

Exploring the Nature of the Gap between Secondary School Mathematics and First-Year University Mathematics: The Case of South Africa

Eric Machisi

Institute for Science & Technology Education, University of South Africa

Abstract: This study explored the mathematics knowledge gap between secondary school mathematics and first-year university mathematics. The study was prompted by the alarming statistics of mathematics, science and engineering students who are failing first-year university mathematics. This has resulted in low throughput and high attrition rates among the current cohorts of university entrants in South Africa. The study employed the documentary analysis research method to collect qualitative data to explain the research phenomenon. Data were collected from the secondary school mathematics Curriculum and Assessment Policy Statement (CAPS) for the Further Education and Training (FET) Phase, and from mathematics syllabi of the three top universities in South Africa. Results obtained revealed that the mathematics we currently teach in South African secondary schools is a very small portion of the range and depth of topics covered in first-year university mathematics major courses. The gap is so enormous that the majority of students will not survive the workload. The study concluded that South African secondary school mathematics in its current stature does not serve its intended purpose of preparing students for higher education studies, particularly for prospective mathematics, science and engineering students. The researcher strongly recommends a transformation of the South African secondary education system to allow students to specialise in only three subjects that are directly linked to their future studies, at Grade 11 and 12 levels. This would make it possible to introduce at secondary school level essential topics such as integration, complex numbers, differential equations, vectors and matrices which are missing in the current South African mathematics curriculum.

Keywords: Secondary school mathematics, university mathematics, gap, major course, curriculum

1. Introduction

The current vision in secondary school mathematics education across many countries in the 21st century is to increase the number of students who qualify to enrol for studies in the fields of Science, Engineering and Technology (SET) at higher education institutions (HEIs). This is

intended to meet the demands of the global economy. Based on the statistics depicted in Figure 1, South Africa appears to be moving in the right direction towards realising its target of 450 000 SET students per year, by the year 2030 (see National Planning Commission, 2011a, p. 305).

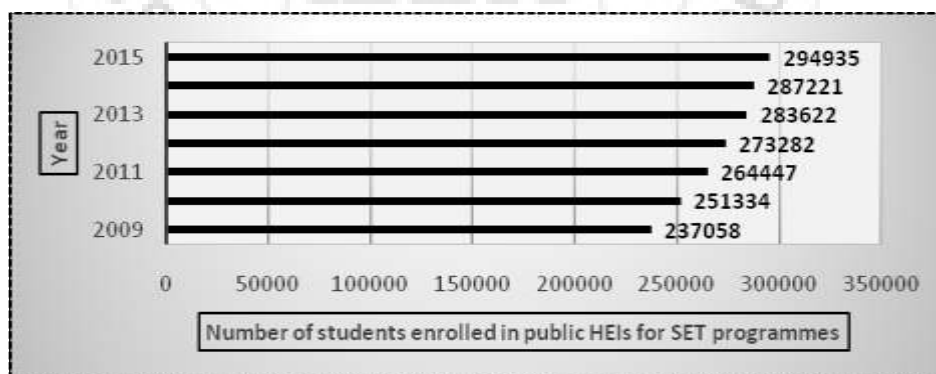


Figure 1: Number of students enrolled in HEIs for SET programmes (2009 to 2015)

[Adapted from Department of Higher Education and Training (2017, p. 11)]

While an upward trend in enrolment figures in the SET programmes is observed over the period 2009-2015, throughput rates “remain unacceptably low and below the benchmarks set in the National Plan for Higher Education” (National Planning Commission, 2011b, p. 274). According to a report by UFISA [User Centred Design for Innovative Services and Applications] (2017), only around 15% of South African university students graduate each year, which is far much below government’s benchmark of 25%. This is attested by the annual statistics on South African universities throughput rates released by the Department of Higher

Education and Training (DHET). The average graduation rates for undergraduate degrees in public HEIs for the years 2012, 2013, 2014 and 2015 were 15%, 15%, 16% and 17% respectively (DHET, 2014, p.14, 2015, p. 17, 2016, p. 17, 2017, p. 20). The graduation percentage is calculated as follows: $[\text{Number of graduates in a qualification in one year}] / (\text{Total enrolment in a qualification in one year}) \times 100$. This is considered to be a proxy for graduate throughput rate.

Low throughput rates could suggest that many of the students who enrol to study undergraduate degrees in South

African universities are either taking longer than regulated time to finish their studies or dropping out of university. The dropout rate is estimated to be between 50-60% (Areff, 2015). The highest failure rates are reportedly amongst students enrolled in mathematics, science and engineering programmes (see Marshall, 2010; Mtshali, 2013). It has been found that students seem to struggle with anything that has a mathematics component (see Mtshali, 2013) and the biggest hurdle appears to be in their first year of study. McDougall (2015), noted that the gap between matric and first-year university mathematics is so wide that 50% of first-year university students who got distinctions in matric mathematics are failing first-year university mathematics.

Several reasons can be drawn to explain the low graduation and high attrition rates in South African universities such as financial constraints, lack of academic preparedness and lack of student support from universities (Mtshali, 2013). However, the fact that students are coming to university "with low levels of mathematical understanding and abilities" is singled out as the biggest factor among students enrolled in the sciences programmes (Reddy, Reddy, & Nair, 2014, p. 167). Reddy, Reddy and Nair assert that the schooling system is dysfunctional because it excludes crucial mathematics topics required in the sciences "where problem solving, analytic and abstract thinking is the order of the day" (p. 167).

From the foregoing discussion, it is clear that there is a curriculum gap between secondary school and university mathematics which makes the transition from high school to university difficult, resulting in high failure and attrition rates and low throughputs. If many students take longer to graduate, it means we are spending more to produce one graduate and there is no room to admit new students into those programmes. Worse still when students drop out of university because the money invested on the students during their time at university will never be recovered. In addition, students who dropout of university are a burden to society since they are unemployable. Low throughput rates suggest that the country will continue to have a dearth of qualified personnel in the critical skills areas of the economy.

While we appreciate the efforts being made by universities to support students who come to university with learning deficits in mathematics by offering extra tuition and allowing them to register for extended programmes, the responsibility to curb the crisis cannot be left to universities alone. A concerted effort from both institutions (secondary school and university) is required in order to navigate the gap and make the transition from school-to-university smoother for our future mathematicians, engineers and scientists. A study conducted by the Council for Higher Education (CHE) and the South African Institute of Physics (SAIP) involving 20 South African universities led to the conclusion that the current secondary school mathematics is failing university entrants (Nkosi, 2013). According to the South African National Development Plan (NDP), Vision 2030, there should be a clear linkage between secondary schools and higher education institutions (HEIs) (National Planning Commission, 2011b). To realise this vision, we need to look into both curricula (secondary school

mathematics and first-year university mathematics) to identify and correct the deficiencies.

Several curriculum policy reforms have been implemented in South Africa since its independence in 1994. These include, Curriculum 2005 (C2005) introduced in 1997, Revised National Curriculum Statement (RNCS) in 2002, National Curriculum Statement (NCS) in 2007, and Curriculum and Assessment Policy Statement (CAPS) launched in 2012 (Adu & Ngibe, 2014). We appreciate the efforts made hitherto, in trying to address historical imbalances and increase learning opportunities for black students. However, the school-to-university transition problem for mathematics and science students remains unresolved and the gap appears to be getting wider (McDougall, 2015). The present study delineates and unravels the nature of the gap between secondary school and first-year university mathematics major courses for science and engineering students. The results of the study could help curriculum developers to align high school and university mathematics to ensure a smooth transition from school to varsity.

2. Theoretical Framework

The present study draws its foundations from the **needs assessment theory**. Needs assessment is an evolving theory derived from contributions by numerous researchers from different fields of study (such as psychology, education, and management). Its history dates back to the early twentieth century and the greatest contributor to the needs assessment theory in the context of education and curriculum development is American psychologist and educator, Professor Roger Kaufman (1944-2012). Kaufman wrote numerous books and articles on the theory (see Watkins, n.d.). A need in the context of the present study is defined as the gap between the current results and the desired results. The status quo in south Africa indicates a high failure rate in first-year university mathematics, high attrition and low graduation rates. Our desire is that all students registered in the science and engineering programmes at any university in South Africa pass their first-year university mathematics courses and progress to second year. They should neither drop out of university during their first-year of study nor take longer to graduate due to failing mathematics. If all registered mathematics, engineering, science and technology students graduate in regulated time, then the country will be able to curb the shortage of qualified workers in critical skills areas of the economy. It is undebatable that there is a need or gap between the current and the desired outcomes in South African mathematics education. A needs assessment is therefore warranted. Needs assessment is defined as the systematic process of determining the nature of the discrepancy or gap between the current condition and the desired condition with a view to improving current performance and correcting deficiencies (Kizlik, 2016). Fulgham and Shaughnessy (2008) add that it helps to clarify problems and identify appropriate remedial measures. Clear identification of the problem will enable us to channel our resources towards developing and implementing a feasible solution (Altschuld & Kumar, 2010). Needs assessment provides concrete evidence that can be used to determine the most effective means to achieve the desired results

(Kaufman, Rojas, & Mayer, 1993). It guides policy and programme decisions, including the design, implementation, and evaluation of policy and programmes that will lead to attaining the desired results (Watkins, West, & Visser, 2012).

3. Purpose of the Study

The purpose of the present study is to explore the nature of the gap between secondary school and university mathematics by making a comparison of the current secondary school mathematics curriculum (CAPS) and first-year university mathematics, based on 2017 universities syllabi. The ultimate intention, is to make recommendations to the curriculum developers on possible curriculum reforms to address the school-to-university mathematics transition problem.

4. Methodology

The present study utilized the documentary analysis research method. This is a form of qualitative research which entails examining and interpreting data from existing documents (printed or electronic), in order to elicit information about the phenomenon being investigated (Ahmed, 2010). The documents from which data were drawn are the Mathematics Curriculum and Assessment Policy Statement (CAPS) for the Further Education and Training (FET) Phase (Grades 10-12), University of the Witwatersrand Faculty of Science 2017 Rules and Syllabuses, University of the Witwatersrand Faculty of Engineering and the Built Environment 2017 Rules and Syllabuses, Stellenbosch University Faculty of Science Academic Programme and Faculty Information 2017, Stellenbosch University Faculty of Engineering Academic Programme and Faculty Information 2017, University of Cape Town Faculty of Engineering and the Built Environment (Undergraduate) Handbook 2017, and University of Cape Town Faculty of Science Handbook 2017. These universities were conveniently selected because

they were rated top three universities in South Africa (ARWU, 2017). In addition, their syllabi were found to be well outlined, detailed and easy to use purposes of this study. Documentary analysis was preferred ahead of other research methods because it is less time consuming and cost effective since data is readily available (Bowen, 2009). Data were analysed qualitatively by means of matching and identifying discrepancies between FET (Grades 10-12) mathematics and first-year university mathematics, with particular attention to topics and content coverage. The analysis was based on compulsory or major mathematics courses for students enrolled in science and engineering programmes.

5. Findings and Discussion

Mathematics in the Further Education and Training Phase (Grades 10-12) covers ten content areas. These are:

- Functions
 - Number Patterns, Sequences and Series
 - Finance, growth and decay
 - Algebra
 - Differential Calculus
 - Probability
 - Euclidean Geometry and Measurement
 - Analytical Geometry
 - Trigonometry
 - Statistics
- (Department of Basic Education, 2011, p. 9)

Each content area makes a contribution towards the acquisition of specific mathematical knowledge and skills. Now, let us look at the content specifications which clarify the concepts and skills that should be taught from Grade 10 to 12 for each content area. The information is depicted in Table 1:

Table 1: FET Mathematics Topics and Content Overview

1. FUNCTIONS			
Grade 10		Grade 11	
	Work with relationships between variables in terms of numerical, graphical, verbal and symbolic representations of functions and convert flexibly between these representations (tables, graphs, words and formulae). Include linear and some quadratic polynomial functions, exponential functions, some rational functions and trigonometric functions.		Extend Grade 10 work on the relationships between variables in terms of numerical, graphical, verbal and symbolic representations of functions and convert flexibly between these representations (tables, graphs, words and formulae). Include linear and quadratic polynomial functions, exponential functions, some rational functions and trigonometric functions
	Generate as many graphs as necessary, initially by means of point-by-point plotting, supported by available technology, to make and test conjectures and hence generalise the effect of the parameter which results in a vertical shift and that which results in a vertical stretch and/or a reflection about the x axis.		Generate as many graphs as necessary, initially by means of point-by-point plotting, supported by available technology, to make and test conjectures and hence generalise the effects of the parameter which results in a horizontal shift and that which results in a horizontal stretch and/or reflection about the y axis.
	Problem solving and graph work involving		Problem solving and graph work
			Introduce a more formal definition of a function and extend Grade 11 work on the relationships between variables in terms of numerical, graphical, verbal and symbolic representations of functions and convert flexibly between these representations (tables, graphs, words and formulae). Include linear, quadratic and some cubic polynomial functions, exponential and logarithmic functions, and some rational functions.
			The inverses of prescribed functions and beware of the fact that, in the case of many-to-one functions, the domain has to be restricted if their inverse is to be a function.
			Problem solving and graph work

	theprescribed functions.	involving the prescribed functions. Average gradient between two points.	involving the prescribed functions (including the logarithmic function).
2. NUMBER PATTERNS, SEQUENCES AND SERIES			
	Investigate number patterns leading to those where there is constant difference between consecutive terms, and the general term is therefore linear.	Investigate number patterns leading to those where there is a constant second difference between consecutive terms, and the general term is therefore quadratic.	Identify and solve problems involving number patterns that lead to arithmetic and geometric sequences and series, including infinite geometric series.
3. FINANCE, GROWTH AND DECAY			
	Use simple and compound growth formulae $A = P(1 + i.n)$ and $A = P(1 + i)^n$ to solve problems (including interest, hire purchase, inflation, population growth and other real-life problems).	Use simple and compound decay formulae $A = P(1 - i.n)$ and $A = P(1 - i)^n$ to solve problems (including straight line depreciation and depreciation on a reducing balance). Link to work on functions.	a) Calculate the value of n in the formulae: $A = P(1 + i)^n$ and $A = P(1 - i)^n$ (b) Apply knowledge of geometric series to solve annuity and bond repayment problems.
4. ALGEBRA			
	(a) Understand that real numbers can be irrational or rational	Take note that there exist numbers other than those on the real number line, the so-called non real numbers. It is possible to square certain non real numbers and obtain negative real numbers as answers. Nature of roots.	
	a) Simplify expressions using the laws of exponents for rational exponents. (b) Establish between which two integers a given simple surd lies. (c) Round real numbers to an appropriate degree of accuracy (to a given number of decimal digits).	(a) Apply the laws of exponents to expressions involving rational exponents. (b) Add, subtract, multiply and divide simple surds	Demonstrate an understanding of the definition of a logarithm and any laws needed to solve real life problems.
	Manipulate algebraic expressions by: • multiplying a binomial by a trinomial; • factorising trinomials; • factorising the difference and sums of two cubes; • factorising by grouping in pairs; and • simplifying, adding and subtracting algebraic fractions with denominators of cubes (limited to sum and difference of cubes).	Revise factorisation.	• Take note and understand, the Remainder and Factor Theorems for polynomials up to the third degree. • Factorise third-degree polynomials (including examples which require the Factor Theorem).
	Solve: • linear equations; • quadratic equations; • literal equations (changing the subject of a formula); • exponential equations; • linear inequalities; • system of linear equations; and • word problems.	Solve: • quadratic equations; • quadratic inequalities in one variable and interpret the solution graphically; and • equations in two unknowns, one of which is linear the other quadratic, algebraically or graphically.	
5. DIFFERENTIAL CALCULUS			
			a) An intuitive understanding of the concept of a limit. (b) Differentiation of specified functions from first principles. (c) Use of the specified rules of differentiation. (d) The equations of tangents to graphs. (e) The ability to sketch graphs of cubic functions. (f) Practical problems involving optimization and rates of change (including the calculus of motion).
6. PROBABILITY			
	(a) Compare the relative frequency of an experimental outcome with the theoretical probability of the outcome.	(a) Dependent and independent events. (b) Venn diagrams or contingency	(a) Generalisation of the fundamental counting principle. (b) Probability problems using the

<p>(b) Venn diagrams as an aid to solving probability problems. (c) Mutually exclusive events and complementary events. (d) The identity for any two events A and B: $P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$</p>	<p>tables and tree diagrams as aids to solving probability problems (where events are not necessarily independent).</p>	<p>fundamental counting principle.</p>
7. EUCLIDEAN GEOMETRY AND MEASUREMENT		
<p>a) Revise basic results established in earlier grades. (b) Investigate line segments joining the midpoints of two sides of a triangle. (c) Properties of special quadrilaterals.</p>	<p>(a) Investigate and prove theorems of the geometry of circles assuming results from earlier grades, together with one other result concerning tangents and radii of circles. (b) Solve circle geometry problems, providing reasons for statements when required. (c) Prove riders.</p>	<p>(a) Revise earlier (Grade 9) work on the necessary and sufficient conditions for polygons to be similar. (b) Prove (accepting results established in earlier grades):</p> <ul style="list-style-type: none"> • that a line drawn parallel to one side of a triangle divides the other two sides proportionally (and the Mid-Point Theorem as a special case of this theorem); • that equiangular triangles are similar; • that triangles with sides in proportion are similar; • the Pythagorean Theorem by similar triangles; and • riders
<p>Solve problems involving volume and surface area of solids studied in earlier grades as well as spheres, pyramids and cones and combinations of those objects.</p>	<p>Revise Grade 10 work.</p>	
8. TRIGONOMETRY		
<p>(a) Definitions of the trigonometric ratios $\sin \theta$, $\cos \theta$ and $\tan \theta$ in a right-angled triangle. (b) Extend the definitions of $\sin \theta$, $\cos \theta$ and $\tan \theta$ to $0^\circ \leq \theta \leq 360^\circ$. (c) Derive and use values of the trigonometric ratios (without using a calculator for the special angles $\theta \in \{0^\circ, 30^\circ, 45^\circ, 60^\circ, 90^\circ\}$) (d) Define the reciprocals of trigonometric ratios.</p>	<p>(a) Derive and use the identities: $\tan \theta = \frac{\sin \theta}{\cos \theta}$ and $\sin^2 \theta + \cos^2 \theta = 1$. (b) Derive the reduction formulae. (c) Determine the general solution and / or specific solutions of trigonometric equations. (d) Establish the sine, cosine and area rules.</p>	<p>Proof and use of the compound angle and double angle identities</p>
<p>Solve problems in two dimensions.</p>	<p>Solve problems in 2-dimensions.</p>	<p>Solve problems in two and three dimensions.</p>
9. ANALYTICAL GEOMETRY		
<p>Represent geometric figures in a Cartesian coordinate system, and derive and apply, for any two points $(x_1; y_1)$ and $(x_2; y_2)$, a formula for calculating:</p> <ul style="list-style-type: none"> • the distance between the two points; • the gradient of the line segment joining the points; • conditions for parallel and perpendicular lines; and • the co-ordinates of the mid-point of the line segment joining the points. 	<p>Use a Cartesian co-ordinate system to derive and apply:</p> <ul style="list-style-type: none"> • the equation of a line through two given points; • the equation of a line through one point and parallel or perpendicular to a given line; and • the inclination of a line. 	<p>Use a two-dimensional Cartesian co-ordinate system to derive and apply:</p> <ul style="list-style-type: none"> • the equation of a circle (any centre); and • the equation of a tangent to a circle at a given point on the circle.
10. STATISTICS		
<p>(a) Collect, organise and interpret univariate numerical data in order to determine:</p> <ul style="list-style-type: none"> • measures of central tendency; • five number summary; • box and whisker diagrams; and • measures of dispersion. 	<p>(a) Represent measures of central tendency and dispersion in univariate numerical data by:</p> <ul style="list-style-type: none"> • using o gives; and • calculating the variance and standard deviation of sets of data manually (for small sets of data) and using calculators (for larger sets of data) and 	<p>(a) Represent bivariate numerical data as a scatter plot and suggest intuitively and by simple investigation whether a linear, quadratic or exponential function would best fit the data. (b) Use a calculator to calculate the linear regression line which best fits a given set of</p>

	representing results graphically. (b) Represent Skewed data in box and whisker diagrams, and frequency polygons. Identify outliers	bivariate numerical data. (c) Use a calculator to calculate the correlation co-efficient of a set of bivariate numerical data and make relevant deductions.
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Source: Department of Basic Education (2011, p. 12-15)

From the information in Table 1, we can observe that all the content areas except *Differential Calculus*, are taught across the three grades (10,11 and 12) in the FET Phase. If we look closely at the content specifications per each content area, we see that in certain topics, the concepts and skills are similar across the grades. The difference lies in the level of difficulty. Thus, the curriculum is spiral in nature. Probability and Euclidean Geometry were introduced in 2012, to replace Linear Programming and Transformation Geometry respectively. It is envisaged that the FET mathematics curriculum will give learners “many opportunities to develop their mathematical reasoning and creative skills in preparation for more abstract mathematics in Higher/Tertiary Education institutions”(Department of Basic Education, 2011, p. 10). However, there are numerous

reports indicating that learners are coming to university underprepared (see Section I). This comes in the wake of a high failure rate in first-year university mathematics among students enrolled in engineering and science programmes across universities in South Africa. After going through the secondary school mathematics curriculum, the researcher then analysed the university first-year mathematics curriculum for science and engineering students. Figure 2 depicts the researcher’s findings from analysing faculty syllabi for science and engineering programmes at three South African universities (University of Witwatersrand [Wits], University of Cape Town [UCT] and Stellenbosch University):

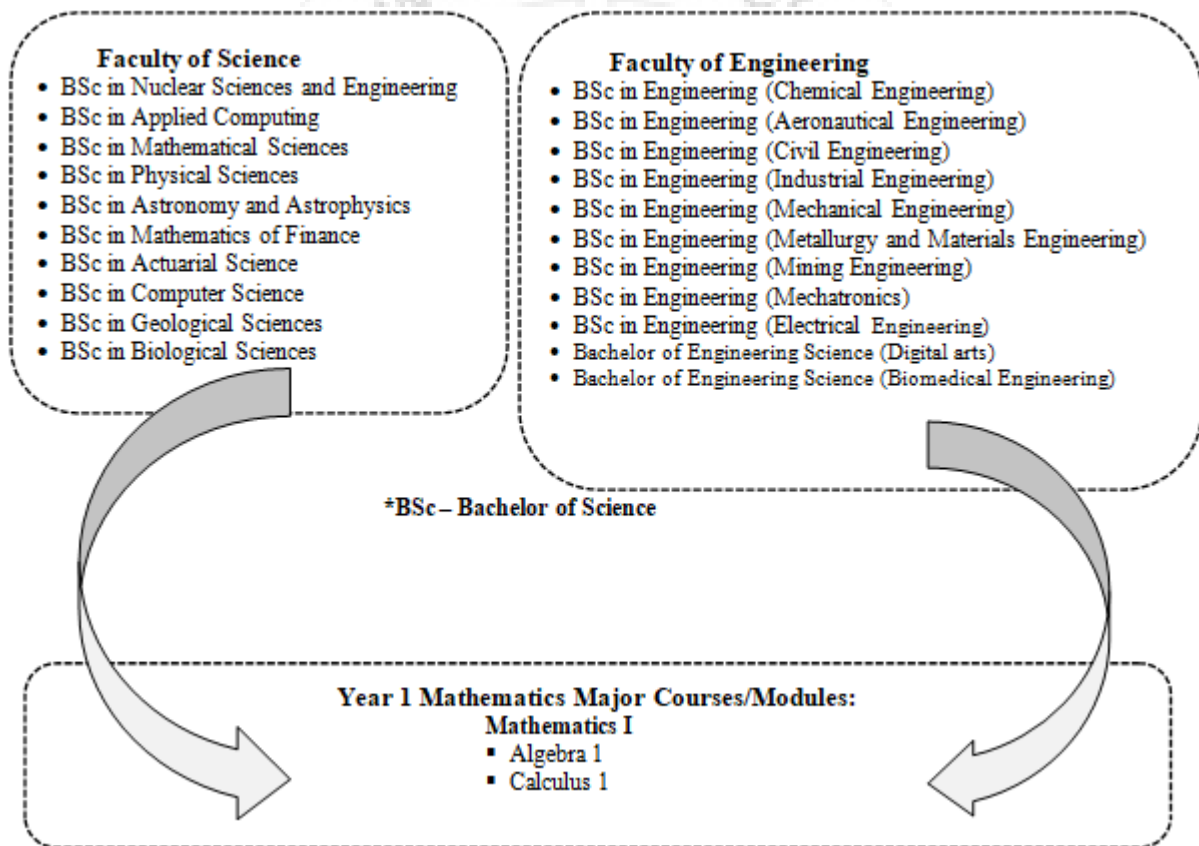


Figure 2: Science and Engineering Programmes With a Compulsory First-year Mathematics Component (Communications and Publications Unit, 2017a; Communications and Publications Unit, 2017b; Knoetze, 2017; Warnich, 2017; University of Cape Town, 2017a; University of Cape Town, 2017b)

Figure 2 indicates that all first-year students enrolled in the stated science and engineering degree programmes have to do **Mathematics I** which consists of two modules/courses: **Algebra 1** and **Calculus 1**. These modules are part of the compulsory (core courses/majors) that students are required to take in order to receive their degrees. Students who fail these two majors are not allowed to register for higher-level courses in which Algebra 1 and/or Calculus 1 are pre-

requisites. This may result in some students taking longer than regulated time to graduate and others may drop out due to lack of progress. Clearly, these are undesirable outcomes for the students and the nation at large.

Algebra and Calculus are part of the ten mathematics topic areas covered in the FET phase at secondary school. It is important to note here that the terms *Algebra* and *Calculus*

are broad. The Algebra and Calculus content specifications for the secondary school FET phase were displayed in Table

1 earlier in this paper. Let us now look at the content specifications for Algebra 1 and Calculus 1 at university:

Algebra 1 Course Outline:	Calculus 1 Course Outline:
<ul style="list-style-type: none"> • Real numbers • Proof by mathematical induction (PMI) • Series and polynomials (Binomial, Taylor, Maclaurin). • Inverse trigonometric functions • Polar coordinates and polar graphs • Conics • Vectors in 2 and 3 dimensions including equations of lines and planes • Linear equations and Gaussian elimination • Matrix algebra and determinants • Complex numbers 	<ul style="list-style-type: none"> • Functions, limits, continuity and differentiability • L'Hospital's rule • Rules for differentiation, applications to curve sketching, maxima and minima, and rates of change • Antiderivatives, techniques of integration, Riemann sums, the definite integral, applications to areas and volumes • Logarithmic and exponential functions. • Further techniques of integration, improper integrals • Partial differentiation • First order differential equations • Parametric equations, arc length and curved surface area

(Communications and Publications Unit, 2017a, p. 263; Communications and Publications Unit, 2017b, p. 222; Knoetze, 2017; University of Cape Town, 2017a, p. 161; University of Cape Town, 2017b, p. 122; Warnich, 2017, p. 162)

The Algebra 1 course aims to develop the deductive and logical skills of students whereas the Calculus 1 course aims to hone the analytical skill of students (see Communications and Publications Unit, 2017b). Similar intentions are

reflected in the secondary school curriculum (see Department of Basic Education, 2011). However, the focus of this paper is not on syllabus aims but rather on the issue of breadth and depth of the key content areas. The first-year university mathematics curriculum for science and engineering students values Algebra and Calculus more than the other content areas. A comparative analysis of the secondary school mathematics curriculum with university first-year mathematics content specifications for science students, yielded the results displayed in Table 2:

Table 2: Similarities and Differences Between Secondary School Mathematics and University First-year Mathematics for Science and Engineering Students

Mathematical Aspects Found in Both Curricula:	Mathematical Aspects Valued at University but Missing at Secondary School Level:
Real numbers Linear equations Functions, logarithmic and exponential functions Limits Rules of differentiation, curve sketching, maxima and minima, and rates of change Sequences and series	Proof by mathematical induction (PMI) Inverse trigonometric functions Polar coordinates and polar graphs The binomial theorem Conics Vectors in 2 and 3 dimensions including equations of lines and planes Gaussian elimination Matrix algebra and determinants Complex numbers Continuity and differentiability L'Hospital's rule Antiderivatives Techniques of integration Riemann sums The definite integral, applications to areas and volumes Further techniques of integration Improper integrals Taylor and Maclaurin series Partial differentiation First order differential equations Parametric equations, arc length and curved surface area

The results in Table 2 indicate that the mathematics content knowledge that the science and engineering students have from their several years in secondary school is a very small portion of the mathematics they are expected to learn in their first year. Students are coming to university unfamiliar with key mathematical aspects such as integration, complex numbers, vectors, differential equations, matrices, conics, polar coordinates, parametric equations and proof by mathematical induction. Clearly, the numerous reports indicating that students are coming to university

underprepared are justified (see for example, Mtshali, 2013; Nkosi, 2013; Reddy, Reddy, & Nair, 2014). The results explain why 50% of students who pass matric mathematics with distinctions are failing to cope with first-year university mathematics (see McDougall, 2015). Universities are trying their best to salvage the situation by offering extended degree programmes to help students catch up. However, the nature of the 'gap' demands efforts to be exerted from both ends.

6. Conclusion and Recommendations

While the current secondary school mathematics curriculum (based on CAPS) appears to cover a wide range of content areas, it lacks depth in critical content areas such as Algebra and Calculus and therefore does not adequately prepare science and engineering students for tertiary education. Many of the core aspects of Algebra and Calculus such as complex numbers, vectors, matrices, proof by mathematical induction, integration and differential equations are excluded from the present CAPS curriculum. This has resulted in so wide a gap between secondary school and university mathematics that has plunged many students into an abyss of failure. In order to bridge the gap between high school and university mathematics, I propose the following:

Transforming South African secondary school education system such that students specialise in only **three** subjects that are directly linked to what they intend to study at university or college, in their last two years of secondary school. Possible combinations for the Science Stream could be:

- Mathematics, Physics and Chemistry [MPC]
- Mathematics, Chemistry and Life Sciences [MCL]
- Mathematics, Physics and Information Technology [MPI]

This would make it possible to introduce into the secondary school mathematics curriculum the mathematical aspects that are valued at university such as **integration, differential equations, vectors, matrices, polar coordinates, complex numbers, parametric equations and proof by mathematical induction**. Such a curriculum would ensure a smooth transition between high school and university for science and engineering students, and reduce the high failure and attrition rates at university. The only challenge to implementing such a curriculum is teacher quality. More educators with bachelor of science degrees in Mathematics, Physics, Chemistry and Life Sciences will be required for such an endeavour to be successful.

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