

Engineering Council of South Africa

Position Paper

Implementing Engineering Qualifications under the HEQF

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Summary

Engineering professionals are essential in a modern society and their education, training, experience and professional competency must be at an acceptable level. Engineering education qualifications must satisfy professional requirements. They are higher education qualifications and are therefore subject to prevailing higher education policy. The Higher Education Qualifications Framework (HEQF) was promulgated by the South African Government as the ruling policy on qualifications types and structures. This paper gives guidance on structuring engineering qualifications within the HEQF. The main recommendations are as follows:

- For persons aspiring to register as Professional Engineers, the existing BEng-type programme will continue. Existing three year degrees designed to articulate into the BEng are recognised.
- For persons aspiring to register as Professional Engineering Technologists, dedicated three year bachelors degrees are proposed, decoupling technologist from technician education.
- For persons aspiring to register as Professional Engineering Technicians, two educational routes are proposed. The primary route is via the Higher and Advanced Certificates, with the current practical component deferred until industry training.
- It is indicated that the Certificated Engineer education model is likely to change and proposals for further investigation are given.

The report identifies a number of items that require further investigation.

1 Background and Purpose of Position Paper

Engineering is an activity and a profession that serves the economy, society and people. It does so by the purposeful application of engineering sciences, technology and techniques to achieve predicted and effective solutions, using available resources efficiently, and managing risks. Engineering is carried out by practitioners performing distinct roles as evidenced by the categories of registration defined in the Engineering Profession Act of 2000:

- Professional Engineer;
- Professional Engineering Technologist;
- Professional Certificated Engineer;
- Professional Engineering Technician.

The engineer, engineering technologist and engineering technician registration and education models conform to practice in many countries. Occupational health and safety legislation in South Africa requires that certain functions in mines and manufacturing as well as on merchant shipping must be performed by a holder of a Government Certificated of Competency (GCC). Holders are known as certificated engineers and those with responsible experience may register as Professional Certificated Engineers.

The normal mode of development of an engineering practitioner involves the attainment of an educational qualification, completion of a programme of training and experience to the level where he/she can demonstrate the competence required for registration. ECSA accredits higher education programmes that meet the educational requirements for a category of registration as shown in Table 1.

Table 1: Current engineering higher education qualifications

Category of Registration	Higher Education Qualification Type
Professional Engineer	BEng, BSc(Eng), BIng
Professional Engineering Technologist	BTech, in an engineering discipline
Professional Engineering Technicians	National Diploma (ND), in an engineering discipline
Professional Certificated Engineers	Education requirements specified for entry to GCC Examination (not accredited by ECSA)

The BEng-type of programme, while it has changed over time to meet evolving accreditation criteria, is a well established and stable qualification serving the engineer category. Technology qualifications, that is, those serving the technician and technologist categories, have undergone several changes over time, the ND and BTech being products of the last decade, as detailed in Appendix 1.

In October 2007, the Department of Education published policy under the Higher Education Act that defines the Higher Education Qualification Framework (HEQF) [1]. The HEQF defines:

- The framework for higher education qualifications as an integral part of the National Qualifications Framework (NQF).
- A set of *qualification types*, their NQF level, credits at exit level and total credits, naming conventions, the broad purpose and characteristics and progression paths.

New qualifications introduced from 2009 must conform to the framework. Existing qualifications must "... conform over time ...". The timescale is undefined at present but is understood to be long.

As indicated below, the present BTech and ND technology qualifications do not map seamlessly onto the new qualification types and therefore require consideration. A new model for Certificated Engineers has been proposed and creates new requirements for their education.

This paper records the position of ECSA on engineering higher education qualifications that are relevant to the practice of engineering. The objectives are twofold:

- To create an understanding of the common characteristics of the educational qualifications for each category of registration within the HEQF. More detailed

requirements are contained in qualification standards registered on the NQF. Existing standards that require modification are identified.

- To inform the Department of Education and the Council for Higher Education of the way that engineering higher education qualifications will be implemented within the HEQF with a view to smoothing the approval and accreditation of new programmes, and the transition of existing programmes to new programme types.

This position paper is mainly about the structure and building blocks of engineering higher education. There are serious concerns currently about the shortage of graduates from engineering higher education programmes. This is not simply a problem of numbers but also of the proportions of engineers, technologists and technicians. The model proposed below for engineering technology education is evaluated against this requirement in Section 11.

2 The Higher Education Qualifications Framework

The HEQF is described in detail in the policy document [1]. It is nevertheless helpful to extract and summarise key information.

The HEQF is part of a 10-level NQF, spanning levels 5 to 10; levels 1-4 remain as currently defined. Level descriptors are referred to in the HEQF policy document but have not been promulgated. ECSA therefore uses a contextualised form of draft level descriptors published previously for the HEQF [2].

The HEQF permits nine qualification types with main characteristics summarised in Table 2.

Table 2: Qualification Types permitted within the HEQF

Qualification Type and Exit Level	Credits: Total and per NQF Level						
	Minima except where shown (\leq), Bold = Exit Level						
	Total	5	6	7	8	9	10
Higher Certificate (L5)	120	120					
Advanced Certificate (L6)	120		120				
Diploma (L6)	360	≤ 120	120	60			
Advanced Diploma (L7)	120			120			
Bachelor's Degree (L7)	360	≤ 96		120			
"Professional" Bachelor's (L8)	480	≤ 96		120	96		
Bachelor Honours Degree (L8)	120				120		
Postgraduate Diploma (L8)	120				120		
Masters Degree (L9)	180					120	
Doctoral Degree (L10)	360						360

The qualification types, together with entry requirements and indicated progression possibilities, gives a structure to the framework in terms of the qualification types. Figure 1 depicts this structure with the main pathways shown. The exit levels and required credits are shown in boldface.

The Higher Certificate, Diploma and the two forms of Bachelor's Degree provide entry from level 4. The legal minimum admission requirement is a National Senior Certificate, with specified subjects and levels. Applicants with other qualifications may be admitted if judged equivalent by "designated equivalence-setting bodies". The HEQF places the right and responsibility of admission on the provider of the programme who must ensure that the entrant has the required competence to enter the programme

3 Engineer Qualifications

The normal or benchmark route to registration as a Professional Engineer requires the completion of a BEng-type degree, followed by at least three years of training and experience before applying for registration. The implications of the HEQF for engineer qualifications are examined below.

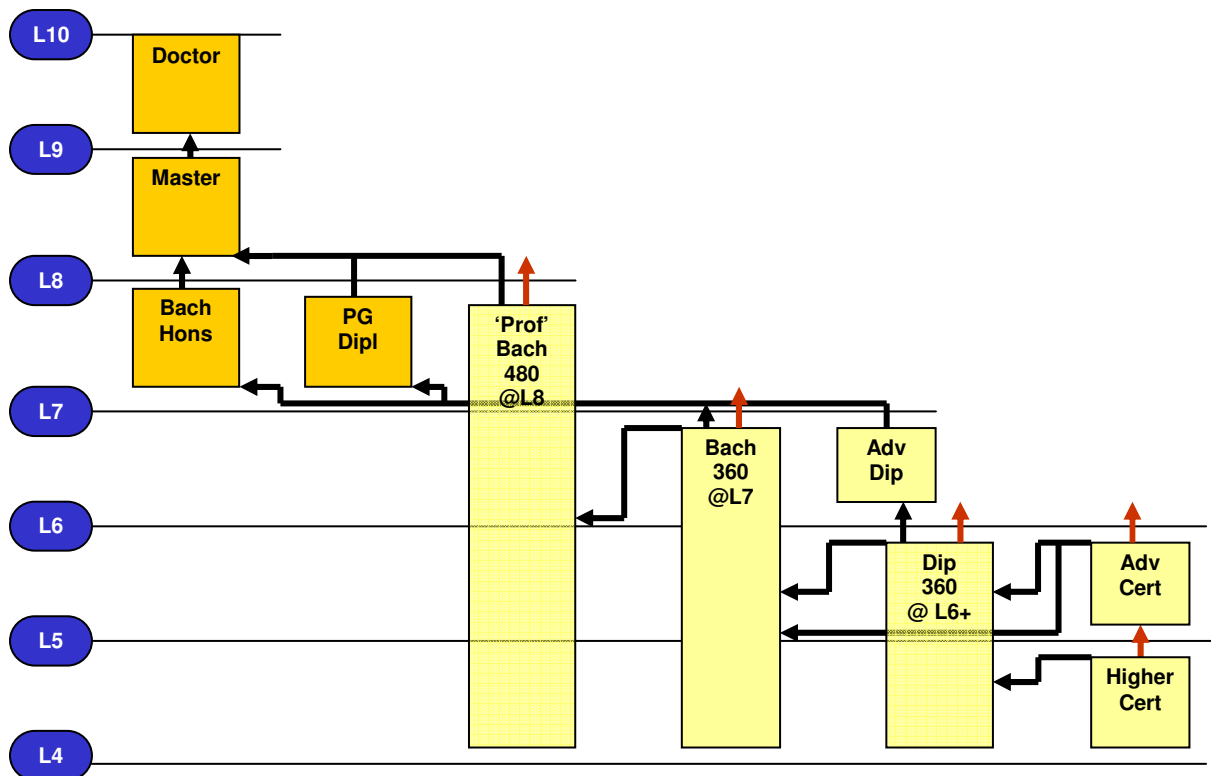


Figure 1: Structure of the HEQF showing progression paths

3.1 The Bachelor of Engineering as a Professional Bachelors Degree

The currently accredited bachelors degree is titled BEng, BSc(Eng) or BIng and is required [4] to have a minimum total of 560 credits with at least 120 credits at the new level 8¹. The purpose of the BEng-type programme is extracted from the standard in Table 3, together with the baseline of credits in defined knowledge areas. Existing programmes have little level 5 material. This type of programme conforms to the HEQF purpose and characteristics statements, having the higher volume of learning and increased cognitive demand than the level 7 bachelor's degree.

The naming conventions accommodate the BEng form of degree title, for example:

Bachelor of Engineering in Chemical Engineering, abbreviated BEng(Chemical Engineering)

The form Bachelor of Science in Engineering in Chemical Engineering is problematic as the second element, the designator (of Science), is expected to be specific. Also, this form relegates Engineering to be a subset of Science. It is likely that this form will have to migrate to the BEng form in due course.

3.2 An Emerging Model: Three plus two

A number of providers of the BEng-type degree also offer a three year bachelor's degree that *serves an identified purpose in its own right* and also allows the holder to complete an accredited BEng degree in two further years of study. These programmes were put forward for approval at various times prior to the current candidacy phase² accreditation system of the Council for Higher Education. Interest exists in proposing further programmes of this type. It is therefore advisable to have guidelines on this general type of programme, to ensure consistency and smooth the SAQA

¹ Existing level 7. The existing qualifications are registered on the 8-level framework. The ten-level system is used throughout this document.

² A higher education provider wishing to introduce a new programme must obtain candidacy phase accreditation from the Council for higher Education, essentially giving permission to offer the programme.

registration and CHE candidacy phase approval of these programmes. The following guidelines are proposed for these degrees:

1. The degree has the purpose defined in Table 3 and must, in terms of objective 2, have a defined area that provides definite opportunities for graduates;
2. The programme must have the intellectual rigour require for bachelor's degrees and must not provide an early exit for failing BEng students;
3. It must articulate with a cognate BEng and, where possible, with honours, other professional or comparable programmes;
4. Its exit level outcomes are a subset of the BEng outcomes, but pitched at level 7;
5. The content should have a suitable profile that emphasizes mathematical, basic science and engineering science fundamentals but allows study in another field.
6. A suitable title is Bachelor of Engineering Science in, abbreviated BEngSc(...).
7. The ESGB should define a generic standard for the BEngSc conforming to the above requirements.

An alternative way of constructing three + two programmes is to structure BSc programmes, for example in physics, chemistry, life sciences or computer science with sufficient relevant engineering content to enable graduates to complete a cognate BEng programme in two further years. The BSc programme must be useful in its own right. If such a programme is formally identified in the university rules, it could be recognized as a route to the BEng in the accreditation process for the BEng. Otherwise, students proceeding from BSc programmes would be treated on an individual basis, as at present.

4 Engineering Technology Qualifications

The current qualifications for technicians and technologists are the National Diploma and BTech respectively.

The National Diploma in engineering fields consists of four semesters of on-campus study, denoted S1 to S4 and two units of work integrated learning, identified as P1 and P2. The result is a three-year full time equivalent programme. The current programmes are constructed according to NATED 151 [5]. While an outcomes-based generic standard for the qualifications has been generated and registered, it has not been implemented by providers or in the accreditation process [6]. This standard however gives expression to the modern understanding of the exit level outcomes, level of achievement and content baseline that is appropriate for technician education. It was envisaged that the post-NATED qualification would have 360 credits in total with 120 credits at new level 6, thus exiting at level 6. It was envisaged that the programme would continue to contain work integrated learning that would contribute to the attainment of some of the exit level outcomes. The HEQF Diploma-type qualification exceeds these requirements, requiring 60 credits at level 7. In the absence of arguments that the level of technician education needs to be raised, alternative proposals are made in section 4.1.

The technologist is the most recent addition to the engineering team. The current educational requirement is a BTech in an engineering discipline. The BTech in turn requires a National Diploma as an entry requirement. As in the case of the ND, an outcomes-based standard had been generated and registered to take over from the NATED 151 specification. The resulting education would be 480 credits that would include the academic and work integrated learning from the diploma and would add 120 credits at new level 7. The HEQF does not provide for the attainment of a degree by means of a 120 credit programme on top of a diploma. A new form of technologist education is therefore proposed in section 4.2.

4.1 Engineering Technician Education

Two possibilities are favoured for the development of engineering technicians. The first is based on the disaggregation of the current national diploma into its academic component (S1 – S4) of at least 240 credits and the work integrated learning (WIL) component (P1 and P2). Responsibility for the

latter is shifted from the higher education providers to the employer/SETA sector. The HEQF-compliant proposal arising from this thinking is as follows:

1. The educational requirement under the HEQF is an Advanced Certificate (120 credits at level 6) that is built on a Higher Certificate (120 credits at Level 5).
2. The purpose of the qualification, extracted from the current registered standard, is given in Table 3, together with indicative credits.
3. The resulting 240 credits of education would culminate in the set of exit level outcomes similar to those currently defined in the registered qualification for the National Diploma. These outcomes require review to ensure consistency with other ECSA standards and international benchmarks.
4. No work-integrated learning is required in the educational phase.
5. The exit level outcomes need re-examination to ensure that requirements that can be fulfilled only by work integrated learning are removed from the standard.
6. The knowledge area credits require further work.
7. The ECSA Registration Committee Training Guidelines should recognise a new form of candidacy programme (probably a year longer than at present) that compensates for the absence of the work-integrated learning in the education phase.
8. The qualification will in terms of the HEQF naming rules be of the form:
Advanced Certificate in Electronic Engineering, abbreviated Adv. Cert. (Electronic Engineering)
There is no designator; the word Engineering should appear in the qualifier(s).

An alternate way of meeting the educational requirement for technicians is via a Diploma as defined in the HEQF. The Diploma would:

1. Meet the same exit level outcome and 240-credit knowledge baseline requirements as the combination of Higher and Advanced Certificates.
2. Include work-integrated learning (approximately 60 credits) that must be organised, assessed and quality assured by the educational provider.
3. It is recognised that the Diploma, with the requirements for 60 credits at level 7 will exceed the minimum requirements for technician education.
4. The Registration Committee Training Guidelines should recognise a candidacy programme as at present for persons proceeding from the Diploma.
5. The provider would be responsible for ensuring that every student who meets the prerequisite credits is placed in a work-based programme.
6. The qualification will in terms of the HEQF naming rules be of the form:
Diploma in Electronic Engineering, abbreviated Dip.(Electronic Engineering)
Diploma in Mining Engineering, abbreviated Dip.(Mining Engineering)
There is no designator; the word Engineering should appear in the qualifier(s).

This proposal would require that programmes leading to both the combination of the Higher and Advanced Certificates and the Diploma will have to be accredited by the ECSA's Technology Programme Accreditation Committee (TPAC).

4.2 Engineering Technologist Education

The technologist education development model should change to an education requirement of a three-year bachelors degree. This programme would have the following characteristics:

1. The total minimum credit is 360 with a minimum of 120 at NQF level 7.
2. The purpose of the qualification, extracted from the current registered standard, is given in Table 3, together with indicative credits.
3. The programme must have intellectual rigour required for bachelors programmes.
4. The title Bachelor of Engineering Technology (BEngTech) is proposed. (There was a plea to retain BTech but the designator "of Technology" is unspecific. The more specific form "of

Engineering Technology” is necessary under the HEQF rules. The nomenclature BEngTech is used in several Sydney Accord jurisdictions.)

5. The programme must satisfy the exit level outcomes already defined and registered [6]. The knowledge area credits will require re-specification within the 360 credit total. The exit level outcomes require review to ensure consistency with other ECSA standards and international benchmarks.
6. The programme will not incorporate work-integrated learning as comparison with the present system and international benchmarks suggests that the full 360 credits will be required for the academic programme.
7. The Registration Committee for Technologists may need to modify its Training Guidelines, including specifying the duration of the candidacy programme.

These new degree programmes will have to be accredited by the TPAC.

4.3 The Certificated Engineer

A new model has been suggested for the certificated engineer, that like the present system, will allow several educational pathways before entering the period of training and experience. The educational level is comparable with a technologist but with special requirements for legal knowledge and mine, plant operations or merchant shipping. A proposal was made in terms of the existing qualifications, namely the ND and BTech. Programmes could be accredited as meeting the generic technologist requirements and the specific knowledge required by certificated engineers. Attainment of such a BTech would meet the educational requirements to enter a training programme. The mining industry expressed the need to be able to admit trainees to training programmes after a National Diploma on the understanding that a further 120 credits of education would be provided (by an unspecified method) during the training programme.

With the HEQF impacting on the continued existence of the BTech and the change from ND to Diploma, the proposal for certificated engineer education requires revisiting. The following options should be investigated:

1. BEngTech programmes in Mining, Mechanical and Electrical Engineering could be structured to meet the generic level 7 outcomes and the specific knowledge requirements of the certificated engineer. The training programme would be extended to compensate for the absence of work integrated learning in the bachelors degree.
2. As an alternative to 1, Diploma programmes in Mining, Mechanical and Electrical Engineering could be structured to meet the generic levels 6 and 7 outcomes and the specific knowledge requirements of the certificated engineer. The candidate would complete WIL in the Diploma Programme. The graduate could then continue to an Advanced Diploma that would meet the remaining level 7 outcomes and content requirements.
3. The Advanced Diploma may also accommodate persons who have accredited BEngTech generic degrees in electrical or mechanical engineering to attain the specialised knowledge for certificated engineers.
4. An argument could be made that a person who has completed an accredited Advanced Diploma and the WIL is at the level to enter a programme as in 2. Such a person would have to satisfy the entry requirements to the Advanced Diploma by other means.

As in the past, the mining industry requires a pathway for persons who have qualified as artisans to be able to proceed to ultimately become certificated engineers. In addition to their trade, such persons will need Mathematics, Science and Language (English) at NSC or NCV level with symbols specified by the provider. A suitable Higher Diploma programme must be willing to admit the person. Thereafter, the person could proceed to an Advanced Diploma. The WIL component as in 3 is may be credited partly or wholly on the grounds of the artisan qualification.

Accreditation arrangements must be settled once the education model is resolved.

Table 3: Indicative comparison of Engineering qualification types

BEng-type		BEngSc- type programme		BEngTech-type Programme		Adv Cert-type Technician Programme	
Purpose - to build the necessary knowledge, understanding, abilities and skills required for further learning towards becoming a competent practicing engineer. Specifically, the qualification provides graduates with: 1. Preparation for careers in engineering itself and areas that potentially benefit from engineering skills, for achieving technical leadership and to make a contribution to the economy and national development; 2. The educational requirement towards registration as a Professional Engineer with ECSA. 3. For graduates with an appropriate level of achievement in the programme, the ability to proceed to postgraduate studies in both course-based and research masters programmes.		Purpose (Tentative) - to build the necessary knowledge, understanding, abilities and skills required for further learning towards becoming a specialist practitioner in a particular area. Specifically, the qualification provides graduates with: 1. A thorough grounding in mathematics, basic sciences, engineering sciences, and an identified specialist area; 2. Preparation for careers in niche engineering and related areas; 3. The ability to readily complete a cognate accredited Bachelors Degree in Engineering; 4. For graduates with an appropriate level of achievement in the programme, the ability to proceed to honours and other programmes for which this degree meets prerequisites.		Purpose - to build the necessary knowledge, understanding, abilities and skills required for further learning towards becoming a competent practicing engineering technologist. Specifically, the qualification provides graduates with: 1. Preparation for careers in engineering itself and areas that potentially benefit from engineering skills, for achieving technological proficiency and to make a contribution to the economy and national development; 2. The educational requirement towards registration as a Professional Engineering Technologist ECSA. 3. For graduates with an appropriate level of achievement, the ability to enter level 8 programmes and then proceed to masters degrees 4. For certificated engineers, achieving proficiency in mining/plant operations and occupational health and safety		Purpose - to build the necessary knowledge, understanding, abilities and skills required for further learning towards becoming a competent practicing engineering technician. Specifically, the qualification provides graduates with: 1. Preparation for careers in engineering itself and areas that potentially benefit from engineering skills, for achieving technical proficiency and to make a contribution to the economy and national development; 2. The educational requirement towards registration as a Professional Engineering Technician ECSA for entry to a candidacy programme with a preparatory component.	
Level Descriptors: Complex engineering problems		Level Descriptors: Subset of complex engineering problems		Level Descriptors: Broadly-defined engineering problems		Level Descriptors: Well-defined engineering problems	
Exit level 8 Credits		Exit level 7 Credits		Exit level 7 Credits		Exit level 6 Credits	
Total	560	Total	360	Total	360	Total	240
Mathematical Sciences	56	Mathematical Sciences	56	Mathematical Sciences	40	Mathematical Sciences	30
Basic Sciences	56	Basic Sciences	56	Basic Sciences	20	Basic Sciences	20
Engineering Sciences	168	Engineering Sciences	84	Engineering Sciences	120	Engineering Sciences	90
Engineering Design & Synthesis	67	Engineering Design & Synthesis	28	Engineering Design & Synthesis	50	Engineering Design & Synthesis	30
Computing and IT	17	Computing and IT	28	Computing and IT	30	Computing and IT	20
Complementary Studies	56	Complementary Studies	28	Complementary Studies	20	Complementary Studies	10
For redistribution	140	For redistribution	80	For redistribution	80	For redistribution	40

5 A note on Three-year Bachelors Degrees

Two forms of three-year bachelors degree, the BEngSc and BEngTEch, are proposed with the broad purposes and characteristics shown in Table 3. They are differentiated by their respective orientations, different outcomes and different content profiles. These details have still to be tested in the review of standards proposed by the Technology Qualifications Workshop.

The argument could be made that there should be only one three year degree that would serve the purposes of technologist education and would provide a route to the BEng degree. This proposal needs to be tested in detail in the standards process, including the equivalence and difference of outcomes, the way the level of achievement is specified and the amount of fundamental credits in the various knowledge areas.

5.1 Integrating proposals

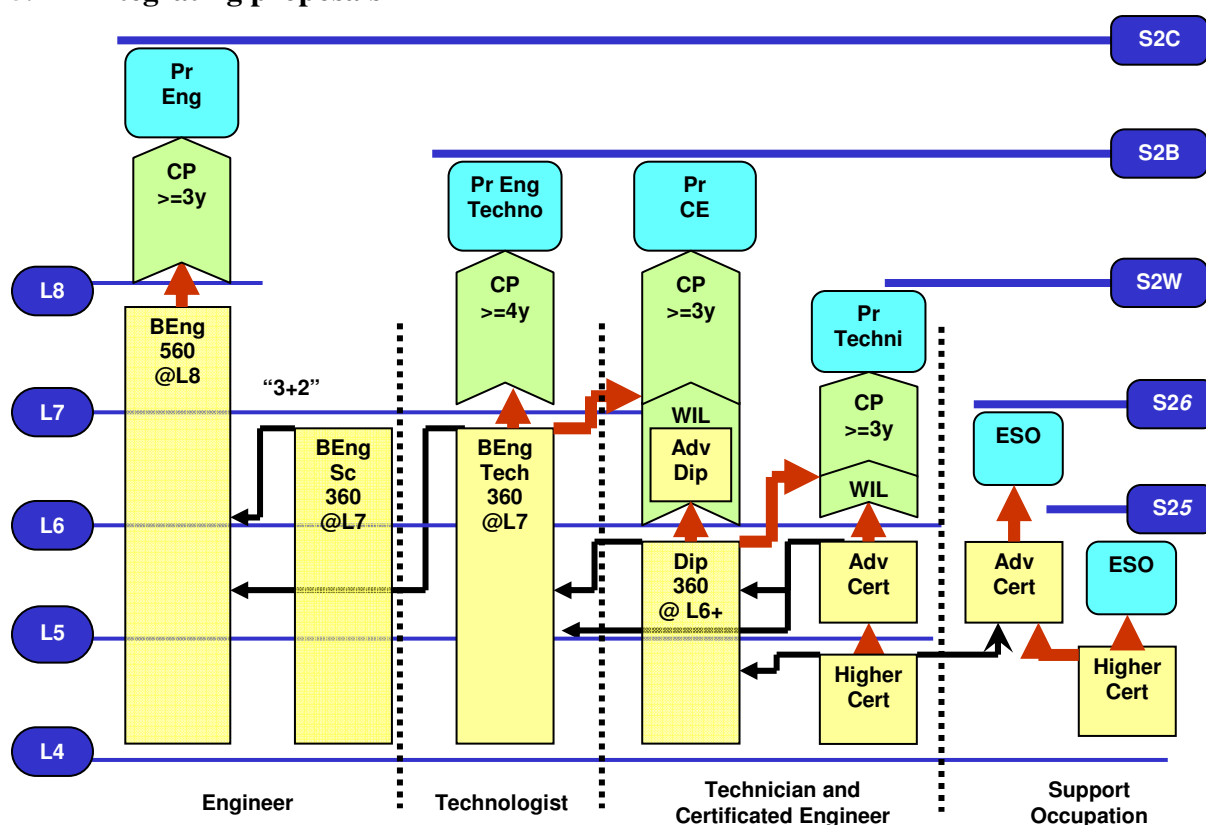


Figure 2: Summarising the proposals: linking education to registration via training

Figure 2 summarised the proposals in sections 3 and 4 and shows the candidacy programmes (CP) that lead to registration in various categories. Levels shown at the left are Higher Education levels on a ten level framework contextualised for engineering [2]. Those on the right are the contextual level descriptors defined by ECSA for engineering at the professional level [3]. These level descriptors contain indications of the demands of practice in each category in terms the level of problem solving and the type of engineering activity as shown in Table 4.

Table 4: Level descriptors used at Stage 2

	Level of Problem Solving	Type of Engineering Activity
S2C	Complex engineering problems	Complex engineering activity
S3B	Broadly-defined engineering problems	Broadly-defined engineering activity
S2W	Well-defined engineering problems	Well-defined engineering activity
S26	Narrowly defined (As S2W in narrow field)	
S25	Consistent with NQF level 5	

6 Engineering Support Occupations

A large number of focussed, specialised or specified occupations support the engineering process. Functions include completion of designs by insertion of codified detail, development and supply of manufacturing and construction information, quality control, inspections, testing or supervision of production or construction in support of engineering professionals.

These engineering support occupations (ESO) may originate in several ways: they may be generally recognised; may be an industry sector requirement; may be required by an Act or may be established by ECSA as specified categories. These occupations have a common set of generic competencies but differ in detailed technical knowledge and work-related skills.

Most of these occupations require educational components at NQF Level 5 and in many cases would replace the N6 diploma. The need for higher levels of education in some occupations and the need to provide articulation paths motivated occupationally oriented qualifications at NQF Level 6. These certificates are not identical to those proposed for technician education. Thus, the need exists for additional Higher and Advanced Certificates in engineering support areas. Qualifications have been developed for this purpose.

Table 5: Rightward Extension of Table 4 to give comparison of engineering support occupation qualifications

Adv Cert-type ESO programme		Higher Cert-type ESO programme	
Purpose The qualification, prepares the learner for an established engineering support occupation (ESO) by incorporating and building on the knowledge gained from a NQF Level 5 engineering qualification to provide: <ol style="list-style-type: none"> 1. competencies required for the specific occupation; 2. fundamental and further knowledge relevant to and applicable in the specific occupation; 3. learners with management principles appropriate to the specific occupation; and 4. sufficient fundamental knowledge to support access, articulation and progression to other qualifications. Curriculum developers will use this generic qualification framework to design their curricula using specified occupation-related content and skills.		Purpose The qualification, prepares the learner for an established engineering support occupation by providing: <ol style="list-style-type: none"> 1. a base of technical knowledge for the specific occupation; 2. competencies required for the specific occupation; 3. fundamental knowledge relevant to and applicable in the specific occupation; 4. learners with management principles appropriate to the specific occupation; and 5. sufficient fundamental knowledge to support access, articulation and progression to other qualifications. Designers of specific qualifications may build on this generic base by specifying occupation-related content and specific skills required. The particular occupation may also require other qualifications, learnerships, skills programmes or further learning.	
Level Descriptors: Well-defined (specific area) engineering problems		Level Descriptors: Level 5 ECLD	
Exit level = 6 Credits		Exit level = 5 Credits	
Total	120	Total	120
Mathematical Sciences	15	Mathematical Sciences	10
Basic Sciences	10	Basic Sciences	10
Engineering Sciences	40	Engineering Sciences	50
Engineering Practice	10	Engineering Practice	
Computing and IT	15	Computing and IT	15
Complementary Studies	10	Complementary Studies	10
For redistribution	20	For redistribution	25

This type of Higher Certificate qualification specifies the generic requirements for a class of focussed engineering support occupations at NQF Level 5 whose function it is to support engineering activity at the professional level. Persons often enter engineering support occupations from vocational qualifications. This qualification seeks to provide a means of access to higher education and vertical and horizontal articulation to and from other technical qualifications.

This Advanced Certificate qualification specifies the generic requirements for a class of focussed engineering support occupations at NQF Level 6 that require greater depth than cognate NQF level 5 qualifications whose function it is to support engineering activity at the professional level. This qualification provides the basis for articulation of persons who have proved themselves at NQF level 5 toward professionally oriented engineering qualifications for technicians and technologists.

7 Progression Considerations

7.1 Progression to Higher Degrees

The concern is often expressed that graduates of technology programmes should be able to proceed to higher degrees. Proposals for such progression must be grounded on three principles. First, exceptional students are being considered. Second, the HEQF policy document is clear that vertical progression is the primary requirement of the framework. Third, while the Framework indicates progression possibilities, actual pathways can only be created by education providers.

It follows that paths from technology qualifications and especially technician qualifications may not be seamless. We also note that, as has happened, exceptional technology graduates after some time in an occupation that provides good learning experiences are admitted to and are successful at studies at masters level.

Figure 1 shows possible paths that could be created by providers for graduates of BEngSc programmes, via Honours or Postgraduate Diploma programmes to Masters programmes. Similarly, a holder of a Diploma would complete an Advanced Diploma and then proceed via Honours or Postgraduate Diploma programmes. A person in the Higher/Advanced Certificate track would need to articulate into the Diploma.

7.2 Inter-category Articulation

Figure 2 indicates a number of progression possibilities from certificates, to diplomas to degrees. Two cases arise in the HEQF policy. When a student who has completed some credits toward a qualification wishes to change to another qualification, the student may offer all the credits completed that are relevant to the transferred-to programme and must take at least half the credits of the transferred-to programme. Also, 120 credits must be taken at the exit level of a transferred-to undergraduate qualification and 180 for a postgraduate qualification.

The second case is enrolling in a second programme, having completed the first. Here there is a limit of 50% of the credits of the previous programme that can be transferred to the second programme.

A possible route via Honours and Masters has been identified as a way to articulate from technologist to engineer. ECSA's accreditation policy permits providers to submit combinations of qualifications for accreditation as meeting the educational requirements in a category. Such a proposal would be further tested when the UoTs concerned apply for candidacy phase accreditation to the CHE and to the Department of Education for inclusion of programmes in its Programme and Qualification Mix (PQM). Issues will arise: the purpose of honours, namely, to "prepare students for research postgraduate study" may be incompatible with professional education; the PG diploma with its objective of "strengthening and deepening knowledge in a particular discipline or profession" may be better suited.

8 International Comparability

International comparability of the qualifications for engineer, engineering technologist and engineering technician is performed primarily through the Washington, Sydney and Dublin Accords. The common benchmark for outcomes and levels of performance are captured in the International Engineering Alliance's *Graduate Attributes and Professional Competencies*. The comparability of the BEng is long established. The new proposals for technology qualifications are felt to be broadly comparable for the following reasons.

- The Graduate Attributes for engineering technician education envisage a minimum of two years of higher education, a set of exit level outcomes that correspond to those envisaged for the combination of Higher and Advanced Certificates, and level/range indicators that correspond to NQF level 6.
- The Graduate Attributes for engineering technologist education envisage a minimum of three years of higher education, a set of exit level outcomes that correspond to those envisaged for the 360 credit BEngTech, and level/range indicators that correspond to NQF level 7.

A need exists to cast the outcomes in a form that is more directly comparable with the Graduate Attributes.

It is natural to draw comparisons between the proposed three year degrees and Bologna first cycle bachelors degrees. Rigorous comparison lies in the future. However, it should be borne in mind that the primary objectives of the Bologna process were harmonising education structures across countries and promoting mobility of students. More recently, governments introduced the objectives of education being an enabler economic competitiveness. Education is measured by volume and there is not a strong focus on outcomes or purpose. The contextualisation of the Bologna 3- and 5-year programmes for engineering through the EUR-ACE [8] initiative is a helpful basis for comparison of outcomes. A remarkable omission from the EUR-ACE criteria is a statement of purpose of the first and second cycle degrees. Not surprisingly, professional programmes in engineering, medicine, law and architecture are having most difficulty complying with the first cycle model. It has been said [9] that, having "... broken their five year programmes into a two cycle structure, many are having difficulty defining what their bachelors degrees in engineering are intended to do". Thus, benchmarking against Bologna programmes should be done with care, particularly comparison on the basis of time and degree title.

9 Delivery Responsibilities

This paper recognises that in the current situation where the possible providers of programmes are traditional universities, comprehensive universities, universities of technology and FET colleges, the ultimate decision on whether a provider is permitted to offer a particular programme is essentially made with the approval of the DoE and, in the case of Higher Education providers, the attainment of candidacy phase accreditation by the CHE.

The position paper argues for the Higher and Advanced Certificates for technician education. As these are HE qualifications it is implicit that HE institutions could gain approval to run such programmes. However, there is the issue of the FET colleges being permitted to operate in the HE band. If a college has the capacity - and that is a crucial precondition - there would be advantages in offering Higher Certificates that meet requirements for technician education under suitable accreditation and certification arrangements.

10 Role of Higher Degrees in Professional Development

Higher degrees play a role in professional education. ECSA is not concerned with research higher degrees but masters involving coursework can form an important part of initial and continuing professional development, particularly for engineers.

The HEQF policy is clear that one of the two primary purposes of the masters degree is to prepare graduates for advanced and specialized employment. There is the stipulation that masters programmes

must have at least 60 credits on "conducting and reporting research". This paper recognizes the role of masters programmes and allows for them to be accredited for particular purposes.

11 Recommendations and Responsibilities

A number of recommendations that various parties must act on arise in this paper. These are summarised in the table below, with an indication of the parties that must consider and respond. After step 1, steps 2, (3, 4, 5), 6 (7, 8) and 9 may proceed in parallel. After step 10, 11 and 12 may be conducted in parallel.

No	Recommendation	To
1	Consider and recommend that this position be further considered as specified below.	EC Engineering Deans
2	The 3 + 2 model for educating engineers and specialists be adopted as part of the system of engineering qualifications: the BEng and BEngSc degrees are essential components of the HEQF-compliant Engineering Qualifications Framework. A generic standard is required for the BEngSc degree.	ECSA RC Engineers EPAC ESGB Providers
3	Two models be adopted for the education of engineering technicians: a) a 240 credit certificate system, with the preparatory work integrated learning being taken over by employers or SETAs; b) a 360 credit diploma incorporating work integrated learning. The generic standards already registered should be revisited	ECSA RC Technicians TPAC ESGB Providers
4	SETAs be approached to undertake candidacy programmes	
5	The requirements for candidacy programmes for engineering technicians be adjusted to accommodate the two models.	ECSA RC Technicians
6	The standards for the Level 5 and 6 certificates already generated may need review in the light of proposal 3a.	ESGB: L5&6 SGG
7	The benchmark educational programme for engineering technologists becomes a 360 credit minimum bachelor's degree programme with (tentative) designation BEngTech The generic standards already registered should be revisited	ECSA RC Technologists TPAC ESGB Providers
8	The requirements for candidacy programmes for technologists may require review	ECSA RC Technologists
9	The Certificated Engineer model must be reviewed	ESGB: CE SGG
10	The ECSA Council consider and adopt the position paper (revised as necessary)	ECSA Council
11	The position paper be sent to the Council on Higher Education as ECSA's implementation of the HEQF	CHE
12	The position paper be sent to the Department of Education as ECSA's implementation of the HEQF	DoE

12 Are these Proposals Conducive to Easing the Engineering Skills Shortage?

In proposing changes to the structure of engineering qualifications, we must be mindful of the medical dictum: *First, do no harm*. Are the proposed changes likely to increase or decrease the supply or improve or compromise the mix of skilled engineering practitioners?

1. The new certificate route removes the WIL problem that prevents students from getting their NDs at present. It uses the capacity of the SETAs to get the WIL. (This will need a lot of driving but if it works it will work well).
2. There is a clear case to increase the number of technologists by a larger proportion than the other categories. To do this at present, we need to put more students through the diploma

programmes, with the problems that entails. The UoTs and CUs clearly need more capacity and the creation of the stand-alone degree programmes for technologists is a way of doing that.

3. The two variants of the 3+2 model for engineers both have the potential to produce more BEng graduates, as well as BEngSc and BSc graduates who can perform useful functions in industry.

These changes should do no harm and they could be beneficial for increasing the outputs of graduates.

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Appendix: The Development of Engineering Technology Qualifications In South Africa

Engineering technology education in South Africa has evolved over the past 30 years in response to the needs of an increasingly technological society.

The 1970's

Colleges for Advanced Technical Education (CATE's) were formed to supply the country's need for technicians to bridge the gap between artisans and engineers in the engineering work-force.

A block release system was implemented whereby full time employees could improve their academic qualifications by alternating periods of attending a CATE full time, with periods of working at their jobs in industry full time. The government provided incentives to industry to encourage employers to release their employees for further study in their respective disciplines.

The alternating periods of academic and work-based learning came to be known as the "sandwich system" and proved to be a good educational model. It led to *Cooperative Education*, a close relationship between the CATE's and the industries that they served, as together they decided on the academic and work-based learning required for technicians. The 3-year *Diploma* qualification for the technician consisted of 18 months of academic learning at a Technikon and 18 months of experiential learning at the work place.

The 1980's

The CATE's were replaced by *Technikons* and the government stopped the educational incentives for industry. Whereas the CATE's had provided some bridging between secondary and tertiary technical education, the Technikons were positioned only in the tertiary education sector.

The above factors led to a change in the profile of the student attending a Technikon. A typical student changed from one who was already fully employed in industry to one who had just obtained a matriculation certificate, but had not yet worked in industry.

The onus fell on the Technikon to find industrial companies who would be prepared to partner with the Technikon by taking on unqualified students and giving them the experiential learning required for the Diploma qualification. It was up to the Technikon to monitor and assess the quality of the learning that the student obtained in industry. As the number of students multiplied, this became a logistical nightmare. Many students worked in locations remote from the Technikon and the government did not provide funding for monitoring work-based learning.

Nevertheless Cooperative Education has continued successfully up until the present time, albeit with significant changes over the years.

The 1990's

The composition of the Diploma qualification changed to 2 years academic learning and 1 year of experiential learning. This was because the minimum academic knowledge required of a technician had greatly increased.

The Cooperative Education model gradually changed for a "thin sandwich" (6 months to a year at the Technikon interspersed with two separate 6 month periods in industry) to a "thick sandwich" (a year at the Technikon, followed by a year in industry, followed by the final year at the Technikon). Most companies found it difficult to use a student with less than a year's academic learning. Once they had invested time in training her, they wanted to keep the student longer than 6 months in order to benefit a little from the training they had given her.

The need for persons with even greater technical expertise led to the recognition of an additional role within the engineering work-force – the technologist. The *Bachelor of Technology* (B Tech) degree offered by Technikons provided the additional year and level of academic learning required by the technologist.

The 2000's

The government introduced a 10-level *National Qualifications Framework* (NQF) as a means of recognising and benchmarking the various qualifications offered in South Africa. The tertiary education band occupies levels 5 to 10 on the NQF. This band is referred to as the *Higher Education Qualifications Framework* (HEQF).

With one exception, Technikons have been reconstituted as *Universities of Technology* (UoT) or merged into *Comprehensive Universities* (CU). It is expected that they will continue to provide the academic learning required by technicians and technologists.

The Cooperative Education model for the Diploma qualification has changed to 2 years at a UoT or CU followed by 1 year in industry for most branches of engineering. This is because the minimum academic learning required before a student can be given worthwhile experiential learning has increased.

As a result of the government's adoption of the *Outcome Based Education* (OBE) model, there has been a general review of education in South Africa. New education standards are being developed for qualifications at all levels on the NQF.