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Mathematical Knowledge for Teaching in the Senior Phase: Entry-Level Teacher Candidates' Subject Content Knowledge

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Abstract. Having mathematical knowledge for teaching is now essential in defining the expertise of a mathematics teacher. Skilled and proficient educators in teaching are effective in attaining the intended educational objectives. Teaching is considered to be a noble profession as teachers rely on students' intellect as the main avenue of learning. It is a challenging role that demands dedication and hard work. Patience, respect, and sound judgment are qualities closely associated with teaching. In addition to sharing knowledge, teachers also reveal their own personalities, thoughts, principles, attitudes, and emotions. This paper reports on a study investigating the entry-level teacher candidates' mathematics content knowledge for teaching in the senior phase. The study adopted a quantitative approach. A mathematical subject content knowledge baseline test for senior phase teacher candidates through Computer-Aided Mathematics Instruction (CAMI) was used to collect data. One hundred and eighty-five (185) teacher candidates who completed the Baseline Tests for all grades 7, 8, and 9 in the senior phase were selected for this paper. Purposive and convenience sampling were used in this paper. The data from the Baseline Test was analysed using descriptive statistics. Due to the inclusion of Baseline Tests in the CAMI package, every question on each grade was deemed valid. The CAMI Reports were then analysed using Microsoft Excel 2013. The findings suggested that at the entry-level, teacher

candidates had limited and insufficient mathematics content knowledge and understanding. Therefore, teacher educators need to enhance the teacher candidates' comprehension of the mathematics they will be instructing in the senior phase. This paper recommends that the barriers in the teacher candidates' mathematics content knowledge and the understanding of the concepts should be addressed in the teacher education course.

Keywords: Baseline test, Entry-level, Mathematics knowledge, Senior phase mathematics, Teacher candidates, Subject content knowledge

Introduction

The lack of strong mathematics skills among students is a pressing issue for both advanced and emerging economies. Several research investigations have concluded that the decline in learners' mathematics proficiency is due to teachers' lack of content knowledge in mathematics (Mji & Makgato, 2006; Norton, 2019a; Pino-Fan, Assis & Castro, 2015; Pournara et al., 2015). It is widely agreed upon that improving teachers' mathematics content knowledge is crucial, as research has shown that teachers with a strong understanding of mathematics are more effective in teaching the subject. Norton (2019a) argues that the depth, scope, and breadth of mathematics instruction at the school level can significantly impact teachers' pedagogical content knowledge. Norton (2019a) and Pino-Fan et al. (2015) state that many elementary school teachers lack conceptual understanding of mathematics as a subject. Norton (2019a) considers that inadequate mathematical knowledge for teaching and the lack of conceptual understanding of mathematics is being directed at teacher education programmes. Shulman (1986, p. 5), as cited in Norton (2019a), believes that (in teacher education courses), knowledge of the theories and methods of teaching play a decidedly secondary role to the content knowledge. Therefore, it is necessary to improve mathematical knowledge for teaching as well as teaching methods during the teacher education training period. There has been growing interest shown by the mathematics education community in finding out how teacher candidates are being prepared to teach mathematics in both primary and secondary schools (Fonseca et al., 2018). Hence, this research endeavours to fill a significant gap in the current literature by incorporating an innovative approach of utilising an online computer-aided mathematics baseline test to assess the mathematical content knowledge of prospective senior phase teacher candidates. This study stands out as it pioneers the utilisation of such a tool in examining the readiness of entry-level educators in the field of mathematics education.

Selected students were from a South African rural Higher Education Institution (HEI). This paper reported on the Baseline Tests investigating the entry-level teacher candidates' mathematical content knowledge for teaching in the senior phase (Grades 7-9) from a rural HEI in South Africa. Thus, this paper aimed to report on the entry-level teacher candidates' content knowledge from a rural HEI in South Africa. All the participants were being trained to teach in the senior phase mathematics classes in South African schools.

Teaching as a Profession

Research has shown that teaching is a multifaceted profession that involves not only the transmission of knowledge but also the cultivation of emotional intelligence and the ability to manage various interpersonal dynamics (Taylor, 2019). Teachers must possess a high level of dedication and commitment in order to effectively engage students and provide them with a quality education (Montano, 2023). The demands of teaching require educators to constantly adapt and evolve in response to the changing needs of their students, making it a complex and challenging profession. It also requires the teachers' knowledge of the subject being taught, the curriculum, effective teaching, learning practices, and the learners' abilities, interests, and personalities. According to Taylor (2019), teaching should not solely be measured by classroom performance and activities, as it involves traits such as wisdom, respect, and patience (Montano, 2023). Teaching is a profession driven by moral principles, ethical considerations, and internal motivation (Skaalvik & Skaalvik, 2023). Tichenor and Tichenor (2005) agree that teachers are expected to fulfil these complicated roles described by Taylor. Guerriero (2014), states that teaching as a profession is rich in information where teachers serve as learning specialists in the classroom. Moreover, the approaches to teaching and learning chosen by individual teachers vary in perspectives, thus, the knowledge about teaching is divided across individuals in the profession. In addition, professional competence in teaching encompasses more than just information, teacher knowledge is undoubtedly a part of it. The mastery of teaching and learning is also influenced by abilities, attitudes, and motivational factors (Guerriero 2014). Therefore, teacher candidates need to be trained in the usage of various, both traditional and modern teaching and evaluation methodologies in order to satisfy the needs of their learners and the high expectations of the teaching profession.

Expert teachers exhibit a high level of Pedagogical Content Knowledge (PCK), particularly demonstrating expertise in Specialised Content Knowledge (SCK). This specialised knowledge is crucial in the field of education and is a defining characteristic of effective teachers (Guerriero, 2014). The knowledge that teachers require to combine their pedagogical expertise with subject-specific content knowledge is known as pedagogical content knowledge. Integration involves comprehending the importance of knowledge and how educators utilise it to guide their choices in the instructional process. Shulman (1986) states that PCK is:

> *That special amalgam of content and pedagogy that is uniquely the province of teachers, their own special form of professional understanding [. . .] It goes beyond knowledge of subject matter per se to the dimension of subject matter knowledge for teaching (Shulman,1986, p. 9).*

Therefore, teacher candidates need to be developed into teaching experts, which is the knowledge in practice that entails analysing experience. This knowledge distinguishes teaching from other forms of academic learning that concentrate on more abstract types of information. In this respect, teacher candidates will acquire valuable experience in receiving instruction and learn to approach teaching in a variety of ways.

As a teacher candidate's pedagogical knowledge and understanding progresses, facilitated by mentor educators, their ability to effectively deliver instruction and foster student learning also improves. These educators assist them in translating their new knowledge into new teaching approaches. Norton (2019a) opines that a requirement for being a good teacher in mathematics is to become knowledgeable and self-assured at a level higher than what they are teaching. Özdil and Kaçar (2023) argue that in order to guarantee that teacher candidates enter the workforce fully prepared, it is crucial to assess their knowledge and comprehension of teacher education. Therefore, Gokalp (2016) maintains that teacher candidates, during their internship training, must encounter authentic mathematics learning to prepare for the profession. Furthermore, the teacher candidates who are qualified and competent in the teaching profession are successful in achieving the desired learning outcomes. Therefore, Alex, (2019) maintains that the teachers' educators (mentor teachers) must allow the teacher candidates to know mathematical content knowledge to teach it effectively in the future (Gokalp, 2016).

This paper examined the entry-level teacher candidates' mathematical content knowledge for teaching senior phase mathematics in South Africa. The significance of this study lies in its specific focus on teaching practices within the senior phase of education. This is particularly notable as previous research on mathematics teachers' content knowledge has primarily centred on the Foundation Phase.

By honing in on the senior phase, this study adds depth and breadth to the existing literature, shedding light on a crucial stage of educational development that is often overlooked in research (Alex & Roberts, 2019; Askew et al., 2019; Spaull, 2011), intermediate phase (IP) teaching (Bowie & Reed, 2016) and Further Education and Training (FET) teaching separately (Alex, 2019; Bansilal et al., 2014; Mji & Makgato, 2006; Pournara et al., 2015). In this study, an attempt was made to address the gap in this issue by investigating the content knowledge of 185 teacher candidates enrolled for a Bachelor of Education degree in Senior Phase and FET Mathematics teaching.

General Education and Training Phase of the South African Education System

The South African education system's General Education and Training Phase (GET) is classified into three hierarchical phases, which are outlined as the Foundation phase – Reception to Grade 3, Intermediate phase – Grades 4 to 6, and Senior Phase – Grades 7 to 9. Most Grade 7 classes are typically found at primary school, while Grades 8 and 9 are at secondary school (South Africa education info). In order to pursue a career as a teacher at any level, individuals must first obtain a Bachelor of Education degree from a university, which typically takes four years to complete. The Bachelor of Education degree in Mathematics Education consists of an academic component for improving mathematical content knowledge and a professional component for learning how to teach mathematics. Teachers who specialise in teaching senior phase mathematics are required to teach in grades 7 to 9.

According to the National Curriculum Statement (NCS), there are various changes in senior phase mathematics and an increased emphasis on qualities, structure, and relationships between quantities (Department of Basic Education, 2018). Learners are expected to reason with definitions and attributes of numbers and shapes throughout this phase, which is a significant transition for students and teachers (Department of Basic Education, 2018).

"Teaching training" are completely irrelevant when it comes to being prepared for and able to work as a teacher, not just to get into the field. Teachers encounter obstacles in acclimating to evolving conditions and proficiently guiding students due to deficiencies in qualifications and subject-specific expertise. The efficacy of teachers and the educational progress of learners can be compromised by deficits in understanding curriculum content, pedagogy, lesson planning, instructional strategies, classroom administration, evaluation methods, and related areas (Boudersa, 2016).

Research Focus

This paper focused on the Common Content Knowledge (CCK) and Specialised Content Knowledge (SCK) aspects of content knowledge. Teachers use Curriculum Content Knowledge (CCK) to plan and teach mathematical concepts. This enables teachers to have a solid understanding of the mathematics they are teaching, assess students' responses, clarify concept definitions, and complete mathematical procedures. Any adult may have a well-developed CCK but the lack of knowledge required to teach, such as the new teacher candidates entering Higher Education Institution (HEI). Teachers use Specialised Content Knowledge (SCK) to assess and analyse students' creative problem-solving strategies. Furthermore, the use of SCK is also identifying the mathematics that underpins an instructional task by the teachers and anticipating the various ways students may think about the concepts, including their misconceptions. Therefore, this study investigated the level of mathematical content knowledge understanding of the teacher candidates at entry-level in senior phase mathematics.

Problem Statement

Developing and industrialised nations are concerned about the low levels of mathematical proficiency among students. Numerous studies have found that teachers' inadequate content knowledge of mathematics is the cause of the decrease in students' mathematical competency. According to research studies, there is a general agreement that teachers' topic understanding in mathematics has to be strengthened because math-savvy teachers have been proven to teach the subject more successfully. Teachers' pedagogical subject knowledge is also influenced by the proper depth, breadth, and scope of mathematics taught in schools. As a result, many primary school teachers do not have a conceptual understanding of the subject of mathematics. Teacher education programs are targeted by those with insufficient mathematical skills for teaching and a lack of conceptual grasp of mathematics. Therefore, in order to enhance instruction during the teacher education training phase, it is essential to improve both teaching strategies and mathematics understanding. This paper presented the results of the Baseline Tests, which examined the mathematics subject knowledge of entry-level teacher candidates from a rural higher education institute in South Africa for teaching in the senior phase (Grades 7-9).

Research Aim and Research Questions

This research aimed to provide information on the subject understanding of entry-level teacher candidates as they prepare to teach senior phase mathematics. The research question formulated for this paper was:

What is the level of mathematical content knowledge understanding of the teacher candidates at the entry level for teaching senior phase mathematics?

Literature Review

The Importance of Content Knowledge in the Teaching Profession

Despite the rapid evolution of technology in education, empirical research consistently demonstrates the indispensable role of the teacher in facilitating effective teaching and learning processes. The tasks and responsibilities of teachers in the classroom are the foundation for teaching. Teachers facilitate learning in the classroom, while students are responsible for acquiring knowledge. Gokalp (2016) states that the teacher's role is to organise learning experiences, especially in mathematics, using various teaching methods and strategies to assess the students' achievement and desired proficiency. Moreover, teachers engage in critical reflection and inquiry in the classroom in order to develop the knowledge and abilities to effectively engage students and improve their learning. Teachers need to have the content knowledge and pedagogical skills to fulfil the needs of all students in and out of the classroom (Department of Education and Training, 2017). In order to facilitate successful teaching and learning, it is essential for educators to possess a comprehensive understanding of the subject they are teaching. Venketsamy (2022) argues that there is much emphasis and recognition of the importance of teachers' mathematical subject knowledge. For good and effective teaching and learning to take place, teachers must have sound pedagogical and subject matter knowledge.

Teachers' domain-specific subject matter knowledge is referred to the content knowledge. According to Ball et al. (2008), a teacher is required to have subject matter knowledge and mathematical skills. A teacher's mathematical content knowledge has been described as a complete understanding of mathematics with breadth, depth, connection, and thoroughness. Teachers are expected to have in-depth knowledge and understanding of mathematics. They play a critical role in transmitting knowledge to learners. Venketsamy (2022) states that the depth and scope of the teacher's content knowledge of the subject have a direct impact on the learning outcomes. Moreover, competent mathematics teachers must possess broad knowledge of the subject, an understanding of numerous methodologies, and a thorough understanding of the pedagogy of mathematics (Ball et al., 2008). Askew et al. (2019), Ma (2010), and Norton (2018) contend that successful teachers should have a comprehensive understanding of the curriculum and how concepts develop from a strong foundational understanding.

When learning mathematical concepts, Livy (2014) emphasises the importance of two types of Mathematical Content Knowledge (MCK): conceptual and procedural knowledge. Procedural knowledge is the "ability to solve problems by executing action sequences" (Livy, 2014, p. 27). It is described as knowing the rules or following a step-by-step process for solving a mathematics problem. Livy (2014) defines the conceptual knowledge as an implicit or explicit understanding of the principles that govern a domain and of the interrelations between units of knowledge in a domain. That is, understanding the principles and the interrelations between knowledge units within the mathematics domain (Rittle-Johnson et al., 2001). Shirvani (2015) agrees that the content knowledge plays a vital role in teaching mathematics. It strengthens the teacher candidates' content understanding as they learn to apply new curriculum materials and approaches and how learners interact with them.

Both Ma (1999) and Shirvani (2015) agree that it helps the teacher candidates to create links between experiences as students and as teachers. This will aid in the development of the teacher candidates' knowledge and perspectives on mathematics. Furthermore, those teachers who may have elementary and fundamental prior knowledge of mathematics will gain experience and knowledge by teaching mathematics lessons. Hence, MCK is a skill one gains while learning to teach (Ma, 1999).

Teacher candidates' decisions about teaching and learning mathematics are influenced by their knowledge of Mathematical Content Knowledge (MCK), which makes it an important consideration while teaching mathematics (Adelabu & Alex, 2022; 2023).

Mathematical Content Knowledge (MCK)

Shulman (1986) coined the term ‘pedagogical content knowledge’ in order to describe a type of knowledge that linked teaching methods expertise with knowledge of the material being taught. The pedagogical content knowledge refers to a wide range of features of subject matter knowledge and subject matter teaching, and it has been applied in various ways across—and even within—subject areas. Shulman (1986) identified three types of knowledge teachers require based on his findings: subject knowledge, pedagogical content knowledge, and curricular knowledge. The content knowledge is concerned with the knowledge of the content. The pedagogical content knowledge is subject matter knowledge for teaching that requires learners to comprehend the information. It is essential to know the best representations of material, what makes the subject simple or challenging for learners, and where students frequently make mistakes (Shulman, 1986). The curricular knowledge is a set of qualities that serve as indications and contra-indications for using a specific curriculum or program material in a specific situation. It is the teacher's obligation to be informed of their learners’ past and future activities.

Ball et al. (2008) extended and defined mathematical knowledge for teaching purposes using Shulman's three kinds of knowledge as a foundation. Ball et al. (2008) developed a paradigm that applied and extended Shulman's knowledge categories in fundamental mathematics. Ball's theory broke down Shulman's categories of content knowledge and pedagogical content knowledge into components.

The content knowledge includes components such as Common Content Knowledge (CCK), Specialised Content Knowledge (SCK), and Horizon Content Knowledge (HCK). The three categories of pedagogical content knowledge are Knowledge of Content and Teaching (KCT), Knowledge of Content and Students (KCS), and Knowledge of the Content and Curriculum (KCC).

The common Content Knowledge (CCK) is mathematical information and expertise used outside the classroom (Ball et al., (2008)), which anyone with a basic comprehension of mathematics can gain. For example, CCK includes algorithms and procedures for adding and subtracting, computing the area and perimeter of a given form and sorting a series of decimals (Olanoff, 2011).

The specialised Content Knowledge (SCK) refers to the mathematical knowledge and skills teachers needed in classroom settings to learn in a specific way (Ball et al., 2008; Olanoff, 2011). These researchers discovered that this knowledge is unique to teaching and is not required in other occupations. Understanding and accurately using mathematical terminology are examples of SCK. Additional examples of scientific activities in education include the ability to evaluate student algorithms for correctness and efficiency, understanding the mathematical principles behind the process of inverting and multiplying when dividing fractions, and analysing and critiquing learner algorithms for accuracy and effectiveness. These tasks require a deep understanding of mathematical concepts, logical reasoning skills, and the ability to apply scientific methodologies to educational practices. By engaging in these scientifically rigorous activities, educators can improve student learning outcomes and promote a more evidence-based approach to teaching and assessment.

The horizon content knowledge (HCK) is understanding how the topic in mathematics is being taught, fits into and is related to a larger mathematical domain. This subject involves understanding where mathematics and concepts come from and how relevant they are to students' learning. HCK helps teachers make informed choices about which concepts are most important (mathematics) highlighted by students, as well as to manage discipline issues with integrity while balancing the primary purpose of connecting students to a comprehensive and well-developed part of mathematics (Ball et al., (2008); Jacinto & Jakobsen, 2020). In addition, the teacher demonstrates HCK when they exhibit comprehension of the complexity of mathematical topics, have advanced knowledge and comprehensive understanding of mathematical ideas as well as relationships, and links their Content Knowledge (CK) with a curriculum that learners should know and as well known in future year (Ball et al., (2008)). Ball et al. (2008, p. 401) further outline how the three components work together in the learning process:

> *Recognising a wrong answer requires Common Content Knowledge (CCK), whereas determining the nature of the error, particularly an unknown error, requires nimbleness in thinking about numbers, attention to patterns, and flexible thinking about meaning in ways that are unique to Specialized Content Knowledge (SCK). On the other hand, knowing the subject and student entails being familiar with typical errors and determining which of several errors' students are most likely to commit.*

Ball et al. (2008) also makes other recommendations that teachers should study further courses and programmes in mathematics through additional mathematics coursework or a subject matter major. In addition, there should be a concentration on mathematical techniques course work, specifically connected to the mathematics demanded of classroom teachers and curriculum material. As a result, teachers must have a solid understanding of the mathematics they are going to teach. Their teaching has a direct influence on learner achievement. According to Lee et al. (2018), the lack of teacher's content knowledge often leads to learners developing misconceptions, misunderstandings, and misinterpretations about mathematics.

Senior phase mathematics

The senior phase mathematics curriculum in South Africa focuses on five primary content areas that lead to specific skills development. Numbers, Operations and Relations; Patterns, Functions and Algebra; Space and Shape (Geometry); Measurement; and Data Handling are the content categories listed in the National Curriculum Statement: Curriculum and Assessment Policy Statement (CAPS) documents (Department of Basic Education, 2011). These content areas are separated into units based on the phase level. According to research conducted by Alex in 2019 and Venketsamy and Hu (2022), the decreasing level of mathematical content knowledge among teachers is directly impacting students' math achievement. This decline is clearly reflected in results from both the Annual National Assessments and TIMMS. The Department of Basic Education (DBE) also acknowledges this issue in their 2019 mathematics diagnostic report, highlighting the urgent need to enhance teachers' content knowledge in order to boost learners' performance. As a result, there is a focus on improving content knowledge by training teacher candidates to comprehend what to teach and how to teach in a way that will be effective in future practice.

Bowie and Reed (2016) claim that teacher candidates in the B. Ed program begin at university with deficient mathematical expertise, thus resulting in barriers to quality teaching and learning. According to Bietenbeck et al. (2018), investing in teacher training is crucial for improving learner performance in schools. In addition, Siyepu and Vimbelo (2021) note that teacher educators should identify teacher candidates' inadequacies and challenges, so that appropriate learning methods in mathematics can be established to improve their (teachers') content knowledge. This study took place in one of the provinces that record-low performance in mathematics. It has been noted that many of the teacher candidates were from under-performing senior secondary schools and a majority of them met only the minimum of 50% in mathematics as one of the entry requirements to enter the B. Ed program. Hence, the study investigated the level of mathematical content knowledge understanding of the teacher candidates at entry-level in senior phase mathematics.

Materials and Methods

The research methodology utilised in this study adhered to a quantitative approach, with data collection achieved through the administration of a standardised mathematical content knowledge test tailored specifically for senior phase teacher candidates. The teacher candidates were exposed to the mathematics content test for the senior phase through the Baseline Test in the licensed online Computer Aided Mathematics Instruction (CAMI) package. CAMI (Computer-Aided Mathematics Instruction) is an interactive educational software system that aided students understanding mathematical concepts (www.cami.co.za). The CAMI test is made up of a series of CAMI exercises that are delivered in a specific order. Each test comprises a collection of predetermined activities so that each student will answer an identical set of questions. The teacher candidates enrolled in the Senior Phase and FET Teaching Bachelor of Education Programme were predominantly from rural secondary schools. Most of them have not been exposed to computer-assisted learning. They were novices to the CAMI package. The Baseline Test was used to measure the mathematical content knowledge of the entry-level teacher candidates.

Sample and Participants

The study included 185 first-year mathematics teacher candidates in the rural Higher Education Institution (HEI) specialising in senior phase (grades 7, 8, and 9) mathematics instruction. One hundred and eighty-five (185) teacher candidates who completed the Baseline Test for all grades (7, 8, and 9) were selected for this paper. These teacher candidates were chosen to assess their MCK for the senior phase (grades 7, 8, and 9) they will be teaching. The used sampling techniques were purposive and convenience samplings. These samplings were used to select the participants based on their availability for the study. Convenience sampling involve choosing participants for the study based only on their availability (Haegele & Hodge, 2015).

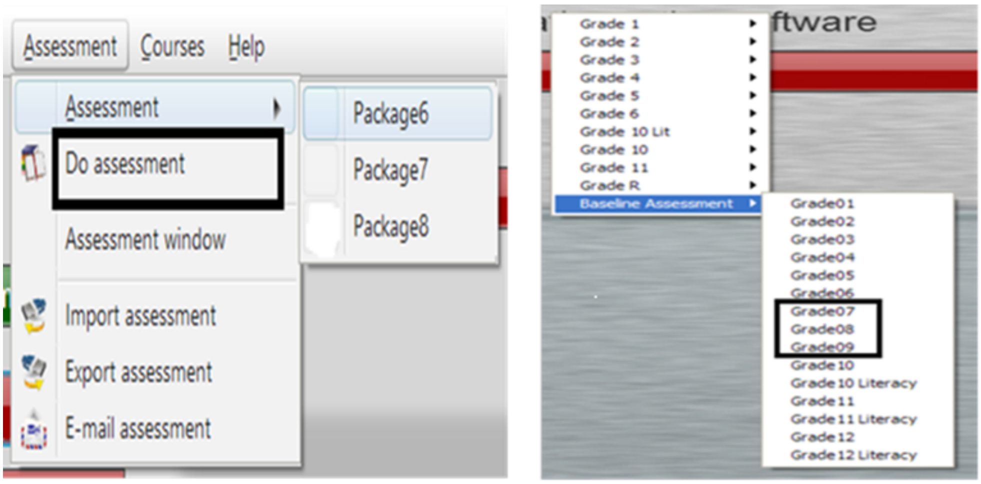
When subjects for random and systematic sampling are not available, researchers employ this kind of sampling. The selection of the most accessible subjects by the researcher is the reason. The purposive sampling is a sampling technique in which researchers choose the sample they wish to utilise by using their judgment (Fraenkel et al., 2012; Haegele & Hodge, 2015). The convenience sampling was used by the researcher to choose the single university and operational computer lab in the establishment where CAMI was installed. The choice of the teacher candidates was made using the purposive sampling judgment, as the experiment is dependent on participant availability.

Instruments and Procedures

The participation in the CAMI Baseline Test was conducted as a blocked session for two weeks in a controlled environment in an invigilated computer lab. CAMI was installed on the computers in the lab, where all the teacher candidates who enrolled for the SP and FET Mathematics course were given passwords to log into and access the Baseline Test in the senior phase (Grades 7, 8, & 9). After the teacher candidates completed the Baseline Tests, the CAMI assessment software allowed automatic marking and immediately generated the results, which could be retrieved by the educator. The figure below illustrates the navigation to senior phase Baseline Tests on the CAMI package.

Figure 1

The Navigation to Senior Phase Baseline Test on CAMI Package

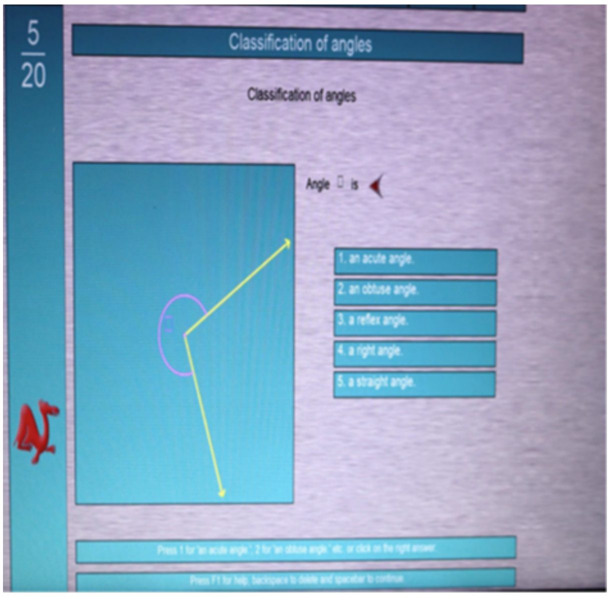


Source: https://cami.co.za/

After logging into the system, the teacher candidates clicked on the Assessment box and selected 'Do an assessment', where Baseline and Grades assessment will pop up. Then, the teacher candidates clicked on the Baseline Assessment, select Grades 7, 8 and 9 and proceed to do the test items one after the other, as shown in figure 1 above. The Baseline Test for Grades 7, 8 and 9 consisted of 25 items. The CAMI package was based on the senior phase mathematics content areas, as shown in Table 1. Below are some of the sample items from the CAMI test. From each grade.

Figure 2

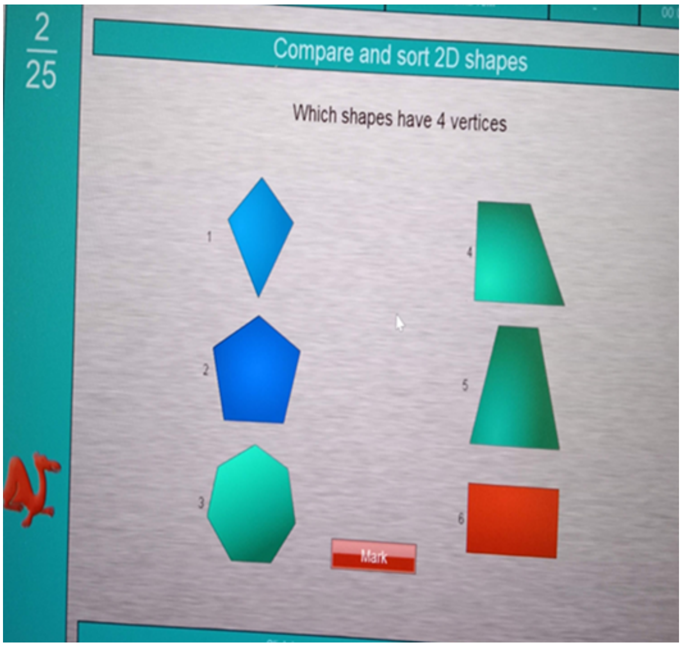
Grade 7, Test Item No. 5



Source: https://cami.co.za/

Figure 3

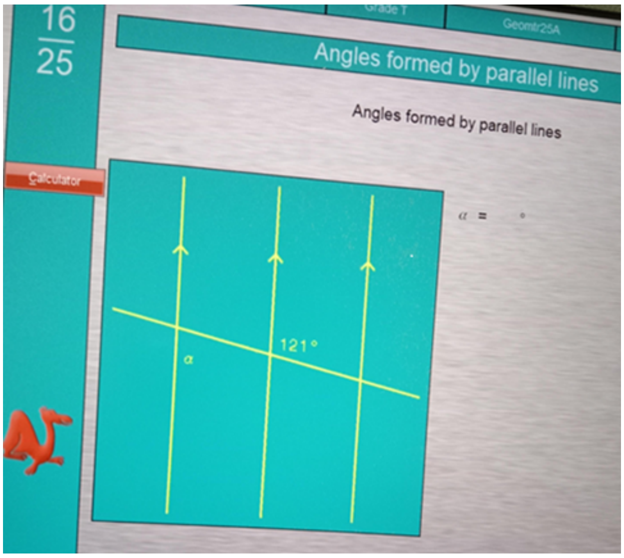
Grade 8, Test Item No. 2



Source: https://cami.co.za/

Figure 4

Grade 9, Test Item No. 16



Source: https://cami.co.za/

Data Analysis

The Baseline Test results were analysed using descriptive statistics, mean, median, mode and standard deviation. All the questions on each grade are valid since the Baseline Test is included in the package. The analysis was accomplished with the help of Microsoft Excel 2013. The teacher candidates participated voluntarily, and all the ethical requirements were met and approved by the institution.

In the South African schooling system, a student at any grade is considered a "pass" in the subject when the student achieves 40% and above. In international benchmarking, 60% is used as a benchmark for mastery at a grade level (Venkat & Spaull, 2015). In this research, a mastery level of 60% was utilized as the threshold for mathematical content knowledge proficiency in the senior phase. Table 1 illustrates the national codes and the description of the percentages which qualify learner performance (Department of Basic Education, 2011).

Table 1

Codes and Percentages for Recording and Reporting in Grades 7–9 Performances

Achievement level	Achievement description	Marks %
7	Outstanding achievement	80 – 100
6	Meritorious achievement	70 – 79
5	Substantial achievement	60 – 69
4	Adequate achievement	50 – 59
3	Moderate achievement	40 – 49
2	Elementary achievement	30 – 39
1	Not achieved	0 – 29

Source: Department of Basic Education (2011).

According to the benchmarking adopted for the subject content knowledge mastery of the teacher candidates at a particular grade, “substantial achievement” was taken as the minimum score.

Results

On completing the Baseline Test, the results of the teacher candidates were analysed. Table 2 shows the percentages of mean scores, median and mode, range, standard deviation, and the confidence level of the Baseline Test of the teacher candidates in the senior phase.

Table 2

The Percentages of Mean Scores, Median and Mode, Range Median and Mode, Standard Deviation, and the Confidence Level of the Baseline Test of the Teacher Candidates in the Senior Phase

Variables	Number	Mean (%)	Median (%)	Mode (%)	Range	Standard deviation	Confidence level (95.0%)
Grade 7	185	39.2	40	35	70	12.02	1.752
Grade 8	185	49.7	52	52	72	12.52	1.816
Grade 9	185	46.5	44	40	72	11.03	1.601

Table 2 revealed the mean percentage scores, median and mode, range, standard deviation, and the confidence level of the Baseline Test of the teacher candidates in the senior phase. The mean percentage scores achieved in the Baseline Test for each grade in the senior phase are 39.2%, 49.7% and 46.5% for Grades 7, 8, and 9, respectively. This indicates that the mean scores of the teacher candidates were within elementary and moderate levels of achievement. The mode score for Grades 7, 8, and 9 were 35%, 52%, and 40%, respectively. This indicates that in the Grade 7 Baseline test, most of the teacher candidates were at the elementary level, adequate level in Grade 8 and moderate level in Grade 9. The confidence interval of the score for Grade 7 at 95% is between 37.45% and 40.95%, while the confidence interval for Grade 8 at 95% is between 47.88% and 51.52%. The confidence interval of the score for Grade 9 at 95% is between 44. 90% and 48.10%. This result indicates that the teacher candidates' Baseline Test achievement levels were between elementary and moderate levels in Grade 7, moderate and adequate levels in Grade 8, and within the moderate level in Grade 9. From this result, it could be deduced that there is low SCK. Table 3 shows the teacher candidates' relative performance by topics in the baseline test and by Grades compared to the national codes.

Table 3

The Relative Performance of the Teacher Candidates in the Baseline Test by Topics and Grades: Comparison of Teacher Candidates' Mean Percentage Scores by Contents and the National Codes

Content areas	Grade 7 (%)	Grade 8 (%)	Grade 9 (%)	Overall mean percentage (%)
Numbers and Operations in context	27.20	32.34	52.55	37.36
Space and Shape (Geometry)	41.45	44.57	42.35	42.79
Patterns, Functions and Algebra	68.39	54.79	39.74	54.31
Data and Statistics	33.51	52.48	62.41	49.47
Measurement	37.39			

Table 3 shows the mean percentage of the teacher candidates in each grade by the topics. The higher performance of the student-teacher in Grades 7 and 8 is on Patterns, Functions and Algebra with 68.39% and 54.79%, respectively. The higher performance in Grade 9 is 62.41% in Data and Statistics. The lower performance of the student-teacher in Grades 7 and 8 is on Numbers and Operations in context with 27.20% and 32.34%, respectively. The lower performance in Grade 9 is 39.74% in Patterns, Functions and Algebra. The measurement content was only separated for the Grade 7 phase level and the teacher candidates' performance was 37.39%. The higher overall mean performance by topics is 54.31% in Patterns, Functions and Algebra, while the lower overall mean performance is 37.36% in Numbers and Operations in a context that is the elementary level in the national codes. This shows that the teacher candidates have more difficulties with Numbers and Operations in the context. Figures 5, 6 and 7 below shows the frequency distribution of the teacher candidates' percentage mark scores in Grades 7, 8, and 9.

Figure 5

Frequency Distribution of the Teacher Candidates' Mark Scores in Grades 7

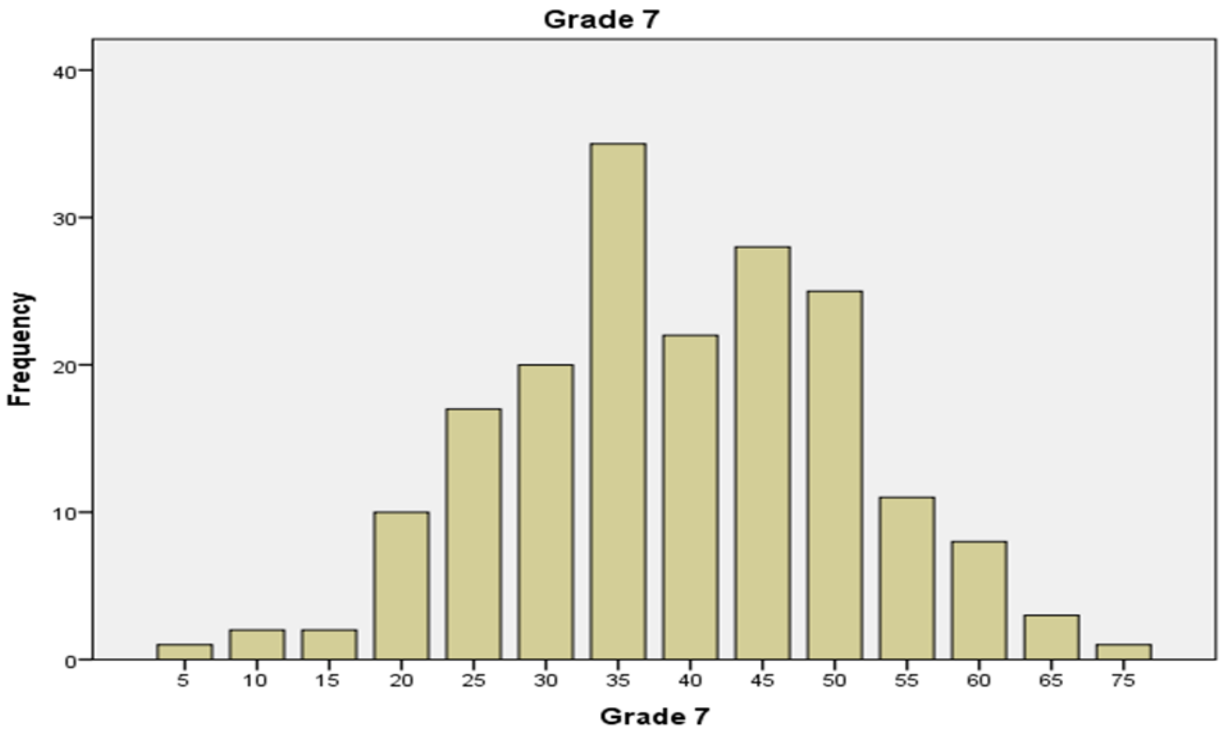
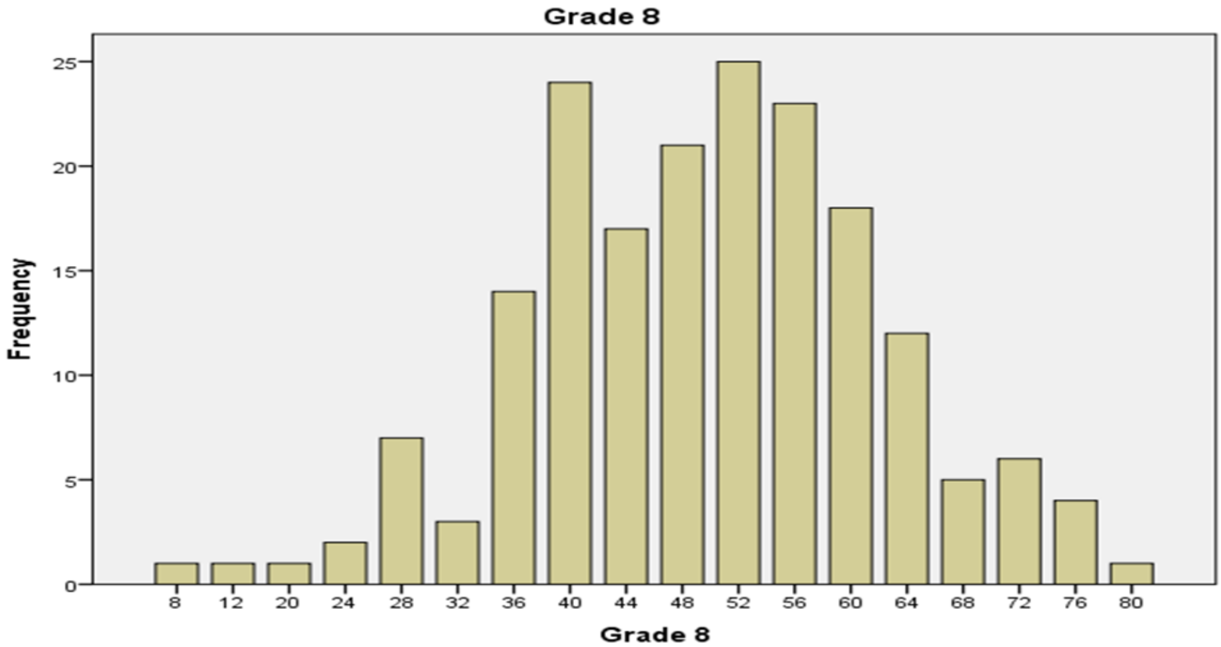


Figure 5 illustrates the frequency distribution of the teacher candidates' mark scores in Grades 7. Only one candidate scores 75% and one candidate scores 5%. Thirty-five of the teachers' candidates scores 35% while 22 scores 40% and 28 scores 45%.

Figure 6

Frequency Distribution of the Teacher Candidates' Mark Scores in Grades 8



The figure 6 above shows the frequency distribution of the teacher candidates mark scores in Grade 8. One teacher candidate scores 80%, four candidates score 76% and 25 candidates scores 52%. Twenty-nine of the teachers' candidates scores below 40%.

Figure 7

Frequency Distribution of the Teacher Candidates' Mark Scores in Grades 9

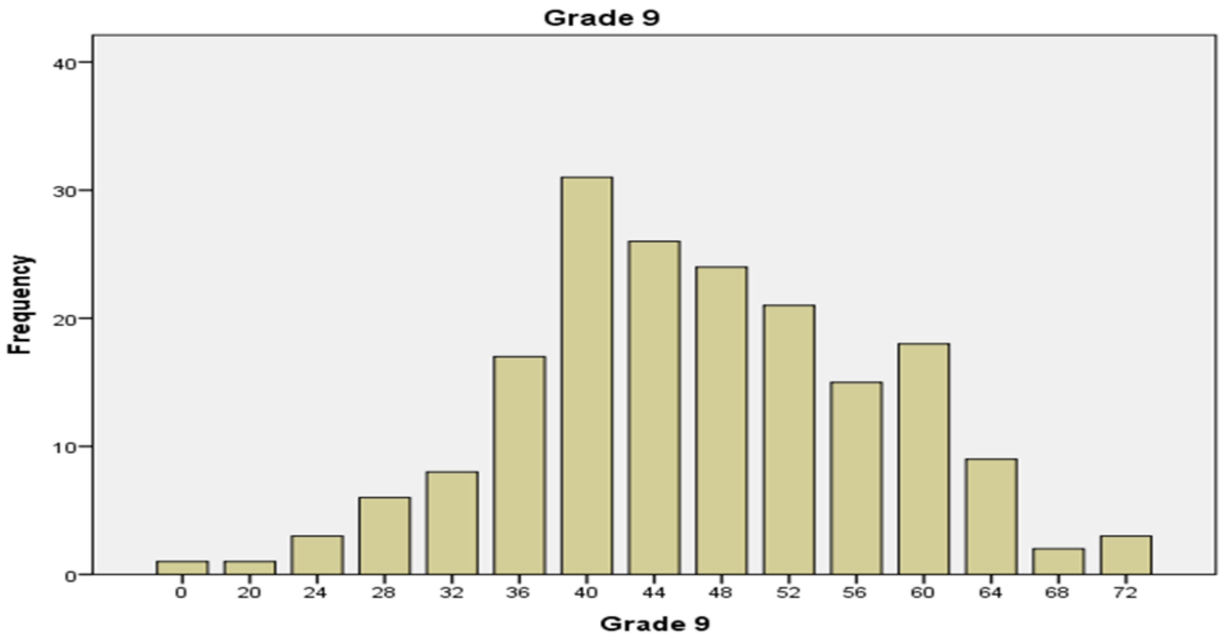


Figure 7 shows the frequency distribution of the teacher candidates 'mark scores in Grade 9. Six-eight of the teacher candidates score above 50% while thirty-six score below 40%. Only 3 candidates score 72% and one of the teacher candidates score zero.

Figure 5, 6 and 7 illustrates the number of entry-level teacher candidates' percentage marks from the CAMI Baseline Test for Grades 7, 8, and 9 in different percentiles. As shown in these figures, most of the student-teacher marks for Grades 7 are within 30% and 39%. While the highest number of teacher candidates' marks for Grades 8 and 9 are within 40% and 49%. The number of student teacher's marks that are above 50% for the three Grades (7, 8 and 9) are 48, 94, and 68, respectively. The number of teacher candidates with marks below 30% in all three grades (7, 8, and 9) is 32, 12, and 11 accordingly. In Grades 7, 8, and 9, there are 50, 62, and 81 teacher candidates, respectively, within the range of (40 – 49) percent. In Grades 7, 8, and 9, the number of teacher candidates in the range of (70-79) percent is 1, 10, and 3, respectively. In Grade 8, only one student teacher receives a score of more than 80%. The indication at the Grade 7 level means there is a low achievement.

According to Department of Basic Education (2011), the rating achievement as indicated in Table 2, the number of teacher candidates with no achievement in the senior phase Baseline Test is 32 in Grade 7, 12 in Grade 8 and 11 in Grade 9. While the number of teacher candidates with elementary achievement is 55, 17 and 25, in all three grades. Furthermore, 50, 62 and 81 are moderate, 36, 48 and 36 are adequate, 11, 35, and 29 are substantial, and 1, 10, and 1 are with meritorious achievement, respectively and one with outstanding achievement in Grade 8 level. As a result, most of the teacher candidates showed moderate achievement, suggesting that they have a moderate level of mathematical content knowledge when starting the program. However, there were also a significant number of candidates who only demonstrated elementary achievement at the Grade 7 level.

Discussion

The findings in this study highlighted an awareness of the mathematical knowledge of entry-level teacher candidates. The results revealed that teacher candidates did not possess adequate and sufficient mathematical knowledge to teach mathematics in the senior phase. The findings revealed the weakness of teacher candidates' content knowledge. The Baseline Test results revealed that the confidence interval of the score for Grade 7 at 95% was between 37.45% and 40.95%, and the frequency distribution revealed that 55 out of 185 of the teacher candidates attained elementary achievement in Grade 7. The overall mean percentage scores also revealed that the teacher candidates had more difficulties in Numbers and Operations in context than other content in the senior phase of mathematics. This indicates that the teacher candidates' mathematical knowledge is still inadequate, especially in CK and SCK. The findings are based on the lower Grade (Grade 7), where the teacher candidates are expected to attain the mastery of the subject matter knowledge. In addition, the results shed light on the mathematical content knowledge of the student teacher's entry-level and their understanding at the Grade 7 level. The teacher candidates have a solid understanding at a Grade 7 level, particularly excelling in Patterns, Functions, and Algebra. However, their content knowledge at the entry-level is lacking in the area of teaching senior phase mathematics.

According to Venkat and Spaull (2015), a benchmark for 'mastery' of the mathematics content in the test was pitched at 60%. This was adopted as a reasonable expectation for students (who had achieved a passing grade in Grade 12 mathematics with a university exemption and met the minimum requirement of 50% to be admitted into the BEd program) and intended to teach in secondary schools. It is noted with great concern that only 12 teacher candidates (6.5% of the 185 teacher candidates) acquired above 60% in the Grade 7 Baseline Test, and only 46 teacher candidates (24.8 % of the 185 teacher candidates) acquired above 60% in the Grade 8 Baseline Test, only 32 teacher candidates

(17.3% of the 185 teacher candidates) made it above 60% in the Grade 9 Baseline Test. In summary, the number of student teacher's marks that are above 60% for the three Grades (7, 8 and 9) are 12, 46, and 32, respectively, which is very low as the total number of students who wrote each of the Baseline Test was 185.

As the Baseline Test was pitched at the level of mathematics the teacher candidates are expected to teach, it is of great concern that most students could not obtain more than 60%. Only 6.5%, 24.8% and 17.3 % in Grades 7, 8 and 9, respectively, managed to surpass the benchmark for the mastery of the subject matter knowledge. The results indicate that teacher candidates lack sufficient mathematical content knowledge for teaching senior phase mathematics upon entering the Bachelor of Education program, raising concerns about their preparedness for teaching this subject.

Therefore, the teacher educators need to strengthen and enhance the mathematical content knowledge of the teacher candidates for teaching in the senior phase. The results of this study are consistent with Alex and Trow, (2023), Danişman and Tanişli (2018), Hill et al. (2008), Narh-Kert (2021), Norton (2019b), Rach and Ufer (2020), and Wong and Lai (2012), who agreed that the entry-level pre-service teachers' mathematical knowledge is inadequate. Alex and Roberts (2019), and Askew et al. (2019) found similar findings in the Foundation Phase. According to Bowie and Reed (2016), these findings are also similar to the Intermediate Phase (IP). Alex (2019) and Alex and Trow, (2023) share similar findings in the Further Education and Training (FET) regarding pre-service entry-level teacher candidates' mathematical content knowledge. In addition, Johannsdottir (2013) concluded that teacher candidates lacked fundamental comprehension of mathematical principles. The weakness in MCK is a critical case that the teacher educators should investigate and develop a meaningful program to improve the insufficient MCK of the teacher candidates. The authors of this study align with the findings of Ball et al. (2008), suggesting that teacher educators should design instructional strategies that enable teacher candidates to acquire a deep understanding of subject content, enabling them to effectively apply their knowledge in diverse contexts.

Van der Sandt and Nieuwoudt (2003) state that content knowledge in mathematics is a vital indicator of a teacher's overall effectiveness. It is noted that teachers must have subject expertise and that the quality of instruction depends on the teachers' knowledge. According to Wong and Lai (2012), teacher candidates' entry-level mathematics subject knowledge is not related to their mathematics pedagogical content knowledge development. Furthermore, teacher candidates should study mathematics and acquire in-depth knowledge to improve their teaching practice. In their study of Grade 7 teachers and prospective teachers' subject knowledge of geometry, Van der Sandt and Nieuwoudt (2003) found that teacher candidates did not achieve the level of geometric reasoning and acquisition anticipated by competent teachers [the Mathematics Content Knowledge (MCK)]. As a result, the above researchers concluded that aspiring teachers lack knowledge over the Grade 7 geometry subject matter [the Content Knowledge (CK)], which they are required to teach. Therefore, it is important to know teacher candidates' entry-level mathematics subject knowledge in all the different topics in the senior phase.

Hill et al. (2008) discovered that levels of Mathematical Knowledge for Teaching (MKfT) and the mathematical quality of teachers' instruction had a significant and favourable association. As a result, these researchers concluded that substantial professional development helped increasing the mathematical quality of education by enhancing teachers' understanding. Narh-Kert (2021) concludes that teacher candidates with average scores in fundamental mathematics have weak grades in entry-level mathematical knowledge. Narh-Kert (2021) recommends that teacher educators introduce Pedagogical Mathematics Content Knowledge (PMCK) along with Mathematical Content Knowledge (MCK) for teacher candidates. This is to improve and strengthen teacher candidates' MCK and PMCK and appropriately equip them with MKfT. Thus, as per the findings of Rach and Ufer (2020), having a strong foundation in mathematics beforehand is a strong predictor of success for teacher candidates in their first-semester mathematics courses. Essentially, individuals who possess a solid understanding of mathematical concepts are better equipped to grasp and incorporate new material compared to those who do not possess the same level of prior knowledge. According to Danişman and Tanişli (2018) and Norton (2019b), teacher candidates' understanding of the mathematical subject is insufficient in some mathematics topics, such as 'Probability'. To improve the classroom teaching abilities of teacher candidates and their motivation and self-efficacy while they are student teachers, teacher educators—including cooperating teachers and supervisors—must be aware of the resources that are currently offered and may become available in the future. These resources are essential for attaining exceptional teaching performance. When given the chance to connect with and observe cooperating teachers in order to gain mastery experiences, teacher aspirants do exceptionally well in the classroom. Supervision is essential in helping teacher candidates to manage teaching in mathematics classroom (Al-Najjar et al., 2024). Therefore, Askew et al. (2019) along with Al-Najjar et al. (2024) suggest that in order to be more well-equipped for future teaching careers, prospective teachers should review elementary school mathematics in a manner that helps them grasp fundamental mathematical concepts. As a result, the authors maintain that the same should hold true for teacher candidates focusing on teaching older students.

Conclusions and Implications

The finding reported in this paper is that the level of understanding of the entry-level teacher candidates' mathematics content knowledge is weak and insufficient. This confirms previous research studies that have shown that teachers limited and inadequate knowledge of mathematics content contributes to students' poor performance in math. Quality teaching requires that all mathematics teachers have a thorough understanding of the subject they are teaching. Therefore, the teacher candidates must be encouraged to master the mathematical content knowledge such as CK and SCK to understand the teaching and learning principles and approaches. Furthermore, changes in teaching beliefs, attitudes, and everyday behaviours in the classroom necessitate teacher applicants to undergo training in their respective disciplines and subject matter. Therefore, improving learner learning and school education, teacher educators should assist in honing the teacher candidates' profession as well as expanding and improving their expertise in the mathematics subject matter they teach.

In addition, teacher candidates must revisit their senior phase school mathematics in order to gain a complete comprehension of key mathematical concepts. Students who enter HEI with a strong foundational knowledge should be able to integrate new parts of mathematics concepts, while students with less foundational understanding should practice coming together to integrate new mathematical concepts. It is envisaged that the conclusions mentioned in this paper will add to the knowledge of what mathematics teacher candidates know and understand about the content they need to teach.

Suggestions for Future Research

In the field of mathematics education, it is crucial for teacher candidates to develop a deep understanding of mathematical concepts from the beginning of their studies. This paper suggests that teacher educators should promote the use of diverse problem-solving techniques, especially in the realms of Grade 7, 8, and 9 mathematics, in order to enhance mastery for the senior teaching phase. Additionally, teacher candidates must cultivate positive attitudes and beliefs towards teaching mathematics.

Addressing the challenges that arise in the acquisition of mathematics content knowledge (CK and SCK) and conceptual understanding is essential in higher education institutions (HEIs) teacher education programs. By doing so, teacher candidates will be better equipped to effectively teach relevant mathematics concepts and improve the academic performance of Further Education and Training (FET) learners.

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Conflict of Interest

There is no conflict of interest.

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