COUNCIL ON HIGHER EDUCATION

Higher Education Qualifications Sub-Framework

Qualification standard

for

Bachelor of Engineering

and

Bachelor of Science in Engineering

The process of drafting this standard is described in the Introduction.

February 2015

The Council on Higher Education (CHE) is an independent statutory body established by the Higher Education Act, no. 101 of 1997 (amended). The CHE is the Quality Council for Higher Education, advises the Minister of Higher Education and Training on all higher education issues and is responsible for quality assurance and promotion through the Higher Education Quality Committee.

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HIGHER EDUCATION QUALIFICATIONS SUB-FRAMEWORK

STANDARDS DEVELOPMENT: POLICY AND PROCESS

Introduction

In terms of the National Qualifications Framework (NQF) Act, 67 of 2008, the Council on Higher Education (CHE) is the Quality Council (QC) for Higher Education. The CHE is responsible for quality assurance of higher education qualifications.

Part of the implementation of the Higher Education Qualifications Sub-Framework (HEQSF) is the development of qualification standards. Standards development is aligned with the *nested approach* incorporated in the HEQSF. In this approach, the outer layer providing the context for qualification standards are the NQF level descriptors developed by the South African Qualifications Authority (SAQA) in agreement with the relevant QC. One of the functions of the QC (in the case of higher education, the CHE) is to ensure that the NQF level descriptors 'remain current and appropriate'. The development of qualification standards for higher education therefore needs to take the NQF level descriptors, as the outer layer in the *nested approach*, into account. An ancillary function is to ensure that they 'remain current and appropriate' in respect of qualifications awarded by higher education institutions.

A secondary layer for the context in which qualification standards are developed is the HEQSF. This framework specifies the types of qualification that may be awarded and, in some cases, the allowable variants of the qualification type. An example of variants is the provision for two variants of the Master's degree (including the 'professional' variant). Another example is the distinction, in the Bachelor's degree type, between the 'general' and 'professionally-oriented' variants. The HEQSF also specifies the purpose and characteristics of each qualification type. However, as indicated in the *Framework for Qualification Standards in Higher Education* (CHE, 2013), neither NQF level descriptors nor the HEQSF is intended to address, or indeed capable of addressing, fully the relationship between generic qualification-type purpose and the specific characteristics of that qualification type in a particular field of study. One of the tasks of standards development is to reconcile the broad, generic description of a qualification type according to the HEQSF and the particular characteristics of qualifications awarded in diverse fields of study and disciplines, as defined by various descriptors and qualifiers.

Development of qualification standards is guided by the principles, protocols and methodology outlined in the *Framework*, approved by the Council in March 2013. The focus of a standards statement is the relationship between the purpose of the qualification, the attributes of a graduate that manifest the purpose, and the contexts and conditions for assessment of those attributes. A standard establishes a threshold. However, on the grounds that a standard also plays a developmental role, the statement may include, as appropriate, elaboration of terms specific to the statement, guidelines for achievement of the graduate attributes, and recommendations for above-threshold practice.

The CHE is engaged in a pilot study, involving a selection of qualification types, offered in various fields of study. The aim of the study is to explore the extent to which the principles, procedures, content and methodology of standards development meet the requirements of all relevant parties: the institutions awarding the qualifications, the CHE as quality assurer of the qualifications, the graduates of those qualifications, and their prospective employers.

The drafting of this standards statement is the work of a consultant recommended, and endorsed, by a group of academic experts in the field of study, convened by the CHE and comprising Deans of Engineering or their nominees. The draft standard was presented to, and endorsed by, a meeting of Engineering Deans held on 24 November 2014. On recommendation by the meeting, the draft was submitted, via the Engineering Council of South Africa to its Engineering Standards Generating Body. Comments from both the Deans and the ESGB have been considered and, where appropriate, incorporated in the draft.

The CHE disseminates the draft standard for the consideration of all relevant and interested parties. Comments received by the CHE are referred, as appropriate, to the Engineering Deans for consideration. When all issues have been considered and reconciled, the Directorate: Standards Development submits to the Council a standards statement for approval.

QUALIFICATION TYPE AND VARIANT

Bachelor's degree *(Professional)*

BACHELOR'S DEGREE (PROFESSIONAL): GENERAL CHARACTERISTICS

There are two types of Bachelor's Degrees, namely general and professionally-oriented Bachelor's Degrees. Both types of degree may be structured as a 360-credit qualification with an exit at level 7 or as a 480-credit qualification with an exit at level 8 on the National Qualifications Framework….The 480-credit Bachelor's Degree at NQF level 8 has both a higher volume of learning and a greater cognitive demand than the 360-credit degree at level 7 and should prepare students to be able to undertake Master's level study by providing them with research capacity in the methodology and research techniques of the discipline.

The primary purpose of both the general and the professional Bachelor's Degree is to provide a well-rounded, broad education that equips graduates with the knowledge base, theory and methodology of disciplines and fields of study, and to enable them to demonstrate initiative and responsibility in an academic or professional context. Both the 360- and 480-credit Bachelor's Degrees may require students to undertake research in a manner that is appropriate to the discipline or field of study in order to prepare them for postgraduate study.

The professional Bachelor's Degree prepares students for professional training, post-graduate studies or professional practice in a wide range of careers. Therefore it emphasises general principles and theory in conjunction with procedural knowledge in order to provide students with a thorough grounding in the knowledge, theory, principles and skills of the profession or career concerned and the ability to apply these to professional or career contexts. The degree programme may contain a component of work-integrated learning.

(The Higher Education Qualifications Sub-Framework, CHE, 2013)

STANDARD FOR THE

BACHELOR OF ENGINEERING

and

BACHELOR OF SCIENCE IN ENGINEERING

Preamble

The competence of a Professional Engineer at the level required for independent practice, that is, on qualifying for professional registration, is generally developed in two stages. First, a professionally-oriented bachelor degree meeting this standard provides the educational foundation. Second, competence must be further developed through training and experience, typically for four or more years after graduation. The educational foundation has a strong conceptual emphasis, building on natural sciences and mathematics to develop engineering science fundamentals and engineering specialist knowledge. Conceptual knowledge is used in engineering applications and design. Training and experience after graduation develops contextual knowledge and the ability to solve problems in real-life situations.

As indicated in the qualification title definition in Section 2, the qualification may be awarded as a result of programmes in one of several disciplines or cross disciplinary fields, including newly emerged fields. This standard specifies the generic knowledge profile and outcomes common to all programmes. Standards are not defined at the qualifier level.

Note

Words and phrases having specific meaning are defined in section 11 of this document or in ECSA Document E-01-P. The method recommended for calculating credits is detailed in ECSA document E-01-P available at www.ecsa.co.za**.**

1. HEQSF specification

HEQSF Qualification Type	Bachelor Degree	
Variant	Professionally-oriented	
NQF Exit Level	**Minimum Total Credits**	**Minimum Credits at Exit Level**
8	560	120

2. Qualification title

Designators: Bachelor of Engineering, Bachelor of Science in Engineering

Qualifiers: The qualifier(s) must contain the word *engineering* and be consistent with the engineering science content of the programme. Disciplinary or cross-disciplinary identifiers include but are not limited to: Agricultural, Aeronautical, Chemical, Civil, Computer, Electrical, Electro-mechanical, Electronic, Environmental, Industrial, Extractive Metallurgical, Information, Materials, Mechanical, Mechatronic, Metallurgical, Mineral(s) Process, Physical Metallurgical and Mining.

3. Purpose statement

The primary purpose of this professionally-oriented Bachelor's Degree is to provide a well-rounded, broad education that equips graduates with the knowledge base, theory, skills and methodology of an engineering discipline or cross-disciplinary field as a foundation for further training and experience towards becoming a competent professional engineer. This foundation is achieved through a thorough grounding in mathematics, natural sciences, engineering sciences, engineering design and the abilities to enable applications in fields of emerging knowledge. Engineering knowledge is complemented by an appreciation of the world and society in which engineering is practiced and an understanding of the impacts of engineering solutions.

The standard requires achievement in research methods and investigation and therefore prepares graduates with appropriate level of achievement for postgraduate study.

Note: This standard is designed to meet the educational requirement towards registration as a Candidate or Professional Engineer with the Engineering Council of South Africa.

4. Normal duration of study

Programmes have normal durations of four years with not less than 560 Credits.

5. Standard for the award of the qualification

The *purpose* and *level* of the qualification will have been achieved when the student has demonstrated:

- the knowledge defined in section 6 and
- the skills and applied competence defined in section 7.

6. Knowledge

Knowledge demonstrated by the graduate has the following characteristics:

6.1: At least the number of credits in the knowledge areas shown:

Knowledge area	Minimum Credits
Mathematical Sciences	56
Natural Sciences	56
Engineering Sciences	180
Design and Synthesis	72
Complementary studies	56

Note: These credits total 420. Credits in selected knowledge areas must be increased to satisfy the 560 minimum total credits.

6.2: The level of knowledge of mathematics, natural sciences and engineering sciences is characterized by:

- A systematic, theory-based understanding of the natural sciences applicable to the discipline;
- Conceptually-based mathematics, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline;
- A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline; and
- Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

6.3: A coherent core of mathematics, natural sciences and engineering fundamentals that provides a viable platform for further studies and lifelong learning. The coherent core must enable development in a traditional discipline or in an emerging field.

6.4: Specialist engineering knowledge at the exit-level. Specialist knowledge may take on many forms including further deepening of a theme in the core, a new sub-discipline, or a specialist topic building on the core. It is recognized that the extent of specialist study is of necessity limited in view of the need to provide a substantial coherent core. Specialist study may take the form of compulsory or elective credits.

6.5: This standard does not specify detailed curriculum content. The engineering fundamentals and specialist engineering science content must be consistent with the designation of the degree.

7. Skills and Applied Competence

The graduate is able to demonstrate attributes 1 to 11:

1: Problem solving
Identify, formulate, analyse and solve complex engineering problems creatively and innovatively.

Level Descriptor: ***Complex Engineering Problems****:*
a) require in-depth fundamental and specialized engineering knowledge;
and have one or more of the characteristics:
b) are ill-posed, under- or overspecified, or require identification and refinement;
c) are high-level problems including component parts or sub-problems;
d) are unfamiliar or involve infrequently encountered issues;
and their solutions have one or more of the characteristics:
e) are not obvious, require originality or analysis based on fundamentals;
f) are outside the scope of standards and codes;
g) require information from variety of sources that is complex, abstract or incomplete;
h) involve wide-ranging or conflicting issues: technical, engineering and interested or affected parties.

2: Application of scientific and engineering knowledge
Apply knowledge of mathematics, natural sciences, engineering fundamentals and an engineering speciality to solve complex engineering problems.

Range Statement: Mathematics, natural science and engineering sciences are applied in formal analysis and modelling of engineering situations, and for reasoning about and conceptualizing engineering problems. Characteristics of knowledge in different areas are defined in Section 6.2.

3: Engineering Design
Perform creative, procedural and non-procedural design and synthesis of components, systems, engineering works, products or processes.

Range Statement: Design problems used in exit-level assessment must conform to the definition of a complex engineering problem, defined under attribute 1. A major design problem should be used to provide evidence. The design knowledge base and components, systems, engineering works, products or processes to be designed are dependent on the discipline or practice area.

4: Investigations, experiments and data analysis
Demonstrate competence to design and conduct investigations and experiments.

Range Statement: The balance of investigation and experiment should be appropriate to the discipline. Research methodology to be applied in research or investigation where the student engages with selected knowledge in the research literature of the discipline.

Note: An investigation differs from a design in that the objective is to produce knowledge and understanding of a phenomenon and a recommended course of action rather than specifying how an artifact could be produced.

5: Engineering methods, skills and tools, including Information Technology
Demonstrate competence to use appropriate engineering methods, skills and tools, including those based on information technology.

Range Statement: A range of methods, skills and tools appropriate to the disciplinary designation of the program including:

1. Discipline-specific tools, processes or procedures;
2. Computer packages for computation, modelling, simulation, and information handling;

Computers and networks and information infrastructures for accessing, processing, managing, and storing information to enhance personal productivity and teamwork

6: Professional and technical communication
Demonstrate competence to communicate effectively, both orally and in writing, with engineering audiences and the community at large.

Range Statement: Material to be communicated is in an academic or simulated professional context. Audiences range from engineering peers, management and lay persons, using appropriate academic or professional discourse. Written reports range from short (300-1000 words plus tables diagrams) to long (10 000 to 15 000 words plus tables, diagrams and appendices), covering material at exit-level. Methods of providing information include the conventional methods of the discipline, for example engineering drawings, as well as subject-specific methods.

7: Sustainability and Impact of Engineering Activity
Demonstrate critical awareness of the sustainability and impact of engineering activity on the social, industrial and physical environment.

Range Statement: The combination of social, workplace (industrial) and physical environmental factors must be appropriate to the discipline or other designation of the qualification. Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: health, safety and environmental protection; risk assessment and management and the impacts of engineering activity: economic, social, cultural, environmental and sustainability

8: Individual, Team and Multidisciplinary Working

Demonstrate competence to work effectively as an individual, in teams and in multidisciplinary environments.

Range Statement: Multidisciplinary tasks require co-operation across at least one disciplinary boundary. Co-operating disciplines may be engineering disciplines with different fundamental bases other than that of the programme or may be outside engineering.

9: Independent Learning Ability

Demonstrate competence to engage in independent learning through well-developed learning skills.

Range Statement: Operate independently in complex, ill-defined contexts requiring personal responsibility and initiative, accurately self-evaluate and take responsibility for learning requirements; be aware of social and ethical implications of applying knowledge in particular contexts.

10: Engineering Professionalism

Demonstrate critical awareness of the need to act professionally and ethically and to exercise judgment and take responsibility within own limits of competence.

Range Statement: Evidence includes case studies typical of engineering practice situations in which the graduate is likely to participate. Ethics and the professional responsibility of an engineer and the contextual knowledge specified in the range statement of attribute 7 is generally applicable here.

11: Engineering Management

Demonstrate knowledge and understanding of engineering management principles and economic decision-making.

Range Statement: Basic techniques from economics, business management; project management applied to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

8. Contexts and conditions for assessment

Graduate attributes defined above are stated generically and may be assessed in various engineering disciplinary or cross-disciplinary contexts in a provider-based or simulated practice environment.

9. Award of the qualification

The qualification may be awarded when the qualification standard has been **met or exceeded**.

10. Progression

As a Level 8, 560 Credit qualification with required graduate attribute 4 in research methods and investigation, this qualification may meet the admission requirements for admission to a research or professional masters degree. In addition, the graduate attributes are such that that a graduate may also meet requirements for entry to a number of programmes including:

1. A candidacy programme toward registration as a Professional Engineer
2. In certain disciplines, progression toward the Government Certificate of Competency
3. A postgraduate Bachelor of Laws (LLB) programme;
4. With appropriate work experience, a Master of Business Administration or similar programme.

11. Guidelines

11.1 Pathway
This qualification lies on a HEQSF Professional Pathway

11.2 Definition of terms

Complementary Studies: cover those disciplines outside of engineering sciences, natural sciences and mathematics which are relevant to the practice of engineering including but not limited to engineering economics, management, the impact of technology on society, effective communication, and the humanities, social sciences or other areas that support an understanding of the world in which engineering is practised.

Engineering Discipline (= Branch of engineering): a generally-recognised, major subdivision of engineering such as the traditional *disciplines* of Chemical, Civil, or Electrical Engineering, or a cross-disciplinary field of comparable breadth including combinations of engineering fields, for example Mechatronics, and the application of engineering in other fields, for example Bio-Medical Engineering.

Engineering Sub-discipline: a generally-recognised practice area or major subdivision within an engineering discipline, for example Structural and Geotechnical Engineering within Civil Engineering.

Engineering fundamentals: engineering sciences that embody a systematic formulation of engineering concepts and principles based on mathematical and natural sciences to support applications.

Engineering Management: the generic management functions of planning, organising, leading and controlling, applied together with engineering knowledge in contexts including the management of projects, construction, operations, maintenance, quality, risk, change and business.

Engineering Design and Synthesis: is the systematic process of conceiving and developing materials, components, systems and processes to serve useful purposes. Design may be procedural, creative or open-ended and requires application of engineering sciences, working under constraints, and taking into account economic, health and safety, social and environmental factors, codes of practice and applicable laws.

Engineering Sciences: have roots in the mathematical and physical sciences, and where applicable, in other natural sciences but extend knowledge and develop models and methods in order to lead to engineering applications and solve engineering problems.

Engineering Speciality: the extension of engineering fundamentals to create theoretical frameworks and bodies of knowledge for engineering practice areas.

Mathematical Sciences: an umbrella term embracing the techniques of mathematics, numerical analysis, statistics and aspects of computer science cast in an appropriate mathematical formalism.

Natural Sciences: physics (including mechanics), chemistry, earth sciences and the biological sciences which focus on understanding the physical world, as applicable in each engineering disciplinary context.

11.3 International comparability of this qualification
This standard is designed to be substantially equivalent to the Washington Accord Graduate Attributes (see www.ieagreements.org). The Washington Accord is an agreement for the mutual

recognition of engineering programmes that provide the educational foundation for professional engineers. Washington Accord signatories at June 2014 are accrediting agencies in: Australia, Canada, Chinese Taipei, Hong Kong China, India, Ireland, Japan, Republic of Korea, Malaysia, Russia, New Zealand, Singapore, South Africa, Sri Lanka, Turkey, United Kingdom, and the United States of America. Comparability of the standard achieved in accredited programmes is audited via a six-yearly Washington Accord review of the Engineering Council of South Africa, the South African signatory to the accord.

ANNEXURE A

NQF LEVEL DESCRIPTORS

The qualification is awarded at **level 8** on the National Qualifications Framework (NQF) and therefore meets the following level descriptors:

a. Scope of knowledge, in respect of which a learner is able to demonstrate knowledge of and engagement in an area at the forefront of a field, discipline or practice; an understanding of the theories, research methodologies, methods and techniques relevant to the field, discipline or practice; and an understanding of how to apply such knowledge in a particular context.
b. Knowledge literacy, in respect of which a learner is able to demonstrate the ability to interrogate multiple sources of knowledge in an area of specialisation and to evaluate knowledge and processes of knowledge production.
c. Method and procedure, in respect of which a learner is able to demonstrate an understanding of the complexities and uncertainties of selecting, applying or transferring appropriate standard procedures, processes or techniques to unfamiliar problems in a specialised field, discipline or practice.
d. Problem solving, in respect of which a learner is able to demonstrate the ability to use a range of specialised skills to identify, analyse and address complex or abstract problems drawing systematically on the body of knowledge and methods appropriate to a field, discipline or practice.
e. Ethics and professional practice, in respect of which a learner is able to demonstrate the ability to identify and address ethical issues based on critical reflection on the suitability of different ethical value systems to specific contexts.
f. Accessing, processing and managing information, in respect of which a learner is able to demonstrate the ability to critically review information gathering, synthesis of data, evaluation and management processes in specialised contexts in order to develop creative responses to problems and issues.
g. Producing and communicating information, in respect of which a learner is able to demonstrate the ability to present and communicate academic, professional or occupational ideas and texts effectively to a range of audiences, offering creative insights, rigorous interpretations and solutions to problems and issues appropriate to the context.
h. Context and systems, in respect of which a learner is able to demonstrate the ability to operate effectively within a system, or manage a system based on an understanding of the roles and relationships between elements within the system.
i. Management of learning, in respect of which a learner is able to demonstrate the ability to apply, in a self-critical manner, learning strategies which effectively address his or her professional and ongoing learning needs and the professional and ongoing learning needs of others.
j. Accountability, in respect of which a learner is able to demonstrate the ability to take full responsibility for his or her work, decision-making and use of resources, and full accountability for the decisions and actions of others where appropriate.