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Mathematical Knowledge for Teaching in Further Education and Training Phase: Evidence from Entry Level Student Teachers' Baseline Assessments

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Abstract. This paper investigates entry-level student teachers' mathematical knowledge for teaching in the Further Education and Training phase (FET) through Baseline Assessment. The study employed a quantitative research technique. The data collection instrument was a mathematics subject knowledge test (Baseline Assessment) for FET phase student teachers. Purposive and convenient sampling methods were employed in the study. The study enlisted the participation of 222 first-year mathematics education student teachers from a rural Higher Education Institution (HEI) specialising in FET phase mathematics teaching. One hundred and seventy-five (175) student teachers completed the Baseline Assessment for all grades in this study (10, 11, and 12). The Baseline Assessment findings were examined using descriptive statistics. The results revealed that student teachers have a moderate knowledge of mathematics topics in the FET phase at the entry-level. In addition, an adequate level of understanding for teaching Grades 10 and 12 Patterns, Functions, Algebra, Space and Shape (Geometry), and Functional Relationships. While the elementary level of understanding for teaching grade 10 Measurement, Grade 11 Patterns, Functions, Algebra, and Trigonometry and Grade 12 Space and Shape (Geometry). There is no level of understanding for teaching FET phase Data and Statistics and Probability. The paper suggests that student teachers must develop a comprehensive understanding of the mathematics curriculum with the assistance of teacher educators in HEIs.

Keywords: Mathematical knowledge; student teachers' entry-level; Baseline Assessments; Further Education and Training

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1. Introduction

There was much emphasis on the teachers' content knowledge in mathematics in 2013, according to Julie (2019). The focus on content knowledge was due to the Diagnostic Measures for the Trends in Mathematics and Science Study (TIMSS) 2011, which focused mainly on student and mathematics teacher performance in public schools. Based on the test results, Reddy et al. (2016) concluded a need for significant improvement in teachers' content knowledge of classroom mathematics. They found that most teachers' lack of mathematical content knowledge is a contributing factor to learners' poor mathematics performance in most South African schools. According to research, several studies in developed countries and developing countries suggest that teachers' content knowledge for teaching mathematics contributes significantly and is a good predictor of student achievement (Mullens, Murnane and Willett, 1996; Altinok, 2013). (e.g. Norton 2019, Shepherd, 2013) (Monk, 1994; Wayne & Youngs, 2003; Hill, Rowan & Ball, 2005; Rivkin, Hanushek & Kain, 2005). This paper presents the findings of a baseline assessment that investigated the mathematical subject content knowledge of entry-level student teachers who are being trained to teach mathematics in the Further Education and Training (FET) phase in South Africa.

The South African educational system is divided into three hierarchical phases: General Education and Training (GET), Further Education and Training (FET), and s Higher Education (HE). The national matriculation examination takes place at the end of Grade 12 to mark the shift from the GET to the FET phase of schooling (DBE, 2011). Secondary school is known as the FET phase, where learners' abilities are improved to prepare them for careers of their choice. During this stage, learners lay the groundwork for future success. At the end of the FET phase, learners prepare to transition into university and higher education. According to the DBE (2011), it is expected that all learners will have a sound foundational grasp of the fundamentals that will assist them in choosing courses or study programmes at a higher education institution. Therefore, at this stage, learners concentrate on course selections consistent with their unique professional objectives and goals, whether in Commerce, Humanities, or Sciences.

To advance to the HE level for Bachelor's degree in South Africa, learners must attain at least 40% minimum passes in three or four subjects, including one official home language in the national matriculation and school-leaving examination (DBE, 2012). Therefore, the teachers who specialise in the FET phase during the Bachelor of Education degree teach subjects in the FET phase in secondary schools. For example, a student teacher with a degree in FET phase mathematics learns how to teach mathematics to learners in Grades 10 to 12. As a result, the student-teacher devotes themselves to mathematics as a subject specialist. The student-teacher concentrates on merging basic mathematics knowledge with efficiently communicating the knowledge to prospective Grades 10 to 12 learners. According to DBE (2011), the link between the Senior Phase and the Higher Education band is FET. Therefore, all learners who complete this phase gain a functional understanding of mathematics, allowing them to make sense of society. FET learners get exposed to various mathematical experiences that provide them with numerous possibilities to build mathematical reasoning and creative skills in preparation for abstract mathematics in higher education. In this regard, the student teachers for the FET phase need to be prepared for the task and the comprehensive role ahead since studies show that learners' poor performance in mathematics is due to the teachers' poor mathematical content knowledge (Pino-Fan, Assis & Castro, 2015; Reddy et al., 2016; Siyepu & Vimbelo, 2021; Verster, 2018). In recent times, there has been increasing attention to investigating knowledge that mathematics teachers should have to execute an adequate control of the learners' learning. Hence, to quantify the mathematical knowledge content for teaching and understanding level of the student-teacher for the FET phase, this paper reports on the Baseline Assessment that investigated the mathematical content knowledge of entry-level FET phase student teachers for teaching mathematics in South Africa.

Specifically, it sought an answer to the following questions:

1. What is the mathematical content knowledge of student teachers for teaching FET phase Mathematics through baseline assessment?
2. What is the level of understanding of the entry-level student teachers' mathematical content knowledge for teaching FET phase mathematics through baseline assessment?

2. Literature review and theoretical framework

2.1 Mathematical Knowledge for Teaching

The theoretical framework that underpins this study is Mathematical Content Knowledge. Mathematical Content Knowledge (MCK) was built on Shulman's pedagogical content knowledge by Ball and colleagues in 2005. Mathematical Content Knowledge (MCK) is an essential factor to consider when teaching mathematics because it influences teachers' decisions towards teaching and learning mathematics. The entry-level mathematics subject knowledge of the student teachers for teaching in the FET phase is crucial because it determines the student achievement in mathematics (Reddy et al., 2016). Jacinto & Jakobsen (2020) argues that several studies highlight that teachers should be able to teach what they know and comprehend. Jakimovik (2013) further supports this, who states that teachers should have the appropriate MCK for effective teaching and learning. (According to Narh-Kert (2021), effective mathematics teachers know the mathematics relevant to the grade level and the value of the mathematics courses they teach. Therefore, the authors believe that the quality of FET mathematics teaching depends on teachers' knowledge of the content in the phase.

Deborah Ball and colleagues in Michigan created a test for mathematics teachers' professional expertise aimed at elementary school teachers in the United States (Ball, Hill & Bass, 2005) to assess their MCK for the grades they teach. The test was a multiple-choice measure of number and operation, pattern, function, algebra and geometry. This test became a measure and was used to evaluate the MCK of mathematics educators, mathematicians, professional developers, project staff, and classroom teachers. Ball et al. (2005) discovered that teachers lack sound mathematical knowledge and skills. The test results led to the definition of mathematical content knowledge and its two components, Common Content Knowledge (CCK) and Specialised Content Knowledge (SCK) (Ball et al. 2005).

These researchers further explained that most of the in-service mathematics teachers in the U.S are graduates of a weak system. Therefore, there is a dire need to improve the mathematical knowledge of educators. Ball et al. (2005) state that the system clarifies that these in-service teachers learned mathematics with irregularity and insufficient mathematical knowledge, leading to many teachers' weak mathematical knowledge. To improve teachers' MCK, Ball et al. (2005) test approach is embedded in Shulman's (1986, 1987) taxonomy of teacher knowledge.

Shulman makes a theoretical distinction between pedagogical content knowledge (PCK), which is the knowledge of how to make the subject accessible to others, and content knowledge (CK), which is the knowledge of deep comprehension of the domain itself (Shulman 1986). As a result, Shulman (1986, 1987) and Ball et al. (2005) use mathematical subject knowledge to assess teachers' performance. Both rely on a distinct teaching philosophy that emphasises teachers' capacity to translate content knowledge into pedagogical strategies that help students learn effectively. Jacinto and Jakobsen (2020) state that Mathematical Knowledge for Teaching (MKfT) also provides a long-term theoretical foundation and practical ramifications for teacher preparation programs. (. Hence, the theory of MKfT proposed by Ball, Thames, and Phelps (2008) is used in this study.

According to the MK, the following domains are the key focus: common content knowledge (CCK), horizon content knowledge (HCK), specialised content knowledge (SCK), knowledge of content and students (KCS), knowledge of content and teaching (KCT), and knowledge of content and curriculum (KCC) (Jacinto & Jakobsen, 2020).

- The first domain (CCK) refers to mathematical knowledge that is frequently utilised and created in various settings, including outside of formal education. This form of knowledge consists of questions that can be answered by those who know mathematics rather than specialised understandings (Ball et al., 2008).
- CCK is demonstrated by using an algorithm to solve an addition problem.
- Horizon content knowledge (HCK) is the knowledge of "how the content being taught fits into and is connected to the larger disciplinary domain." This domain includes knowing the origins and concepts of the subject and how useful it may be to students' learning. HCK allows teachers to "make judgements about the value of particular concepts" raised by students, as well as address "the discipline with integrity, all resources for balancing the core goal of linking students to a large and highly developed area" (Ball et al., 2008: 400; Jacinto & Jakobsen, 2020).
- Specialized Content Knowledge (SCK) is defined as "the mathematical knowledge specific to the teaching profession." It entails an unusual form of mathematical unpacking that is not required in environments other than education. It necessitates knowledge that extends beyond a thorough understanding of the subject matter. Teachers' roles include being able to present mathematical ideas during instruction and responding to students' queries, both of which necessitate mathematical expertise specific to teaching mathematics (Ball et al., 2008: 400; Jacinto & Jakobsen, 2020).

- Knowledge of content and students (KCS) was another sub-construct that needed to be redefined because it did not fit the criterion for one-dimensionality. For instance, respondents such as teachers, non-teachers, and mathematicians used standard mathematical procedures to answer the items designed to reflect KCS, according to cognitive tracing interviews. Furthermore, the use of multiple-choice items in KCS measurement was reviewed in favour of open-ended questions.

Teachers utilise CCK to plan and teach mathematics concepts, allowing them to evaluate students' answers, respond to concept definitions, and complete a mathematical approach. Therefore, any adult with a well-developed CCK but not the knowledge required to educate, such as new student teachers entering Higher Education Institutions (HEI), may have a well-developed CCK but lack the necessary knowledge to teach. Hence, this study investigates the mathematical content knowledge of entry-level student teachers in the FET phase training phase for teaching mathematics through Baseline Assessment in South Africa.

2.2. Educational assessment

Educational assessment supports knowledge, skills, attitudes, and beliefs, usually in measurable terms. Assessment is an essential component of a coherent educational experience (Sarka, Lijalem & Shibiru, 2017). According to Sarka et al. (2017), assessment methods considerably influence the breadth and depth of students' learning, that is, the approach to studying and retention, with either a strong influence or a lack thereof. Assessments are used in a variety of ways, which include motivating students and focusing their attention on what is essential, providing feedback on the students' thinking, determining what understandings and ideas that are within the zone of proximal development, and gauging the effectiveness of teaching, including identifying parts of lessons that could be improved. (Patterson, Parrott & Belnap, 2020).

Assessment is a process of collecting, analysing and interpreting information to assist teachers, parents and other stakeholders in making decisions about the progress of learners (DBE, 2011). Therefore, assessment serves a wide range of functions, including permission to progress to the next level, classifying students' performance in ranked order, improving their learning and evaluating the success of a particular technique for improvement (Sarka et al., 2017). Furthermore, the assessment goals include curriculum development, teaching, gathering data to aid decision-making, communication with stakeholders, instructional improvement, program support, and motivation (Pattersonet et al., 2020; Sarka et al., 2017; Wilson, 2018).

According to the DBE (2011), there are various types of assessments. These include formative assessment, summative assessment, diagnostic and baseline assessment. Formative assessment is assessing students' progress and knowledge regularly to identify learning needs and adapt teaching accordingly (Wilson, 2018). The Centre for Educational Research and Innovation (CERI) (2008) states that teachers who use formative assessment methods and strategies are better equipped to address the requirements of a wide range of students. This can be done by differentiating and adapting their instruction to enhance students' achievement to achieve more significant equity in their learning outcomes. Formative assessment can also be defined as the activity that supports learning by giving information that can be utilised as feedback by teachers and students to evaluate themselves and each other to improve the teaching and learning activities. Therefore, formative assessment is one of the primary core activities in teachers' work (Wilson, 2018).

Summative assessments are used to determine what students have learned at the end of a unit and are used as a measure for promotion purposes. Dolin et al. (2018) state that summative assessment ensures that students have fulfilled the requirements to achieve certification for school completion or admittance into higher education institutions or occupations. In addition, when an assessment activity is used to provide a summary of what a student knows, understands, and can do rather than to aid in the modification of the teaching and learning activities in which the student is engaged by providing feedback, it is considered summative (CERI, 2008; Wilson, 2018). Summative assessments are used in education for a variety of reasons. Individual students and their parents discuss progress and receive an overall assessment that includes praise, inspiration, and guidance for what has been accomplished. Summative assessments provide a comprehensive guide to the effectiveness of the students' work, which may be externally standardised ((Dolin et al., 2018; Wilson, 2018). Wilson (2018) agrees that summative assessments assist schools in making the best possible grouping and subject choices for the learners. Both a school and a public authority employ summative assessments to inform teachers and the school’s accountability. As a result, a common element of summative assessments is that the results are utilised to guide future decisions.

The initial assessment occurs when a student begins a new learning program. The initial assessment is a comprehensive process in which students start to piece together a picture of an individual's accomplishments, abilities, interests, prior learning experiences, ambitions, and the learning requirements associated with those ambitions. The information from the initial assessment is used to negotiate a program or course (Quality Improvement Agency (QI), 2008). Diagnostic assessment supports the identification of individual learning strengths and weaknesses. It provides learning objectives and the necessary teaching and learning strategies for achievement. This is necessary because many students excel in some areas but struggle in others. Diagnostic evaluation occurs at the start of a learning program and again when required. It has to do with the specialised talents needed for specific tasks. The information acquired from the initial examination is supplemented by diagnostic testing (QIA, 2008).

Baseline assessment commonly used in early childhood education gathers information regarding a child's development or achievement as they transition to a new environment or grade. These assessments are conducted in various ways, ranging from casual observations to standardised examinations. The information gathered from these assessments assists educators in fulfilling the learner's requirements, highlighting their strengths and areas for improvement. All these assessments are helpful in their capacity to assess the learners. Baseline assessments assist schools in understanding the students' requirements. It also aids in determining learners' learning capability and potential and assessing the influence the schools have on learners. Information from baseline assessment facilitates schools in customising planning, teaching, and learning, including determining the most effective resource allocation to track learners' progress throughout the school year. According to Khuzwayo and Khuzwayo (2020) and Tomlinson (2020), the baseline assessment findings provide information to the teacher regarding the learners' abilities and knowledge gaps. This evidence assists the teacher in organising learning content, selecting, and matching teaching and learning approaches with the learning needs of individual students or groups of students.

The three assessments (The Initial, Diagnostic, and Baseline assessments) are interrelated in education. The assessments are always administered at the beginning or entry of students into the school, measure the strengths and weaknesses, and deduce places for improvement in a learner. The assessments are embedded in formative assessment.

The baseline assessment (CAMI) utilised in this paper is in accordance with the Curriculum and Assessment Policy Statement (CAPS) for Further Education and Training in South Africa. The licensed online Computer Aided Mathematics Instruction (CAMI) software is used to program the baseline assessments. CAMI is a high-productivity software system that can improve mathematics grades in a minimal amount of time. One of the software's functions is to correct extension work for a more advanced student. CAMI employs the computer as a "Drill and Practice" system rather than a tutoring system because it focuses on knowledge retention (see www.cami.co.za).

The main mathematics topics in the FET phase are Functions; Number Patterns, Sequences, and Series; Finance, growth, and decay; Algebra; Differential Calculus; Probability; Euclidean Geometry and Measurement; Analytical Geometry; Trigonometry; and Statistics. The topics constitute Papers 1 and 2 of the national examinations in South Africa. The weighting of content areas is shown in Table 1 below:

Table 1: The weight of content areas description of FET's mathematics topics

The weighting of Content Areas			
Description	**Grade 10**	**Grade 11**	**Grade 12**
Paper 1 (Grades 12: bookwork: maximum 6 marks)			
Algebra and Equations (and Inequalities)	30 ± 3	45 ± 3	25 ± 3
Patterns and Sequences	15 ± 3	25 ± 3	25 ± 3
Finance and Growth	10 ± 3		
Finance, growth, and decay		15 ± 3	15 ± 3
Functions and Graphs	30 ± 3	45 ± 3	35 ± 3
Differential Calculus			35 ± 3
Probability	15 ± 3	20 ± 3	15 ± 3
TOTAL	**100**	**150**	**150**

Paper 2: Grade 11 and 12: theorems and /or trigonometric proofs: maximum 12 marks			
Description	**Grade 10**	**Grade 11**	**Grade 12**
Statistics	15 ± 3	20 ± 3	20 ± 3
Analytical Geometry	15 ± 3	30 ± 3	40 ± 3
Trigonometry	40 ± 3	50 ± 3	40 ± 3
Euclidean Geometry and Measurement	30 ± 3	50 ± 3	50 ± 3
TOTAL	**100**	**150**	**150**

(Source: CAPS Documents, DBE, 2011)

3. Research methodology

3.1 Research design and sampling

A quantitative research design and methodology were used in this study. The data collection instrument was a mathematics subject knowledge test (Baseline Assessment by CAMI) for FET phase student teachers. The Baseline Assessment was used to assess the entry-level student teachers' mathematical content knowledge through online Computer Aided Mathematics Instruction (CAMI) software. The CAMI programme is part of the ongoing research conducted in the Mathematics Education and Research Centre established in rural higher education (HEI) in South Africa. Two hundred and twenty-two (222) first-year mathematics student teachers specialising in FET phase mathematics teaching participated in the study. This paper included 175 student teachers who completed the Baseline Assessment for all grades (10, 11, and 12). Purposive and convenience samplings were utilised to collect data. Participation in the CAMI Baseline Assessment was done in a controlled environment in an invigilated computer lab for two weeks. The majority of the student teachers enrolled in the FET Teaching Bachelor of Education Course came from rural secondary schools and had not experienced computer-assisted learning.

3.2 Data collection

3.2.1 Baseline Assessment through CAMI

Computer-Aided Mathematics Instruction (CAMI) baseline assessment is an online assessment available in the CAMI EduSuite program (further information is available from www.cami.co.za). The FET baseline assessment consisted of a 60-minute online test with 25 items that student teachers can easily access through internet connectivity. CAMI was installed on the lab computers, and all student teachers participating in the FET Mathematics courses were given credentials to log in and access the FET Baseline Test (Grades 10, 11, and 12). After completing the Baseline Assessment, the teacher can access their results.

The navigation to the FET Baseline Test on the CAMI package is illustrated in the figure below.

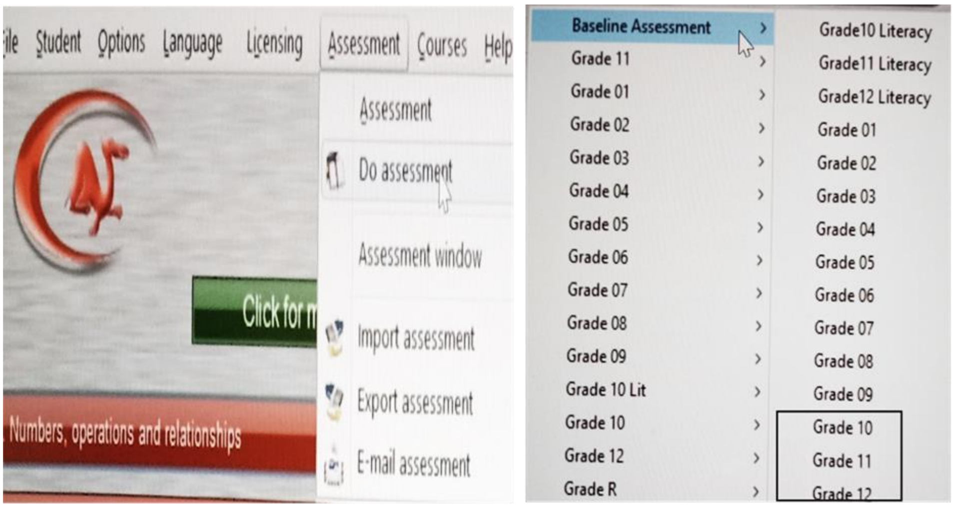


Figure 1: The navigation to the senior phase Baseline Test on the CAMI package

After logging into the system, student teachers should go to the Assessment box and click 'Do assessment', which will bring up the Baseline and Grades assessments. After that, the student teachers choose Grades 10, 11, and 12 from the Baseline Assessment and complete the test items one by one, as shown in figure 1. Each of the Baseline Assessments for Grades 10, 11, and 12 has 25 items.

3.3. Data analysis

The findings of the Baseline Assessment were analyses using descriptive statistics. The frequency distributions were used to establish the mathematical content knowledge and the level of understanding of the contents for teaching mathematics in the FET phase. One-way ANOVA was used to establish the variability of the mean performance of the student teachers from grade to grade. Because the program includes the Baseline Assessment, all the questions on each grade are valid. All ethical requirements were completed, and the student teachers participated (Ethical Clearance Number: FEDSRECC001-06-21).

Below are some of the sample items from the CAMI Baseline Assessment.

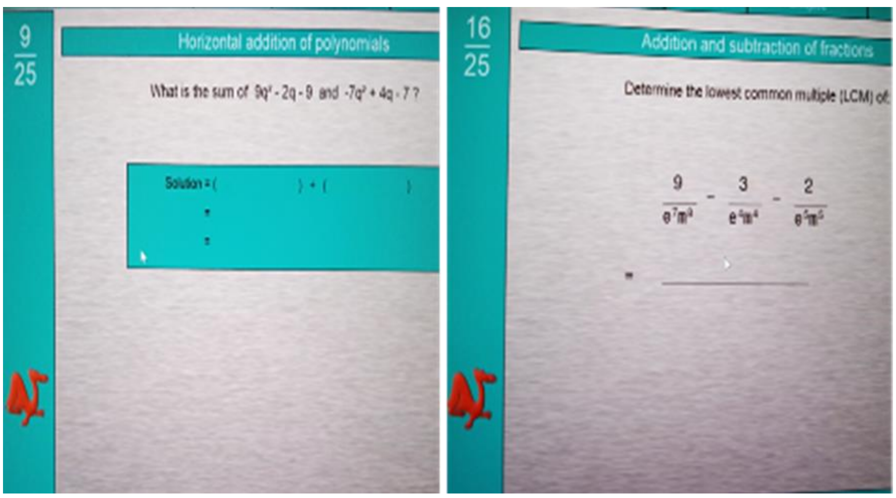


Figure 2: assessment items no. 9 and 16 (source: www.cami.co.za)

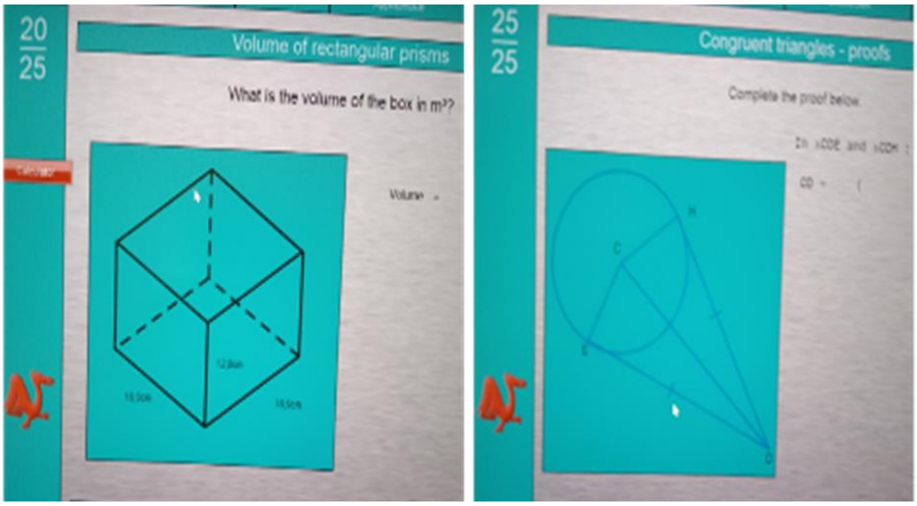


Figure 3: assessment items no. 20 and 25 (source: www.cami.co.za)

According to international benchmarks, 60 per cent was used as the understanding level of mathematical content knowledge in the FET phase in this study. The national codes and descriptions of the percentages that qualify learner performance can be found in Table 2 (DBE, 2011).

Table 2: Codes and percentages for recording and reporting in Grades R-12 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: DBE, 2011)

According to the benchmarking, "Substantial achievement" was the minimum score for student teachers' subject content knowledge mastery at a specific grade level.

4. Results

4.1. Baseline assessment of the mathematical content knowledge of student teachers for teaching FET phase Mathematics

The mean of the Baseline Assessment in the three grades of the FET phase was determined using a one-way single factor ANOVA. The following tables depict the outcome:

Table 3: ANOVA Summary table

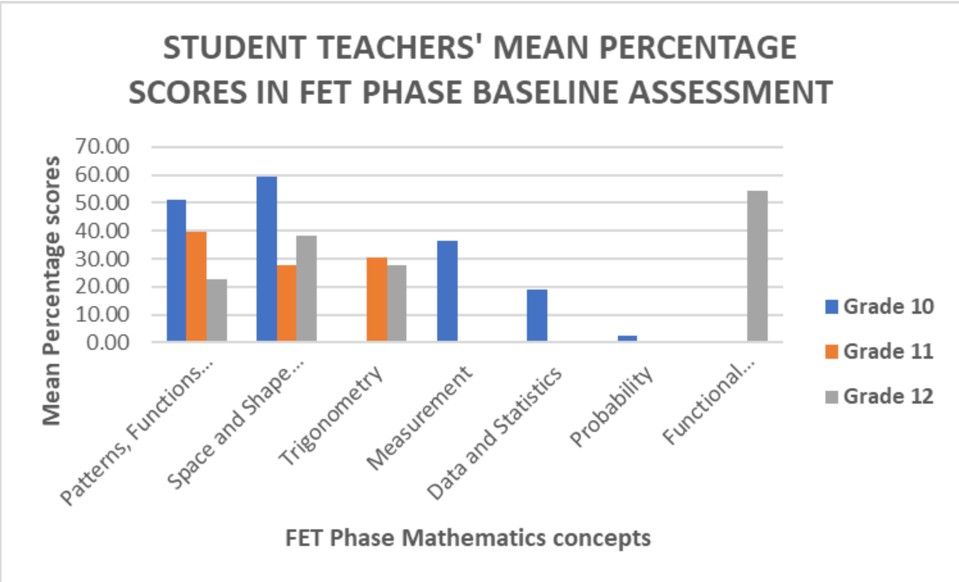
Groups	Count	Sum	Average	Variance
Grade 10	175	7832	44.75429	113.3588
Grade 11	175	6580	37.6	166.9885
Grade 12	175	5756	32.89143	171.7985

Table 4: One-way ANOVA single factor

Source of Variation	Sum of Squares	Df	Mean Squares	F	P-value	F crit
Between Groups	12488.11	2	6244.053	41.42947	2E-17	3.012991
Within Groups	78673.37	522	150.7153			
Total	91161.48	524				

Notes: *Df – Degree of freedom; P-value: $p < 0.05$*

As shown in Table 3, the mean strengths range from 32.89 for Grade 12 to 44.75 for Grade 10, indicating that the sample means are different. That is to say; the average score is not the same. Table 4 shows that the p-value of 2×10^{-17} is less than the significant level of 0.05, implying that the Baseline Assessment mean scores for FET student teachers are not equal. This means that student teachers' average performance in the FET phase varies from grade to grade. The mean percentage scores of student teachers in the FET phase Baseline Assessment are shown in the graph below.



Figures 4: The mean percentage scores of the student teachers in the FET phase Baseline Assessment according to content areas

The mean percentage scores of student teachers in the FET phase Baseline Assessment according to the content areas are shown in Figure 4 above. The results revealed that the students' mean percentage in Space and Shape (Geometry) Grade 10 was 59.18%, Patterns, Functions, and Algebra at 50.96%, measurement at 36.48 per cent, data and statistics at 19.13%, and probability at 2.55%. Patterns, Functions, and Algebra (39.59%), Trigonometry (30.35%), and Space and Shape (Geometry) (27.69%) are the average percentage scores of student teachers in Grade 11. The student teachers had the highest mean percentage in Functional Relationships Grade 12 (54.28%), 38.07%percent in Space and Shape (Geometry), 27.60% in Trigonometry, and 22.68% in Patterns, Functions, and Algebra (see Figure 4).

According to the above findings, student teachers scored better in Grade 10 concepts than in Grades 11 and 12 during the FET phase. Patterns, Functions, and Algebra in Grade 12 and Measurement and Space and Shape (Geometry) in Grade 11 were all below average. Students in Grades 11 and 12 should study trigonometry and functional relationships, whereas, in Grade 10, students should study Data Statistics and Probability. The frequency distribution of the student teachers' achievements was analysed to corroborate the study's findings. Figure 5 depicts the frequency distribution of student-teacher marks for the FET phase:

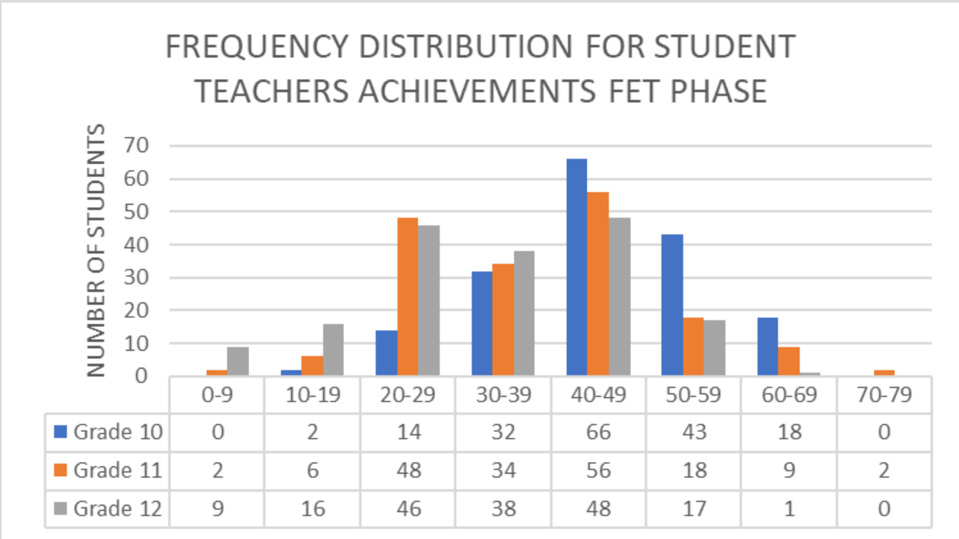


Figure 5: Frequency distribution of the student teachers' achievements in Grades 10, 11, and 12

The percentage marks from the CAMI Baseline Assessment for Grades 10, 11, and 12 for entry-level student teachers are shown in different percentiles in Figure 5. As indicated in the graph, most student teachers' achievements for Grades 10, 11, and 12 are within 40% and 49% of each other, corresponding to 66, 56, and 48 in Grades 10, 11, and 12, respectively. For the three FET Grades (10, 11 and 12), the number of student-teacher marks above 50% is 61, 29, and 18. The number of student teachers with scores below 30% in Grades 10, 11, and 12 is 16, 56, and 71. In Grades 10, 11, and 12, - 32, 34, and 38, student teachers within 30 per cent and 39 per cent, respectively. In Grades 10 and 12, no student-teacher receives a score higher than 70%. In Grade 11, just two student teachers receive a score of more than 70%. The signal denotes moderate achievement in Grades 10, 11, and 12.

According to national codes and descriptions (DBE, 2011), the number of 'not achieved' student teachers in the FET phase Baseline Assessment is 16, 56, and 71 in Grades 10, 11, and 12, respectively as shown in Figure 5 above. In Grades 10, 11, and 12; 32, 34, and 38 of the student teachers have elementary achievement, 66, 56, and 48 have moderate achievement, 43, 18, and 17 have adequate achievement, 18, 9 and 1 have substantial achievement, respectively and just two have meritorious achievement at Grade 11 level. In the FET phase Baseline Assessment, no student-teacher achieved the outstanding achievement (80% and above). According to the findings, the student teachers have a moderate level of accomplishment. As a result, student teachers' entry-level mathematical content knowledge in the FET phase is of modest achievement.

4.2. Level of understanding of student teachers' mathematical content knowledge for teaching FET phase mathematics through baseline assessment

Table 5 shows the student teachers' mathematical content knowledge level for teaching the FET phase in each grade according to the content areas.

Table 5: The understanding level of student teachers' mathematical content knowledge for teaching FET phase mathematics according to content areas

Achievement level	Achievement description	Grade 10	Grade 11	Grade 12
7	Outstanding achievement	-	-	-
6	Meritorious achievement	-	-	-
5	Substantial achievement	-	-	-
4	Adequate achievement	Patterns, Functions, and Algebra; Space and Shape (Geometry)	-	Functional Relationships
3	Moderate achievement	-	-	-
2	Elementary achievement	Measurement	Patterns, Functions, and Algebra; Trigonometry	Space and Shape (Geometry)
1	Not achieved	Data and statistics; Probability; Trigonometry; Functional Relationships	Data and statistics; Space and Shape (Geometry); Measurement Probability; Functional Relationships	Data and statistics; Measurement; Probability; Patterns, Functions, and Algebra; Trigonometry

The results given in Table 5 show the level of understanding of the student teachers according to the content areas. The findings revealed that student teachers have an adequate level of understanding of Patterns, Functions, Algebra and Space and Shape (Geometry) in Grade 10 and Functional Relationships in Grade 12. Furthermore, the student teachers have an elementary level of understanding of Measurement in Grade 10, Patterns, Functions, and Algebra, Trigonometry in Grade 11, and Space and Shape (Geometry) in Grade 12. The student teachers have no level of understanding of Data and statistics and Probability in any of the grades, that is, Grade 10, 11 and 12. The finding indicated that the level of understanding of the student teachers' mathematical content knowledge for teaching Grade 10 Patterns, Functions, and Algebra, as well as Space and Shape (Geometry) and Grade 12 Functional Relationships, is adequate level. While the level of understanding of the student teachers' mathematical content knowledge for teaching Grade 10 Measurement, Grade 11 Patterns, Functions, Algebra, and Trigonometry and Grade 12 Space and Shape (Geometry) is elementary level. In addition, the results revealed that the student teachers did not have sufficient understanding of the mathematical content knowledge for teaching FET phase Data and Statistics and Probability.

5. Discussion

The evidence can be drawn from the findings that the entry-level student teachers' mathematical knowledge for the FET phase is at the 'moderate level' of achievement. In contrast, the actual level of understanding was not attainable. However, the findings in table 5 revealed an adequate level of understanding of the entry-level student teachers' mathematical content knowledge for teaching grades 10 and 12 Patterns, Functions, and Algebra, Space and Shape (Geometry) Functional Relationships. Elementary level of understanding for teaching Grade 10 Measurement, Grade 11 Patterns, Functions, and Algebra, including Trigonometry and Grade 12 Space and Shape (Geometry). The entry-level student teachers do not have adequate mathematical content knowledge for teaching FET phase Data and Statistics and Probability.

The result of the mean percentage from the Baseline Assessment (Figure 4) determined the mathematical content knowledge of the student teachers to be in Grade 10 Space and Shape (Geometry) and Patterns, Functions, and Algebra with (59.18%) and (50.96%) respectively as well as Grade 12 Functional Relationships with (54.28%). Similar results were obtained by Fonseca, Maseko, and Roberts (2018) in their study 'Students' mathematical knowledge in a Bachelor of Education (Foundation or intermediate phase) programme' that there is a good distribution of attainment for the first-year students in their pilot test. In contrast, the findings in this study disagree with Alex and Roberts (2019), where low percentage performance and poor mathematical knowledge for teaching were recorded in their research. There is a need to improve entry-level first-year student teachers' mathematical content knowledge. The finding also revealed that none of the student teachers achieved the "outstanding achievement", and only two have "meritorious achievement" at Grade 11 level.

The results of the student teachers' level of understanding are in agreement with Reid and Reid (2017). They found that student teachers had difficulty understanding mathematical content knowledge, such as probability and standard algorithms. According to the above researchers, the student teachers performed below the expected standard. As a result, student teachers must have a strong understanding of mathematical concepts and be able to express and explain them in a variety of ways in their future teaching.

According to studies, the primary purpose of a baseline assessment in teaching and learning is to get to know students at the entry level of a new school year (Khuzwayo & Khuzwayo, 2020; Nguare, Hungi & Matisya, 2018; Tiymms, 2013; Tomlinson, 2020). Therefore, the goal of baseline assessment in this study is to assist HEIs teacher educators in developing learning activities inclusive of various learning styles. This would also assist in detecting student teachers' special needs at an early stage so that a remediation program can be implemented (DBE, 2019). Taylor (2021) states that in South Africa, a vicious-cycle system problem is evident. Due to the negative public perception of teaching, ITE programs cannot attract competent matriculants to study for a teaching qualifications. Most of the students intending to study teaching as a career are often rejected in their first and second choices at the university level. Often universities are forced to recruit a lesser quality of pre-service teachers into the programme, which demands a reduction in the rigour of their training. A lower-quality or competent teacher is thus deployed into schools, resulting in poor quality teaching, thus lowering the learner performance and the prestige of the teaching profession. Matriculant quality while also lowering the perceived prestige of teaching. Taylor & Robinson (2016) opine that the inability to recruit qualified pre-service teachers enhances the cycle of poor quality teaching and learning.

According to Deacon (2016), the entrance requirements for Initial Teacher Education programs are generally lower than most other entry-level degree programs. The evidence suggested that the weakest students enter education faculties as a last resort, motivated by a desire to earn a university qualification rather than a desire to make a difference in students' lives. Taylor (2021) supported his claim with data from the Centre for Educational Testing for Access and Placement's National Benchmark Tests (NBTs) (CETAP, 2020). Most university applicants take the NBTs, which require a minimum to gain admission into a particular programme. However, this is not applicable to most Initial Teacher Development Programme. Over 75 000 university applicants took the Academic Literacy (AL) and Quantitative Literacy (QL) examinations, while over 58 000 took the Mathematics Test (MAT) during the 2019 NBT entry cycle. Candidates planning to study Education had the second-lowest average score of all applications to all faculties, with only those intending to study Allied Healthcare or Nursing having a lower average (CETAP, 2020). Basic, Intermediate, and Proficient are the three tiers of NBT scores, with applicants in the Basic band defined as:

> *"Test performance reveals serious learning challenges: it is predicted that students will not cope with degree-level study without extensive and long-term support, perhaps best provided through bridging programmes (i.e., non-credit preparatory courses, special skills provision) or FET provision. Institutions admitting students performing at this level need to provide such support themselves." (CETAP, 2020, p. 18).*

Due to the low mathematics achievement of students entering teacher education programs, the goal of creating a deep understanding of mathematics required for teaching should become an essential aspect of the mathematics course design and implementation (Jakimovik, 2013). Furthermore, Jakimovik (2013) claims that the complete lack of a link between mathematics and methods courses is a long-standing trend in teacher preparation programs. The only stipulation is that students complete the mathematics course's exams before enrolling in the methods courses. The mathematics courses are taught by university mathematicians and academics who teach the techniques courses, which place less emphasis on the interaction between subject matter expertise and teaching.

According to Ma (1999), teachers should possess a Profound Understanding of Fundamental Mathematics (PUFM). This means teachers' mathematical content knowledge should be a thorough understanding of mathematics that has breadth, depth, connectedness, and thoroughness, not on the average level. Jakimovik (2013) maintains that one of the most critical aspects of teaching is understanding what will be taught. In addition, mathematics is one of the fundamental realms of human thought and investigation. Learners need to build intellectual resources for knowing about and actively engaging in mathematics. The above researcher explains that the future teachers must use their mathematical knowledge in conducting classroom discourse in a learning community, mentioning students' educational needs by involving them in genuine mathematics learning, analysing students' productions, examining students' mathematical knowledge and skills in lesson preparation, or in evaluating curriculum materials. Consequently, to provide successful learning for future teachers, educators must establish specialised instructional methodologies in the HEIs.

According to Burghes and Geach (2011), the requirements for being a good mathematics teacher are confidence, competency, commitment and a passion for mathematics at a level much higher than the one being taught. Furthermore, knowledge of the topic to be taught is a significant factor in determining the quality of training. Goldsmith, Doerr and Lewis (2014) believe that teacher's capacity to recognise and analyse student's thinking also their ability to engage in effective professional conversations are hampered by a lack of mathematical content understanding.

6. Conclusions

In conclusion, to become a FET mathematics teacher, student teachers must be exposed to many mathematical experiences. They should be offered a variety of opportunities to hone their mathematical reasoning and creative abilities in preparation for teaching mathematics in the FET phase. Their low level of mathematical knowledge and understanding may make it difficult for the student teachers to teach the FET phase in the future. To teach in the FET phase, student teachers must have mathematical solid foundational knowledge and understanding. Since FET is the link between the Senior Phase and the Higher Education band, the student teachers should have an appropriate achievement level, namely, adequate, substantial, meritorious, and outstanding achievement level, to link FET learners to the Higher Education band.

Consequently, student teachers will need to improve their ability to teach mathematics effectively and ensure that it is meaningful for learners. They will be able to effectively teach mathematics in the future, even further than their current level of knowledge and ability. Then the mathematics performance of the learners will improve.

7. Recommendations

This paper showed that the mathematical content knowledge of the student teachers at the entry-level is at a moderate level, and the level of understanding was low. Therefore, this paper recommends that with the assistance of teacher educators in HEIs, student teachers must gain a thorough understanding of the mathematics curriculum. Furthermore, the mathematics appropriate to the grade level and mathematical courses that the student teachers are responsible for teaching should be known and well understood. This study also recommends that only those students who have attained substantial achievement in mathematics should be allowed to study FET mathematics at higher education institutions. HEI should consider those students who have applied for teaching as their 1st option rather than their last option as an entry requirement. Stricter entry-level to FET teaching programmes should be implemented at HEIs, such as good mathematics attainment levels in the matriculation examination. Finally, every university should build into their entry-level programme a 'Baseline assessment' for all students intending to study towards teaching mathematics in the FET phase.

8. Implications and contribution of the study

In conclusion, the authors believe that teachers with a low entry-level and a low level of understanding will have poor content knowledge of mathematics. As a result, there will be ineffective classroom teaching and poor mathematics performance in secondary schools. Therefore, for learner performance improvement, HEIs and the Department of Higher Education and Training (DHET) should ensure that student teachers have a solid entry-level level of understanding of the mathematics curriculum. Student teachers' entry level should be investigated for all educational system stages, including general education and training, further education and training, and higher education for future studies.

9. Limitations of the study

This research is confined to student teachers who enrolled in a FET mathematics teaching programme and came from poor, disadvantaged backgrounds. The majority of the student teachers had not experienced computer-assisted learning, which may have contributed to their performance in the baseline test.

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