of mathematics, effective communication skills, and thorough preparation to ensure students are well-prepared for the challenges of higher education (Altynbekov et al., 2023).

While some research has shown that beginning mathematics teachers have adequate content knowledge to teach specific topics in the secondary grades, there are still gaps in their deep understanding of materials such as probability, statistics, and standard algorithms, which can potentially hinder their ability to communicate mathematical concepts effectively in the classroom (Lindberg, 2024). Little research specifically explores strategies or interventions that can improve preservice teachers' mathematical content understanding in these areas of weakness (Kay & Buxton, 2024).

Although baseline assessments have been widely recognized as essential instruments for identifying the initial needs, learning styles, and potential of prospective teachers, there is a gap in research examining how data from these assessments can be systematically processed and integrated into the design of teacher education programs. In particular, few studies explore the mechanisms for implementing baseline assessment results in the selection process, adaptive learning design, and ongoing coaching strategies that can accommodate the diversity of prospective teachers' academic backgrounds (English, 2023; Idrizi et al., 2023). Proper integration can significantly improve learning effectiveness, reduce competency gaps, and produce more pedagogically and content-ready prospective teachers (Kostyrya et al., 2022; Sidekerskienė & Damaševičius, 2023).

While several studies have revealed that the low quality of prospective

teachers and lax admission standards in teacher education programs negatively impact the quality of teaching and the prestige of the teaching profession, there is still a gap in research on effective data-based selection strategies and interventions to improve the quality of prospective teacher recruitment from the early stages (Dimos et al., 2023; Wort et al., 2024). Research that comprehensively evaluates the relationship between entry standards, prospective teacher motivation, and academic achievements during teacher education is still limited, even though this is crucial to breaking the recurring cycle of low-quality teaching in schools (Sanchayan et al., 2024; Stewart & Ball, 2023).

While studies have shown that many preservice teachers enter education programs with low mathematics achievement and face serious learning challenges, there is a gap in research on how teacher education curriculum design can effectively bridge the mathematics competency gap through the integration of mathematics content and pedagogy (Pramasdyahsari et al., 2023). Research on learning models or intervention programs that link conceptual understanding of mathematics with applicable teaching strategies for preservice teachers is still limited, even though this is crucial to ensuring their readiness to teach mathematics effectively in the classroom (Braund, 2021; Rohani et al., 2024).

While many studies emphasize the importance of a deep understanding of fundamental mathematics for preservice teachers to be able to teach effectively, evaluate student work, and lead meaningful classroom discussions, there is a gap in research on how learning approaches in higher education institutions (HEIs) can systematically build and develop such understanding (Wort et al., 2024). In particular, there is limited research exploring instructional designs that integrate content depth, inter-conceptual connectivity, and real-world applications in the training of preservice mathematics teachers and how such approaches impact their professional competence and teaching confidence in the field (Romero-Esquinas et al., 2022).

Efforts to improve the quality of mathematics education at the secondary school level, which has a long-term impact on the progress and welfare of society, are the primary focus of this research. By emphasizing the importance of improving teachers' knowledge of mathematics content, this research supports the development of educators' professional capacity as the primary foundation for creating a competent, skilled, and competitive generation in the global era (Q. Wang & Muttar, 2023). The results of this research are expected to be the basis for designing sustainable teacher training and development policies and strengthening the education system to encourage students' academic achievement sustainably, both in developed and developing countries (Karjanto & Acelajado, 2022; Naidoo & Reddy, 2023).

This study was conducted based on the urgent need to understand the relationship between teachers' mathematical content knowledge and its impact on student achievement at the secondary education level. Previous studies have shown that the quality of teaching is greatly influenced by the level of the teacher's understanding of the material being taught (Geiger & Schmid, 2024). Therefore, it is essential to examine the types and depth of mathematical knowledge required in teaching in secondary schools. This study is needed to develop teacher training and

education programs that can equip prospective teachers with relevant and applicable knowledge. Thus, this study is crucial in improving the quality of education by providing teachers who are more prepared, competent, and able to control the learning process effectively.

METHOD

The study involved 55 secondary mathematics teachers, selected through a combination of purposive and convenience sampling, and data were collected using a 25-question mathematics subject knowledge test administered via EduSuite CAI software. Data were analyzed using descriptive statistics, frequency distributions, and one-way analysis of variance (ANOVA) to evaluate variations in content knowledge and categorize achievement levels according to established benchmarks.

Participants in this study were fifty-five secondary education mathematics teachers who specialize in Senior Secondary (SS)-level mathematics subjects, specifically teaching grades 10, 11, and 12. These participants were selected through a purposive and convenience sampling technique, which enabled the researchers to deliberately choose individuals based on their subject matter expertise, professional experience, and accessibility during the research period. The purposive aspect ensured that only those with relevant teaching backgrounds and qualifications in secondary mathematics were included, thereby enhancing the relevance and credibility of the study findings. Meanwhile, convenience sampling accounted for the participants' availability and willingness to engage in the study within the allocated timeframe and research setting. This combination of sampling strategies was considered appropriate for capturing a representative understanding of mathematics content knowledge among practising teachers in actual classroom contexts. The selected participants reflect a diverse range of professional experiences, teaching styles, and institutional environments, which adds depth to the analysis and allows for a more comprehensive interpretation of the results.

The data collection instrument employed in this study was a mathematics subject knowledge test specifically developed to assess the content mastery of teachers at the secondary education and administrative levels. The test was carefully constructed to align with the mathematics curriculum standards for grades 10, 11, and 12, ensuring its relevance and applicability to real classroom teaching. Delivered using bold computer-assisted instruction (CAI) through the EduSuite software platform, the test provided a modern, efficient, and standardized method of administration. It consisted of 25 multiple-choice and short-answer questions designed to evaluate a broad range of mathematical topics, including algebra, functions, geometry, measurement, and trigonometry. The test duration was 60 minutes, allowing sufficient time for participants to demonstrate their depth of understanding and problem-solving abilities. This instrument was specifically designed for novice teachers, aiming to assess their readiness and content knowledge during the early stages of their teaching careers. The computerized format ensured consistency in test delivery and scoring, minimizing human error and enhancing the accuracy of data collection. By using a well-structured and curriculum-aligned test, the study aimed to generate valid and reliable data that accurately reflected the participants' actual mathematical competencies.

Furthermore, the integration of CAI technology enabled efficient data management and analysis, supporting the overall goal of identifying strengths and areas for improvement in teachers' mathematical knowledge, which is critical for informing teacher development programs.

Research data analysis used descriptive statistics, frequency distribution, and one-way ANOVA test. Statistical descriptions provide an overview of the data distribution, while frequency distributions help understand patterns and variations in teachers' mathematics content knowledge. A one-way ANOVA test was used to analyze the variability of mean achievements from class to class at the PM level. Codes and percentages for reporting and documenting achievementss in classes R–12. Level of achievement. Description of an achievement Grades %: According to, Exceptional (80–100), meritorious (70–79), significant (60–69), adequate (50–59), medium (40–49), elementary (30–39), and not accomplished (0–29) are the seven categories of achievement. According to the benchmark, "Substantial achievement" is the lowest score required for a student teacher to demonstrate mastery of the subject matter at a given grade level. Ethical aspects were emphasized, with data collection carried out with permission and approval from the participating teachers, to ensure safety, confidentiality and comfort.

RESULT AND DISCUSSION

Results

Basic assessment of content knowledge of mathematics teachers teaching in secondary schools.

The following researcher presents the results of research that focuses on the knowledge of mathematical content owned by teachers that affects students' learning outcomes or academic performance. The results of assessing mathematics content knowledge for mathematics teachers teaching in secondary schools (SS) at three levels using one-way ANOVA are described in the following Table 1 and 2.

Table 1. ANOVA Summary

Groups	Count	Sum	Average	Variance
Grade 12	125	5657	32.98	172.00
Grade 11	125	6508	37.26	167.00
Grade 10	125	7823	47.45	114.06

Table 2. One-Way ANOVA Single-Factor

Source of Variation	Some of Squares	Df	Mean Squares	F	P-value	F crit
Between Groups	12848.11	2	6424.60	44.31	0.01	3.02
Within Groups	76873.73	522	157.02			
Total	89721.84	524				

The sample averages reveal noticeable differences in mathematics subject knowledge among secondary school teachers, as shown by the average scores for grades 10 and 12, which range from 32.98 to 47.45, as presented in Table 2. This variation suggests that teacher proficiency in mathematical content is not uniform across grade levels, highlighting inconsistencies in subject mastery. Furthermore, Table 2. supports this observation by displaying disparities in

the average scores from the baseline assessments given to mathematics teachers at the secondary school (SS) level. A one-way ANOVA test reveals a statistically significant difference in mean achievements, with a p-value of 0.01—well below the standard significance threshold of 0.05. This result confirms that teachers' content knowledge varies significantly depending on the grade level they teach. The accompanying graph visually illustrates the distribution of average teacher scores on the SS baseline assessment, offering a clear depiction of achievements trends and further emphasizing the need for differentiated professional development strategies to address the specific content knowledge gaps at each grade level. These findings highlight the importance of targeted interventions and ongoing support to ensure consistency in teachers' mastery of mathematical concepts across all secondary grades.

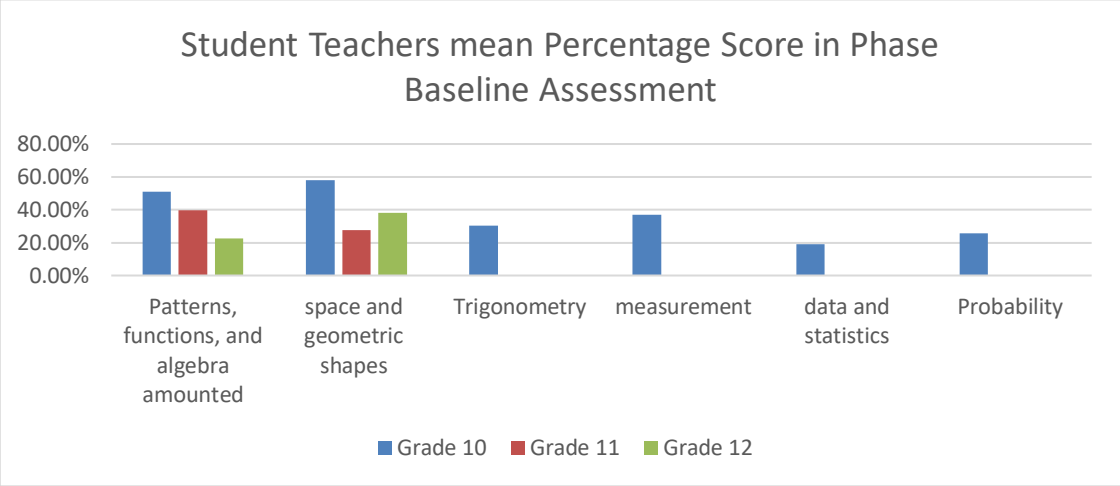

Figure 1. The Average Percentage Value of the Ability of Mathematics Teachers Who Teach at SS

Figure 1 illustrates the average percentage scores of aspiring secondary school mathematics teachers on the content-specific portion of the SS baseline assessment, broken down by mathematical domains across grades 10, 11, and 12. For grade 10 teachers, the highest achievements was observed in the domain of space and geometric shapes, with an average score of 59.18%, followed by patterns, functions, and algebra at 50.96%. However, scores dropped significantly in other areas, with measurement at 36.48%, data and statistics at 19.13%, and probability showing the lowest average at just 2.55%. This suggests that while foundational geometric understanding is relatively strong at this level, data literacy and probabilistic reasoning are significant areas of concern.

For grade 11 teachers, the average scores show a decline across all content areas, with 39.59% in patterns, functions, and algebra, 30.35% in trigonometry, and only 27.69% in space and geometric shapes, indicating a dip in content mastery as mathematical complexity increases. Interestingly, grade 12 teachers demonstrated their strongest achievements in function-related topics, achieving an average score of 54.28%. This was followed by 38.07% in geometry and space, 27.60% in trigonometry, and just 22.68% in algebra, patterns, and functions. These results highlight variations in teacher content knowledge by topic and grade level, suggesting that

targeted professional development is needed—particularly in statistics, probability, and trigonometry—to strengthen content readiness for classroom instruction. Figure 1 provides a detailed visual representation of these domain-specific achievements trends.

The results demonstrate that math teachers in class 10 outperform those in classes 11 and 12 regarding conceptual understanding. In the meantime, teachers in class 12 are below average in patterns, functions, and algebra; in class 11, instructors are below average in measurements, space, and geometric shapes. While students in grade 10 are required to study statistical data and probability, teachers in grades 11 and 12 are required to study trigonometry and functional relationships. The teacher achievement frequency distribution was analyzed to support the research findings. The frequency distribution of results for secondary school mathematics teachers is shown in Figure 2.

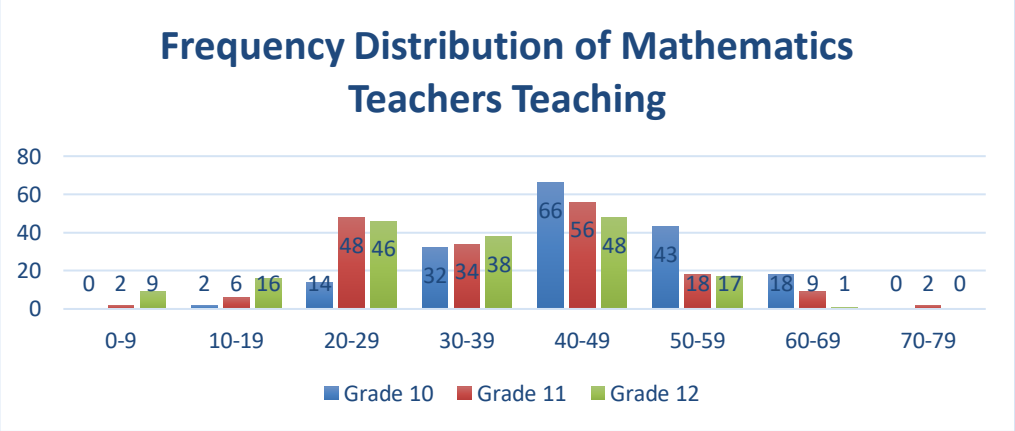

Figure 2. Frequency Distribution of Mathematics Teachers Teaching in Grades 10,11, and 12

The frequency distribution showed that the 40–49 score group was the most dominant range for all grade levels, with 66 teachers in grade 10, 56 teachers in grade 11, and 48 teachers in grade 12 in this range. This signifies that most teachers show a moderate level of performance in mastery of math content. In the score range of 20–29, there was a significant increase in the number of teachers, especially for grades 11 and 12, with 48 and 46 teachers, respectively. This figure is higher than that of 10th-grade teachers, who number 14 in the same score range. This shows that the higher the grade level taught, the more teachers are in the low-scoring category. The range of 30-39 also recorded a relatively even distribution, namely 32 teachers (grade 10), 34 teachers (grade 11), and 38 teachers (grade 12).

Meanwhile, in the range of 50–59, the number of teachers who reached this level began to decrease: 43 10th-grade teachers, 18 11th-grade teachers, and 17 12th-grade teachers. The highest score ranges, 60–69 and 70–79, were filled by only a handful of teachers: 18 10th-grade teachers, 9 11th-grade teachers, and 12th-grade teachers, as well as 1 or 2 teachers each in the 70–79 range, indicating that only a few teachers achieved high scores. On the other hand, in the lowest score range of 0–9, there were 0 10th-grade teachers, 2 11th-grade teachers, and 9 12th-grade teachers, indicating that there were serious problems in mastery of the material among teachers who taught

12th-grade. The data on this graph shows a downward trend in the ability to master mathematics content in teachers who teach at higher grade levels, especially in grade 12. This phenomenon shows the need for intervention in improving the competence of mathematics teachers, especially in targeting the strengthening of content for teachers at the final level of secondary education.

Frequency distribution data showed that the majority of novice math teachers in grades 10, 11, and 12 obtained scores in the range of 40–49, which was categorized as a moderate level of performance in mastery of math content. The highest number of teachers is found in grade 10, then decreases in grades 11 and 12. Despite showing suboptimal performance, most teachers are still at a basic level of mastery. However, attention needs to be directed to the low score range (20–29), which indicates a surge in the number of teachers in grades 11 and 12, indicating a decrease in mastery of the material as the level of classes taught increases.

The distribution of scores in the range of 30–39 is relatively even in all three levels, but the number of teachers who achieve high scores (50–69) is decreasing, especially in grade 12. In fact, in the score range of 60–69, only one grade 12 teacher was recorded, and in the highest range (70–79), the number was very minimal. More worryingly, teachers with very low scores (0–9) were only found in grades 11 and 12, while grades 10 showed no similar cases. This reinforces the indication that teachers who teach in the upper grades tend to have weaker mastery of content.

Overall, the trend of declining mathematics content mastery skills in teachers who teach at higher grade levels is a serious concern. Given that teachers in the upper grades have a greater responsibility in preparing students for final exams and the next level of education, real intervention is needed. Efforts such as training, mentoring, and strengthening of teaching materials are very important, especially for teachers in grades 11 and 12, to ensure the quality of mathematics learning and support the improvement of student learning achievement.

Level of understanding of mathematical content knowledge of teachers teaching at the SS level through baseline assessment

The results of the assessment of teachers' understanding of mathematical content knowledge at the secondary school (SS) level are presented in Table 3. This table provides a detailed overview of the proficiency levels of teachers across various mathematics domains, including algebra, geometry, measurement, and statistics. The data in Table 3 reveal the strengths and weaknesses in teachers' mastery of subject matter, highlighting specific areas where teachers demonstrate adequate comprehension as well as areas requiring further improvement. By analysing these results, stakeholders can identify patterns in content knowledge across different grade levels and use this information to inform professional development programs, targeted interventions, and curriculum enhancements that aim to strengthen mathematics instruction in secondary education.

Table 3. Level of Understanding of Mathematical Content Knowledge of Mathematics Teachers Who Teach at the SS Level in the Content Area

Achievement level	Achievement Description	Grade 10	Grade 11	Grade 12
1	Not achieved	Data and statistics, function relations, trigonometry, probability	Data and statistics; function relations; space and form (geometry); measurement probability;	Data and statistics; trigonometry; measurement; probability; patterns; functions, and algebra
2	Basic achievements	Measurement	Patterns, Trigonometry, functions, and algebra	Space and form
3	Medium achievements	-	-	-
4	Adequate achievements	Patterns, Functions, and Algebra; Space and Shape (Geometry)	-	Function relations
5	High achievements	-	-	-
6	Very high achievements	-	-	-
7	Extraordinary	-	-	-

Table 3 presents the comprehension levels of secondary school mathematics teachers across various curriculum content areas. The data indicate that teachers teaching in grades 10 and 12 generally demonstrate sufficient understanding of key mathematical domains such as patterns, functions, algebra, space, and geometric shapes. In addition to this, it is evident that some teachers in grades 10 and 12 show a more advanced understanding of a broader range of topics, including measurements, trigonometry, and other core mathematics content, suggesting stronger content mastery in certain areas. However, there is a notable concern regarding the level of understanding of data, statistics, and probability—particularly in grade 10—where foundational knowledge in interpreting and analyzing data is essential. Moreover, the findings highlight that greater comprehension is still needed in several areas: for instance, in grade 10 for measurements and algebra, in grade 11 for patterns, functions, and trigonometry, and in grade 12 for spatial reasoning and geometric understanding. These gaps highlight inconsistencies in teacher preparedness across various mathematical strands and grade levels. Overall, the findings from Table 3 underscore the need for enhanced and more targeted professional development to enable teachers to develop a deeper understanding of content, particularly in data-related topics, which are essential for effective mathematics instruction at the secondary level.

Discussion

The discovery that the mathematics understanding of first-level teachers at the SS level is at a "medium level of attainment" provides evidence. A genuine level of comprehension cannot be attained in any other way. Table 3 indicates that entry-level mathematics teachers possess adequate content knowledge to instruct students in algebraic patterns, functions and their relationships, space, and geometric

shapes in grades 10 and 12. a fundamental level of comprehension for teaching algebra in grades 11 and 12, covering trigonometry and grade 12 geometric spaces and shapes, as well as measures, patterns, and functions in grades 10. To teach data at the SS level, statistics, and probability, entry-level teachers require a deeper understanding of mathematical topics (Dewi & Kuswanto, 2023; Díaz et al., 2023; Idrizi et al., 2023; Pramasdyahsari et al., 2023).

Figure 1, the average percentage results from the basic assessment, reveals that teachers who teach algebra, geometric shapes, patterns, and functions in class 10 have a mathematics content knowledge of 54.28%, while those who teach functional relationships in class 12 have 59.18%. Handayani's research yielded similar results, indicating that first-year students' accomplishments in undergraduate education programs (Foundation or Intermediate stage) had a decent distribution of mathematical knowledge (Díaz et al., 2023; English, 2023). On the other hand, Diana found that if there was a low achievements % and inadequate mathematical understanding, she disagreed with teaching mathematics (Wei et al., 2023). Enhancing the content expertise of entry-level math teachers is necessary (Li et al., 2024). Two teachers had "meritorious achievement" at the 11th grade level, and none had "outstanding achievement," according to the data (Wort et al., 2024). The results of the level of understanding of prospective teacher students found that prospective teachers needed help understanding mathematics content knowledge, such as probability and standard algorithms (Dimos et al., 2023; English, 2023). The researchers stated that the achievements of student-teacher candidates was above average (Gilbert & Gilbert, 2025; Østerlie et al., 2025). To effectively communicate and explain mathematical ideas in their future classrooms, prospective teachers must have a solid grasp (Karjanto & Acelajado, 2022).

According to several research findings, the primary objective of a baseline assessment at the beginning of a new school year is to gain an initial understanding of students' learning profiles and readiness levels. In the context of this study, the baseline assessment serves a similar purpose by helping teacher educators identify the content knowledge levels of aspiring secondary school mathematics teachers. This foundational assessment enables educators to design learning activities that accommodate various learning styles and cognitive needs, thereby promoting more inclusive and effective instruction (Altynbekov et al., 2023; Wort et al., 2024). Furthermore, the baseline assessment plays a critical role in identifying specific learning gaps and individual challenges faced by novice teachers. By recognizing these needs early on, educational institutions can implement timely remediation programs, provide targeted support, and personalize instructional approaches to enhance professional development (Østerlie et al., 2025; Zhu et al., 2024). This proactive strategy not only improves the quality of teacher preparation but also ensures that aspiring teachers are equipped with the mathematical content knowledge necessary for effective teaching at the secondary level.

Taylor highlights a critical issue in the South African education system—what he describes as a "vicious circle" that perpetuates low standards in teacher education. This cycle begins with the public's negative perception of the teaching profession, which diminishes its appeal and discourages high-achieving

students from considering it as a viable career path (Karjanto & Acelajado, 2022; Zhou et al., 2023). Consequently, Initial Teacher Education (ITE) programs struggle to attract top-tier candidates, which affects the overall quality and prestige of the profession.

Further compounding the problem, many students who are genuinely interested in pursuing a career in teaching are often rejected by universities during their first and second application attempts (Altynbekov et al., 2023). As a result, institutions are frequently left with no option but to accept preservice teachers who may lack strong academic backgrounds or genuine interest in teaching. This admission of lower-performing candidates often forces universities to reduce the academic rigour of their programs to accommodate varying levels of preparedness (Kay & Buxton, 2023; Lindberg, 2024). Such a compromise ultimately undermines the quality of teacher training. It contributes to the continuation of underqualified teachers entering the education system, thereby reinforcing the very cycle that the system aims to break.

The placement of low-quality or insufficiently competent teachers in schools contributes significantly to poor teaching quality, which in turn leads to diminished student achievements and a general decline in the reputation of the teaching profession. This deterioration not only affects educational outcomes but also impacts how the public perceives teaching as a career. As the prestige of the profession weakens, so does its ability to attract high-achieving students, creating a feedback loop of declining interest and quality (Østerlie et al., 2025; Y. Wang et al., 2024). This cycle is further exacerbated by the persistent inability of educational institutions to recruit well-qualified and motivated teacher candidates. When teacher preparation programs fail to attract top-tier students, the overall calibre of teacher education declines, and the system becomes saturated with underprepared graduates. As argued by Altynbekov this ongoing cycle of underqualification results in continuous poor teaching and learning experiences in classrooms, ultimately making it more challenging to break free from systemic mediocrity in teacher quality and student achievement (Altynbekov et al., 2023; Wort et al., 2024). Addressing this issue requires systemic reform aimed at enhancing the appeal of the teaching profession, improving recruitment strategies, and elevating standards in teacher education programs.

However, initial entry requirements for teacher education programs are generally lower than for most entry-level degree programs. Evidence suggests that the most vulnerable students enter education faculties as a last resort, motivated by a desire to gain a university qualification rather than make a difference in students' lives (Østerlie et al., 2025; Sanchayan et al., 2024; Sutama et al., 2022). Most university applicants take roles that require minimum entry into a particular program. However, this is only the case for some teacher development programs. More than 75,000 university applicants take academic literacy and quantitative literacy tests, while more than 58,000 take a mathematics assessment test (MAT) during the admission cycle (Idrizi et al., 2023).

Candidates planning to study education had the second lowest average score of all applications to all faculties, with only those intending to study allied health care or nursing having a lower average. Candidates in the basic group are classified as follows: "Test achievements

reveals serious learning challenges: it is estimated that students will not cope with undergraduate level study without extensive and long-term support, perhaps best provided through the program bridging (i.e., non-credit preparatory courses, special skills provision) or supply SS (Tam & Lee, 2023) (Geiger & Schmid, 2024). There are three score tiers available: basic, intermediate, and advanced (Gilbert & Gilbert, 2025; Zhu et al., 2024). Schools that admit students with this kind of achievements should also offer this kind of assistance (El Abbadi & Alaoui, 2023; Wort et al., 2024).

Due to the low mathematics achievement of college students entering teacher education programs, the goal of creating a deep understanding of mathematics necessary for teaching should be an important aspect of mathematics course design and implementation. Furthermore, several research results indicate that the lack of connection between mathematics subjects and methods is a long-standing trend in teacher preparation programs (Karjanto & Acelajado, 2022). The only requirement is that before enrolling in a methods course, students must pass the exam for the math course (Al Malki et al., 2023; Kay & Buxton, 2023) Less emphasis is placed on the relationship between subject matter competence and teaching because mathematics courses are taught by university mathematicians and academics who also teach engineering courses (Rosana et al., 2021; Zhou et al., 2023).

Teachers must profoundly understand fundamental mathematics (PUFM). This means that teachers' mathematical content knowledge must comprehensively understand mathematics with breadth, depth, connectedness, and precision, not at an average level (Hernández et al., 2024; Zhou et al., 2023). One of the most important aspects of teaching is understanding what will be taught. Furthermore, one of the core disciplines of human cognition and research is mathematics (Dimos et al., 2023; Sidekerskienė & Damaševičius, 2023). Learners must develop their intellectual resources to understand and actively participate in mathematics (El Abbadi & Alaoui, 2023; Niu, 2023). According to the researchers above, aspiring educators should apply their understanding of mathematics to lead classroom discussions in learning communities, meet the educational needs of their students by incorporating them in real-world mathematics instruction, evaluate students' work, and assess their proficiency in the subject (Díaz et al., 2023; English, 2023). As an alternative, while assessing course materials (Dimos et al., 2023; Gilbert & Gilbert, 2025). Therefore, to ensure that future teachers have a successful education, educators in HEIs must implement particular instructional approaches.

To become an effective mathematics teacher, one must possess a combination of self-confidence, subject-matter competence, strong commitment, and a deep passion for mathematics that goes beyond the level being taught. These qualities are foundational in shaping not only the teacher's instructional delivery but also their capacity to inspire and challenge students. A profound understanding of mathematical content is essential, as it forms the backbone of effective teaching practices and directly influences the quality of teacher training and classroom instruction (Østerlie et al., 2025; Tam & Lee, 2023). Moreover, a teacher's ability to understand the subject deeply is closely linked to their effectiveness in diagnosing student misconceptions, analyzing student

thinking processes, and engaging in meaningful professional discourse with colleagues. When teachers lack strong content knowledge, their capacity to recognize diverse learning needs, adapt instruction, and contribute to collaborative problem-solving within professional communities is significantly weakened (Altynbekov et al., 2023; Kay & Buxton, 2024; Sanchayan et al., 2024). Therefore, improving teachers' understanding of mathematics content is not just about enhancing individual competence but also about building a robust culture of reflective practice and ongoing professional growth in mathematics education.

This research uniquely highlights the persistent gap between prospective secondary school mathematics teachers' content knowledge and their pedagogical preparation, emphasizing not only the uneven mastery across mathematical domains (notably in statistics and probability) but also the systemic challenges—such as low entry standards and poor public perception—that reinforce a cycle of inadequate teaching quality. Unlike previous studies focusing solely on knowledge deficits, this study integrates the critical role of basic assessments in the early identification of learning needs and advocates for comprehensive reform in teacher education programs that concurrently develop deep mathematical understanding and practical instructional skills to better prepare future teachers for diverse classroom challenges.

Implication of Research

The results of this study provide an important foundation for further development in the field of mathematics teacher education. The finding that the mathematics content knowledge of student teachers is at a moderate level with a low level of understanding indicates an urgent need for structured and sustainable interventions. Therefore, the continuation of this research needs to be directed at developing coaching and training programs that can equip prospective teachers with a deeper conceptual understanding of the applicable mathematics curriculum. Further research can be focused on the effectiveness of learning strategies and pedagogical approaches used by educators in helping prospective teachers relate mathematics material to the context of the level of education they will teach. In addition, further studies also need to explore how adjusting lecture materials to real needs in the field can improve the readiness of prospective teachers to deliver material appropriately and meaningfully in class. Thus, the direction of teacher education policy can be more focused on balancing content mastery and pedagogical competence to improve the quality of mathematics education.

Limitation

This study has several limitations that need to be noted. First, the scope of the study is still limited to measuring the mathematical content knowledge of prospective teachers in specific regions or institutions, so generalization of the results to a broader population needs to be done carefully. Second, the approach focuses more on the cognitive aspect without delving deeper into affective factors such as motivation, self-confidence, or perceptions of prospective teachers towards mathematics learning. In addition, this study has not explicitly explored the relationship between content mastery and teaching effectiveness in real classrooms.

Therefore, further research is highly recommended to expand the scope of analysis with a more holistic and multimethodological approach, including longitudinal studies to assess the long-term impact of interventions or training programs provided to prospective teachers.

CONCLUSION

Based on the results of research and discussion, it can be concluded that mathematical worksheet based Tri-N in material relation and function Improving the critical thinking skills of junior high school students has been successfully developed. Relation and function worksheet based Tri-N has theoretically and empirically fulfilled the feasibility test. Empirically, this worksheet obtained a Vaiken index of more than 0.78 for each assessment sub-indicator, so it can be declared valid. The results of students' responses to relation and function worksheet based Tri-N to improve the critical thinking skills of junior high school students obtained the result that 62.28% of students gave a very agree response and 37.79% of students gave a very agree response. From the students' responses, it can be concluded that relation and function worksheet-based Tri-N obtained positive responses (practical) from students to improve their critical thinking skills. Apart from the test results at the dissemination stage, it was found that the N-gain results were 0.53, and the effect size was 1.37. These results indicate that the Relation and Function worksheet based on Tri-N is effective for use in mathematics learning regarding students' critical thinking abilities.

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