ENSURING THE EXPERTISE TO GROW SOUTH AFRICA

ENGINEERING SKILLS PIPELINE

ENGINEERING COUNCIL OF SOUTH AFRICA
Tel: 011 607 9500 | Fax: 011 622 9295
Email: engineer@ecsa.co.za | Website: www.ecsa.co.za

ECSA

TABLE OF CONTENTS

EXECUTIVE SUMMARY

The engineering education system can be thought of as a pipeline. Of the many thousands of children who enter the schooling system in Grade One, only very few meet the thresholds necessary to continue their studies in engineering programmes and eventually be registered as engineering professionals. There is a significant loss of talented individuals along the way; leakage from the pipe.

This report attempts to quantify the pipeline of potential engineering professionals as they complete their schooling and progress to professional registration with the Engineering Council of South Africa (ECSA). **Figure 1** presents a high-level snapshot of the students moving through the different pipeline stages for the year 2020.

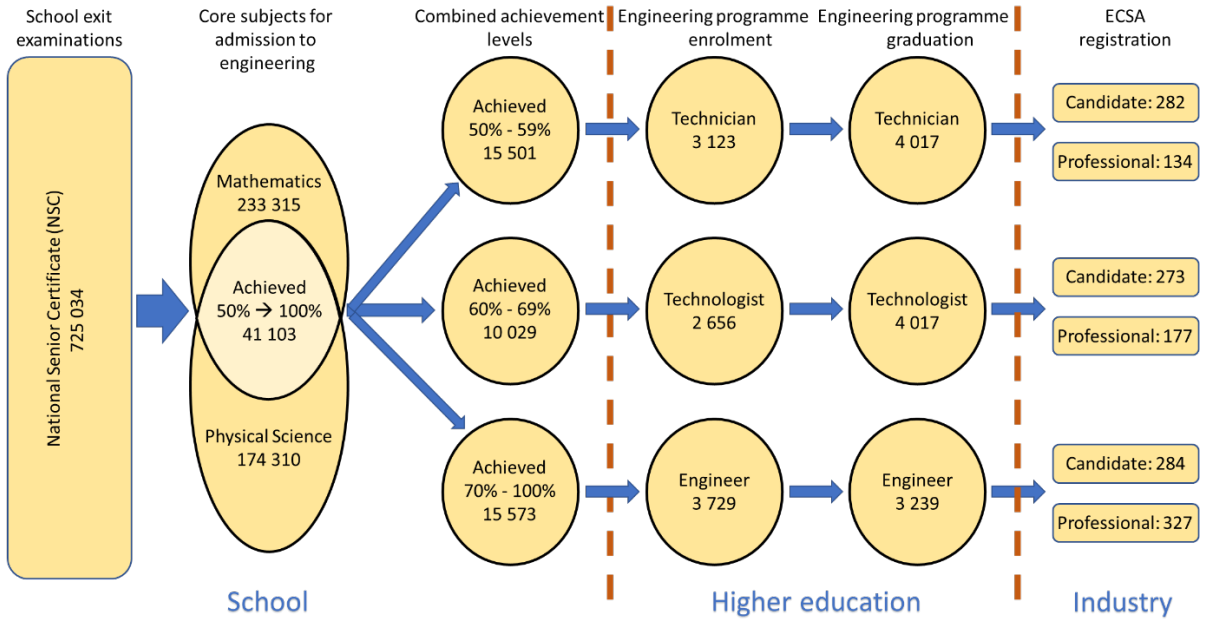

Figure 1: Summary of pipeline from school exit examinations to professional registration (2020)

A total of 725 034 students wrote their final National Senior Certificate (NSC) examinations in 2020. Only 20% of the 15 501 students were *eligible* for entrance to an engineering diploma qualification (having achieved Level 4, or 50%-59%) enrollment. 27% of eligible students enrolled in a technologist qualification, and 24% enrolled in an engineering degree qualification. While this may

appear a reasonable conversion of students into engineering education, it does mean that up to three-quarters of eligible students do not study engineering.

Only 1.6% of the number of students eligible to enter engineering qualifications achieved professional registration status in 2020. When one considers that this only increases to 6% when one only includes those students who enrolled in engineering programmes, the reality of the poor conversion rate to professional registration status is starkly highlighted.

The gazetting of the Identification of Engineering Work Regulations will impact the imperative for professional registration for all graduates that practise in the engineering fraternity, but this will not change what happens at the transition from school to university. Students who achieve qualifying grades for both Mathematics and Physical Science in their NSC examinations are eligible to enrol in many other qualifications. Given the importance of engineering to the future of the economy and thus the country, it is imperative that students are encouraged to pursue careers in engineering right through the pipeline.

DEFINITIONS

"Stage One" means A point in the professional or occupational development process in engineering at which a person fulfils the educational requirements to register as a candidate in the relevant category.

"Higher Education and Training Qualifications Sub-Framework (HEQSF)" means the Sub-Framework, of the NQF, for Higher Education that is developed and managed by the Council on Higher Education

ABBREVIATIONS

CESM Classification of Educational Subject Matter

ECSA Engineering Council of South Africa

DHET Department of Higher Education and Training

HEMIS Higher Education Management Information System

HEQSF Higher Education Qualification Sub-Framework

NRS New Registration System

NSC National Senior Certificate

NQF National Qualification Framework

LIST OF TABLES

LIST OF FIGURES

1. BACKGROUND

The pipeline for engineering consists of three distinct sections: Basic Education (Primary and High School), Higher Education (Technical and Vocational Education and Training colleges, Universities of Technology, and University) and Professional Registration with ECSA. Each section of the pipeline has an input and an output in terms of those capable/eligible to continue on the pathway to an engineering qualification, followed by admission as a candidate and then, finally, as a registered professional with ECSA. In keeping with the "pipeline" analogy, at each point along the pipeline, there are losses to the potential number of people available to become registered engineering professionals.

The educational pathways to professional registration are outlined in the Higher Education Qualifications Sub-Framework [1]. For this report, the traditional pathways to registration with the Engineering Council of South Africa (ECSA) as Professional Engineer, Professional Technologist and Professional Technician are analysed. The associated engineering degrees are Bachelor of Engineering, Bachelor of Engineering Technologist and Diploma in Engineering Technology, respectively. The other qualifications described in [1] that comprise the engineering qualifications described on the Higher Education Qualification Sub-Framework (HEQSF) are not considered.

A challenge with a project of this nature is that even if a person who enters primary school progresses through the pipeline in minimum time, for someone to be registered as a professional engineer (as an example), they would have started their educational journey at least 19 years ago – in 2003. Given that the throughput in engineering programmes is often very poor [2], with students regularly taking more than 50% longer to qualify, and the candidature phase of registration taking in excess of the minimum 3 years post-graduation, to follow a specific cohort through the pipeline would require focus on a cohort that started primary school in the mid-1990s. However, there have been significant educational changes across all sections of the educational pipeline over the past two decades, including, importantly, the recent rollout of the HEQSF qualifications in the University of Technology sector [3].

This project does not take a longitudinal, cohort-based approach to the analysis of the entire pipeline, but rather it looks at a snapshot of each section in turn. For each section of the pipeline, an entry cohort is analysed to understand the students' output from that section in terms of their eligibility to

continue to the next stage, while still on the pathway to professional registration. Each cohort is selected to ensure that, as far as possible, no students remain in that section of the pipeline.

2. INTRODUCTION

The Engineering Council of South Africa, through the Engineering Profession Act, 46 of 2000, is mandated with regulating the practice of engineering in South Africa. With the recent gazetting (Vol. 669, No. 44333, 26 March 2021) of the Identification of Engineering Work Regulations [4], the importance of engineering work being undertaken by registered professionals is becoming increasingly important.

To be eligible to register as an engineering professional, a person must have successfully completed a qualification at an ECSA accredited higher education institution and have demonstrated their competence in a variety of areas [5]. There are 16 higher education institutions in South Africa whose graduates meet the Stage One requirements [6] necessary for them to be eligible to be registered as engineering professionals once their industry training is complete. These institutions are listed below:

Traditional research universities

- University of Cape Town
- University of KwaZulu-Natal
- North West University
- University of Pretoria
- University of Stellenbosch
- University of the Witwatersrand

Universities of technology

- Cape Peninsula of Technology
- Central University of Technology
- Durban University of Technology
- University of South Africa
- Tshwane University of Technology
- Vaal University of Technology

- Walter Sisulu University
- Mangosuthu University of Technology

Comprehensive universities

- Nelson Mandela University
- University of Johannesburg

The accredited engineering programmes offered by these 16 higher education institutions can be found in ECSA's **E-20-PN** [7].

To enter one of the 16 higher education institutions, students need to achieve a certain threshold for the National Senior Certificate (NSC) subjects, Mathematics and Physical Science. Of the many thousands of children who enter the schooling system in Grade One, only very few meet the thresholds necessary to continue their studies in engineering.

This report looks to quantify the pipeline of potential engineering professionals as they complete their schooling and progress to professional registration in a category that corresponds to their qualification: DipEng graduates qualify to be Professional Technicians, BEngTech and BTech graduates qualify to be Professional Technologists and BEng graduates qualify to be Professional Engineers.

3. METHOD

As discussed earlier, two approaches can be adopted to understand the number of students/graduates/professionals making their way through the pipeline: longitudinal or cross-sectional studies [8]. In a longitudinal study, a specific cohort is tracked from the time students enter Grade One to the time some of those who make it through the pipeline successfully register as engineering professionals. Cross-sectional analysis "produces a 'snapshot' of a population at a particular point in time" [8, p.213]. Given that the length of the pipeline from Grade One to registration as a professional engineer can be up to 20 years and that in 2013 a new higher education qualification framework was introduced [3], a cross-sectional analysis of the available data was undertaken for the year 2020.

Universities of Technology are in the process of phasing out the legacy NATED 151 qualifications and phasing in the new HEQSF-aligned qualifications, with 2019 being the first year in which the

NATED 151 qualifications were not offered (and only being 'taught out'). As such, and to ensure that this was a forward-looking "prospective enquiry" [8, p.213], data from 2020 were analysed.

3.1 Sources of school data

Each year, the Department of Basic Education publishes a diagnostic report that analyses in detail the performance and outcomes of various subjects in the NSC examinations. The 2020 report [9] includes full details of those who wrote the NSC examinations, including success thresholds for those completing Mathematics and Physical Science.

3.2 Sources of higher education data

The Department of Higher Education and Training's (DHET's) Higher Education Management Information System (HEMIS) brings together audited enrolment and graduation data from each higher education institution. This data is made available as a series of tables with programmes clustered by Classification of Educational Subject Matter (CESM) categories. Engineering falls into CESM 08. The following tables, which contain the most recently audited data, were drawn on for this report:

- 2020 Table 2.12 for all institutions to 2nd order CESM
- 2020 Table 2.13 for all institutions to 2nd order CESM.

HEMIS Table 2.12 contains enrolment data for 2020 and HEMIS Table 2.13 contains graduation data for 2020.

Additional data was sourced from an Education Researcher at the Department of Basic Education [10], who analysed the raw NSC micro-data and calculated the intersection between Mathematics and Physical Science results, as shown in **Figure 1**.

3.3 Sources of registered candidate and professional data

ECSA's data of those admitted as candidates and those who registered as professionals in the year 2020 was made available for analysis.

4. ANALYSIS AND RESULTS

To better understand the pipeline and recognise that technicians, technologists and engineers require different NSC results in Mathematics and Physical Science for entrance into higher education, it is important to define entry-level thresholds for the different qualifications. An investigation was undertaken into the admission requirements for various engineering qualifications at the higher education institutions described in the Introduction. Through this analysis, the following thresholds for Mathematics and Physical Science were determined for admission:

- Diploma in Engineering: NSC Level of performance 4 (50–59%)
- Bachelor of Engineering Technology: NSC Level of performance 5 (60–69%)
- Bachelor of Engineering: NSC Level of performance 6 (70–79%) or higher.

Drawing on these admission thresholds, the Department of Basic Education's diagnostic report for 2020 was used to gather data related to students' success in Mathematics and Physical Science in each of these categories.

4.1 School education

Arising from the analysis undertaken of the DBE's diagnostic data, the following results emerge.

The number of candidates who wrote the October/November 2020 NSC examination was 607 226 full-time candidates and 117 808 part-time candidates, with a total of 725 034 candidates, as shown in **Table 1**.

Table 1: NSC achievement in Mathematics and Physical Science in 2020

	Mathematics	Physical Science
Number who wrote	233 315	174 310
Achieved 40–49%	30 935	28 117
Achieved 50–59%	21 355	19 267
Achieved 60–69%	14 209	12 502
Achieved 70–79%	9 226	7 768
Achieved 80–100%	14 755	11 377

The Department of Basic Education [10] analysed the raw NSC micro-data and provided statistics of students who had achieved 50–59%, 60–69% and 70–100% for both Mathematics and Physical Science. These ranges align with the admission requirements for Diploma (row 1), Technologist (row 2), and Engineer (row 3) programmes as shown in **Table 2**.

Table 2: NSC achievement in both Mathematics and Physical Science in all schools in 2020

	Mathematics and Physical Science
Achieved 50–59%	15 501
Achieved 60–69%	10 029
Achieved 70–100%	15 573

4.2 Higher education

The following results emerge from the analysis undertaken of the HEMIS data for each institution that offers engineering programmes. **Table 3** presents the number of students who entered engineering institutions directly from the school. This data is broken down by the standard HEMIS programme descriptors. For this analysis, Technologist Programmes are considered a combination of “1st BACH DEG (3YRS)”, the Bachelor of Engineering Technology, and “B TECH (1 YR)”, the Bachelor of Technology (a legacy qualification). **Table 4** describes total student enrolment, similarly broken down, while **Table 5** presents engineering student graduation data for 2020. The data is summarised in **Table 6**.

Table 3: First-time entering (FEN) student intake in 2020 per institution

	Diploma	Technologist	BTech	Engineer
HEMIS Description	***UG DIP / CERT (3 YRS)***	***1ST BACH DEG (3YRS)***	***B TECH (1 YR)***	***1ST BACH DEG (4YRS OR MORE NQF 8)***
CPUT	723	181	0	0
UCT	0	0	0	420
CUT	76	201	0	0
DUT	94	748	0	0
UJ	0	860	0	321
UKZN	0	0	0	379
NMU	0	206	0	87
NWU	0	0	0	311

	Diploma	Technologist	BTech	Engineer
HEMIS Description	***UG DIP / CERT (3 YRS)***	***1ST BACH DEG (3YRS)***	***B TECH (1 YR)***	***1ST BACH DEG (4YRS OR MORE NQF 8)***
UP	0	0	0	837
UNISA	202	0	0	0
US	0	0	0	646
TUT	111	460	0	0
VUT	724	0	0	0
WSU	246	0	0	0
WITS	0	0	0	728
MUT	947	0	0	0
Totals	**3 123**	**2 656**	**0**	**3 729**

Table 4: Engineering student enrolment in 2020 per institution

	Diploma	Technologist	BTech	Engineer
HEMIS Description	***UG DIP / CERT (3 YRS)***	***1ST BACH DEG (3YRS)***	***B TECH (1 YR)***	***1ST BACH DEG (4YRS OR MORE NQF 8)***
CPUT	3 689	433	538	0
UCT	0	0	0	2 469
CUT	910	581	373	0
DUT	990	2 001	1 755	0
UJ	370	2 923	338	1 393
UKZN	0	0	0	2 071
NMU	359	799	361	386
NWU	0	0	0	1 434
UP	0	0	0	5 070
UNISA	4 560	291	2 188	0
US	0	0	0	2 779
TUT	3 491	1 319	2 145	0
VUT	5 266	0	506	0
WSU	1 830	0	196	0

	Diploma	Technologist	BTech	Engineer
HEMIS Description	***UG DIP / CERT (3 YRS)***	***1ST BACH DEG (3YRS)***	***B TECH (1 YR)***	***1ST BACH DEG (4YRS OR MORE NQF 8)***
WITS	0	0	0	4 093
MUT	5 036	0	37	0
Totals	**26 501**	**8 347**	**8 437**	**19 695**

Table 5: Engineering student graduation in 2020 per institution

	Diploma	Technologist	BTech	Engineer
HEMIS Description	***UG DIP / CERT (3 YRS)***	***1ST BACH DEG (3YRS)***	***B TECH (1 YR)***	***1ST BACH DEG (4YRS OR MORE NQF 8)***
CPUT	641	0	327	0
UCT	0	0	0	554
CUT	245	11	254	0
DUT	477	110	746	0
UJ	226	323	300	178
UKZN	0	0	0	277
NMU	152	43	112	25
NWU	0	0	0	225
UP	0	0	0	837
UNISA	287	23	721	0
US	0	0	0	540
TUT	731	17	638	0
VUT	405	0	261	0
WSU	206	0	108	0
WITS	0	0	0	603
MUT	648	0	25	0
Totals	**4 017**	**526**	**3 491**	**3 239**

Table 6: Summary of 2020 university intake, enrolment and graduation statistics per qualification

	Intake	Total enrolment	Graduation
Diploma Eng	3 123	26 501	4 017
BEngTech+BTech	2 656	16 784	4 017
BEng	3 729	19 695	3 239

4.3 Candidate and professional registration

Arising from the analysis ECSA's candidate and professional registration data for 2020, the following results emerge, as shown in **Table 7**.

Table 7: ECSA registration of candidates and professionals in 2020

	Candidate	Professional registration
Technician	282	134
Technologist	273	177
Engineer	284	327
Total	**846**	**640**

5. DISCUSSION

In total, 725 034 students wrote their final NSC examinations in 2020. Of these, 174 310 wrote Physical Science and 233 315 wrote Mathematics. Of the students who wrote both Mathematics and Physical Science, only 41 103 achieved grades greater than 50% (greater than Level 4, the minimum threshold for entry to engineering education). This is significantly fewer than the number of students who sat these examinations. **Figure 1** illustrates the limited progression of students from school into tertiary engineering education and then further to final professional registration.

Low participation rates in higher education have previously been identified by Scott et al. [2], who argue that South Africa's 15% overall participation rate is significantly lower than the 20% "benchmark for countries at a comparable level of economic development" [2, p.10]. Drawing on **Table 2** and **Table 6**, one sees that 20% of the 15 501 students *eligible* for entrance into an engineering diploma qualification enrolled (having achieved Level 4 or 50–59%), while 27% of eligible students enrolled in a technologist qualification and 24% in an engineering degree

qualification. While this may appear a reasonable conversion of students into engineering education, it means that up to 75% of eligible students do not study engineering. While many of these students enrol in alternative qualifications, the question is whether engineering is broadly seen as a legitimate career option for all.

With no more enrolment possible into NATED 151 qualifications and the new HEQSF-aligned qualifications not fully rolled out and available across all institutions, it is challenging to draw inferences about the efficiency of student throughput. Data in **Table 1** and **Table 6** suggests that more students graduated from Diploma and Technologist programmes than entered – possibly related to this qualification transition. **Table 6** also suggests that slightly fewer Engineering students qualify than were admitted. This is a typically indicative level given that the BEng programmes have largely reached a steady state, while the new HEQSF programmes are still in a transition phase, with the non-HEQSF-aligned NATED-151 programmes no longer accepting students.

Scott et al. [2] used 2000 HEMIS cohort data to show that engineering programme completion rates were very poor. They describe the BEng programmes (which they refer to as “highly selective” programmes) as having only 54% of students graduating within 5 years and 19% of students still registered after 5 years. Considering the Bachelor of Engineering data in **Table 6**, a 4-year qualification enrolling 3 729 students per year and a total enrolment of 19 695 suggests that the students are in the system for more than five years. This aligns with Scott et al.’s 2000 cohort analysis data, suggesting that not much progress has been made over the past 15 years.

It is evident from **Table 6** that many graduates who meet the Stage One requirements necessary for professional registration do not ultimately get registered. **Figure 1** provides a representation of this attrition. Assuming a steady state in the pipeline (which has been argued earlier is not yet the case), there are currently only 640 newly registered professionals out of more than 10 000 possible – less than 6%. The Mail and Guardian newspaper [11] has highlighted that South Arica has a dire need for engineering professionals to “foster development on the continent”. The currently very limited conversion rate of engineering graduates to registered professionals directly impacts South Africa’s development, especially bearing in mind the gazetting of the Identification of Engineering Work Regulations, which requires that everyone participating in engineering work be professionally registered.

6. CONCLUSION

While not strictly accurate, particularly given the transition into the new HEQSF-aligned qualifications, one can consider this a steady-state educational system. The results and discussion make it clear that there is significant potential to increase the number of registered professionals. In considering a snapshot of 2020, only 1.6% of the students eligible to enter engineering qualifications achieved professional registration status in 2020. When one considers that this only increases to 6% when including those students who actually enrolled in engineering programmes, the reality of the poor conversion rate to professional registration is starkly highlighted. It is possible that the change in the process of registration from the “legacy system” to the “New Registration System” (NRS) has played a role in limiting growth in the number of professional registrations and anecdotal evidence suggests that engineering mentors and others in the competency development chain are not fully versed in the updated requirements of the NRS.

The gazetting of the Identification of Engineering Work Regulations will impact the imperative for professional registration but will not change what happens at the transition from school to university. Students who achieve qualifying grades for Mathematics and Physical Science in their NSC examinations are eligible to enrol in many other qualifications. Given the importance of engineering to the future of the economy and thus the country, it is imperative that right through the pipeline, students are encouraged to pursue careers in engineering.

REFERENCES

1. Engineering Council of South Africa, *Engineering Qualifications in the Higher* Education *Qualifications Sub-framework, E-23-P, Revision 1*. 2019.
2. Scott, I., N. Yeld, and J. Hendry, *Higher education monitor: A case for improving teaching and learning in South African higher education*. 2007: Council on Higher Education Pretoria.
3. Department of Higher Education and Training, *Higher Education Qualifications Sub-Framework*, Department of Education, Editor. 2013, Government Gazette: Pretoria.
4. Engineering Council of South Africa, *Identification of engineering work regulations*. 2021.
5. Engineering Council of South Africa, *Policy on Registration in Professional Categories, R-01-POL-PC, Revision 3*. 2020.
6. Engineering Council of South Africa, *Training and Mentoring Guide for Professional Categories, R-04-T&M-GUIDE-PC, Revision 3*. 2021.
7. Engineering Council of South Africa, *Degrees Diplomas as Meeting the Educational Requirement for Registration as a Candidate or Professional Engineering Technician, E-20-PN, REVISION 33: 02 December 2021*. 2021.
8. Cohen, L., L. Manion, and K. Morrison, *Research methods in education*. 6th ed. 2007, London; New York: Routledge. xviii, 638 p.
9. Department of Basic Education (DBE), *National Senior Certificate 2020 Diagnostic Report Part 1: Content Subjects*, Department of Basic Education (DBE), Editor. 2021, Department of Basic Education (DBE),: Pretoria.
10. Taylor, A., *Raw NSC micro-data and the intersection between Mathematics and Physical Science*, B.I. Collier-Reed, Editor. 2022.
11. Staff Reporter, *South Africa urgently requires engineers for development*, in *Mail and Guardian*. 17 March 2017.

	Revision Date	Revision Details	Approved By
Draft A	1 April 2021	A complete report from the Research Business Unit	MB Mtshali
Draft B	4 April 2021	Customization to ECSA format and preparation for approval by RPSC	MB Mtshali
Rev. 0	12 April 2022	Consideration and approval	RPSC
Rev. 0	23 June 2022	Consideration and approval	Council

Research report on Engineering Skills Pipeline

Revision 0, dated 12 April 2022, consisting of 20 pages, was reviewed for adequacy by the Business Unit Manager and approved by the Acting Executive: Research, Policy and Standards **(RPS)**.

2022/07/19

Business Unit Manager

Date

2022/07/20

Acting Executive: RPS

Date

This definitive version of this research report is available on our website.