

A photograph of a multi-story building under construction. The concrete frame is visible, with numerous rebar protrusions. Two large cranes are positioned on the site: a yellow tower crane and a white concrete pump truck with a long, articulated boom. The sky is clear and blue. The image is framed by a large blue curved graphic element on the right side.

ENSURING THE EXPERTISE TO GROW SOUTH AFRICA

Engineering Education Programme Accreditation (EIPA) Research Project

ENGINEERING COUNCIL OF SOUTH AFRICA
Tel: 011 6079500 | Fax: 011 6229295
Email: engineer@ecsa.co.za | Website: www.ecsa.co.za





Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 2 of 39

TABLE OF CONTENT

EXPERTISE TO GROW	1
ACRONYMS	3
ABSTRACT	5
1. INTRODUCTION	6
1.1 Background	6
1.2 Purpose of this research	7
1.3 The approach	7
1.4 The structure of the report	8
2. REVIEW OF THE LITERATURE	8
2.1 New and emergent trends and approaches to engineering education programmes	8
2.1.1 On-line education	9
2.2 Accreditation policy considerations	12
2.2.1 ECSA's policy posture	12
2.2.2 Engineers Australia's accreditation policy posture	14
2.3 Engineering pedagogy	16
2.3.1 Role of education theory	17
2.3.2 Experiential learning game theory application	19
2.4 Critical elements of an on-line engineering education platform	20
2.4.1 Management requirements	20
2.4.2 Laboratory work	21
2.5 Policy and Legislative Framework for Accreditation in HE System	22
2.5.1 Accreditation in the built environment	25
2.5.2 Engineering Council of South Africa	26
3. RESEARCH METHODOLOGY	29
3.1 Quantitative considerations for the survey	30
3.2 Qualitative considerations from the Literature Review (Chapter 2)	31
3.3 Survey responses	31
5. RECOMMENDATIONS	35
REVISION HISTORY	39

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 3 of 39

ACRONYMS

BEP	Built Environment Profession
BEPC	Built Environment Professional Council
CBE	Council for the Built Environment
CHE	Council on Higher Education
CPD	Continuing Professional Development
DoE	Department of Education
DPW	Department of Public Works
EA	Engineers Australia
ECSA	Engineering Council of South Africa
EIT	Engineering Institute of Technology
HEI	Higher Education Institution
ELG	Experiential Learning Model
HEQC	Higher Education Quality Committee (of the Council on Higher Education)
HEQF	Higher Education Qualifications Framework
HESA	Higher Education South Africa
LSM	Learning Management System
MoU	Memorandum of Understanding
NPHE	National Plan for Higher Education
NQF	National Qualifications Framework

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 4 of 39

PAJA	Promotion of Administrative Justice Act
QA	Quality Assurance
QC	Quality Council
QCTO	Quality Council for Trades and Occupations
RPL	Recognition of Prior Learning
SA	South Africa (n)
SACAP	South African Council for the Architectural Profession
SACMCP	South African Council for the Project & Construction Management Professions
SACPVP	South African Council for the Property Valuers Profession
SACQSP	South African Council for the Quantity Surveying Profession
SACLAP	South African Council for the Landscape Architectural Profession
SAQA	South African Qualifications Authority
SETA	Sector Education and Training Authority
TVET	Technical and Vocational Education and Training Institution
UoT	University of Technology
VA	Voluntary Association

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 5 of 39

ABSTRACT

The advent of online education programmes offered at institutions of higher learning worldwide has brought with it the challenge of quality assurance within those programmes. The Engineering Council of South Africa (ECSA) commissioned a research on emerging engineering education platforms and conducted a gap analysis, which previous work on accreditation has failed to cover, on ECSA engineering programme accreditation. The purpose of this paper was to establish if the emergent Engineering Education Platforms (on-line) meet the Accreditation Criteria 1,2,3 and 4. The research was set out as a combination of both qualitative and quantitative methods in establishing population parameters in South Africa. The research was done through surveys with traditional universities, universities of technology and Technical and Vocational Education and Training (TVET) Colleges. The margin of error calculation for universities was 52.93% and that of TVETs was 39.71%, which rendered the results of the survey unusable. Therefore, the research had to rely on the qualitative element to draw conclusions and make recommendations. The conclusion was that the emergent trends have a significant bearing on the future of accreditation of engineering education in South Africa. There is therefore a need for policy review and amendments with regards to Accreditation Criteria 1,2,3 and 4 in order to respond to the emerging platforms and to remain relevant within the quality assurance spectrum.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 6 of 39

1. INTRODUCTION

1.1 Background

The Engineering Council of South Africa (ECSA) is a statutory body for the Engineering profession in South Africa, established in terms of the Engineering Profession Act, 46 of 2000 (EPA). Its aims are to promote a high level of education and training of practitioners and professionalism in the Engineering profession. The Council is tasked with 13 administrative functions of which this research paper is concerned with one, namely the accreditation function.

ECSA's policy on accreditation characterises it as follows, "... formal recognition process by ECSA, through a quality assurance procedure, that an education programme meets accreditation criteria laid down for the type of programme".


ECSA commissioned this work to conduct extensive research on the new and emerging trends and approaches to Engineering Education Programmes Accreditation, prompted by the observation and approach to accredit on-line based Engineering Education programmes.

ECSA's brief set out two objectives:

1. Research Engineering Education Platforms
 - (a) Determine the current emerging Engineering Education Platforms available locally and internationally.
 - (b) Determine the critical elements of an Engineering Education Platform to satisfy the current accreditation policies and/or proposed amendments informed by research.
2. Research Engineering Programme Accreditation
 - (a) Gap Analysis on the ECSA Engineering Programme for Accreditation.
 - (b) Propose amendments and/or the development of new policies for Engineering Programme Accreditation in line with research.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 7 of 39

These objectives, with their respective subsets as key variables, shaped the conceptual framework of the research to do the following:

- Clarify the concepts and propose relationships
- Provide a context for interpretation
- Explain observations and consequential impacts.

This document presents the review of literature and documents around the subject and the findings and issues arising, and from the above distils the principles that should underpin accreditation of the new and emergent Engineering Education (on-line) platforms.

1.2 Purpose of this research


The purpose of the research is set out in the two objectives detailed in the background to ultimately establish, “*Can the emergent Engineering Education Platforms (on-line) meet the Accreditation Criteria (1,2,3,4)?*”

1.3 The approach

This study began with a review and analysis of the existing accreditation process as implemented by the ECSA in South Africa in its e-series documentation (specifically e-series 01, 02, 03, 10 and 14). The study also observed the accreditation process at four institutions of higher learning with an even split between Universities of Technology and traditional Universities. This also coincided with the review of ECSA’s accreditation process and membership status by the International Engineering Alliance (IEA). It also reviewed the literature around the subject, aided by the International Conference on “interactive Collaborative learning” and the “International Conference on Engineering Pedagogy”, to provide some idea of the issues to be addressed and questions to be raised in investigating best practice in engineering education platforms, pedagogy and accreditation. The research also engaged Engineers Australia (EA), a full member of the IEA, on how it has attended to the emergent and new education platforms and approaches in Engineering Education.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 8 of 39

This was accompanied by an on-site engagement, observation of practical deployment of the on-line education platform for Engineering Education in Australia by the Engineering Institute of Technology (EIT).

The policy frameworks that provide policy direction to all Built Environment Professional Councils on Accreditation, Standards Generation, International Agreements, including their respective research papers, alongside the Promotion of Administrative Justice Act, 3 of 2000 (PAJA) and the EPA, were all reviewed to ensure the context of interpretation was relevant.

To evaluate the findings of the legislative, documentary and literature review and determine the relevant issues in the South Africa context, the study next formulated data collection tools for a survey of providers of Engineering Education programmes.

The survey was carried out with a representative sample of Public Institutions, Private Institutions and, Technical and Vocational Education and Training Institutions (TVET) offering Engineering Education Programmes in South Africa.

1.4 The structure of the report

Chapter 2 summarises the findings of the literature, legislative and documentary review, while Chapter 3 deals with the research methodology. Chapter 4 then deals with conclusions that pave the way for Chapter 5 with recommendations suggesting the way forward for decisions.


2. REVIEW OF THE LITERATURE

2.1 New and emergent trends and approaches to engineering education programmes

The emergence of on-line education platforms has dominated the new and emergent trends, to which engineering education programmes have not been immune. Consistent with the conceptual framework, the presentation of the literature review is firstly to clarify concepts on on-line education platforms, which in turn provide a baseline for contextual interpretation of the new and emergent education platforms. The third leg of the conceptual framework, dealing with explaining observations and consequential impacts is dealt with in Chapter 4 of the report.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 9 of 39

2.1.1 On-line education

On-line education platforms, in short, provide for teaching and learning to be conducted over the internet in three main formats/types that deal with the concept of presence differently.

On-line education found its genesis in a range of distance learning approaches¹ like:

- Correspondence study
- pre-recorded media
- two-way audio with or without graphics
- one-way live video
- two-way audio, one-way or two-way video
- desktop two-way audio/video.

In the historical review of on-line learning², it becomes evident that the packaging of content in either analogue or digital format followed by either dissemination or creation of electronic libraries does not constitute an on-line education platform.

Online education platforms can be broken down into three main types:

Synchronous – provides real-time interaction, removing space and time limitations by connecting dispersed learners in real time, providing a sense of immediacy, co-presence, access to expensive and highly knowledgeable instructors wherever they are in the world, with a standardised learning experience.


Asynchronous – provides non real-time interaction, providing for flexibility to accommodate space and time limitations, provides for self-paced learning, 24/7 access to course material, learning locations unrestricted.

Blended – combines synchronous and asynchronous modes of on-line education delivery, with traditional face-to-face class and laboratory activities. The literature on the blended format provides for variations⁵ in the blended learning format from levels 1–5 as follows, which enables grading criteria for Engineering education programmes by level of adopting on-line platforms and/or training manuals for assessors:

Level 1: no web-based courses provided, only web-based details of course/syllabus and institution providing the course.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 10 of 39

Level 2: Some (but not all) course materials online for download; additional reference material available through the website.

Level 3: The web is the key element of the course with most course resources available online. The student cannot function without effective access to the website; asynchronous communication.

Level 4: Blended/hybrid course – use of a judicious mixture of classroom and website; synchronous and asynchronous web tools are used to provide online portion.

Level 5: Completely online, Online distance learning course with virtual communities – use of only synchronous and asynchronous tools to conduct classes.

It is important to observe that the concept of presence³ is treated differently by the three types of on-line education platforms, As such literature and research work emphatically state that, “*Online learning should never be considered in isolation, but as a component of the overall learning experience*”.⁴ This already sets a parameter within which the critical elements of an Engineering Education Platform must operate for Accreditation.

The three on-line education platforms provide the baseline differentiation of the new and emergent engineering education platforms available locally and internationally. The various product line-up offerings available (various brands) fall within the scope of the three main types.⁵


2.1.2 The principle of accreditation

At this point, it is important to reflect on the object of accreditation so that the context of interpreting the literature review is located within the need to enable ECSA to have a robust policy, standard and procedures to deal with new and emergent engineering education platforms.

Accreditation refers to the assessment of an academic programme, department or institution against predetermined criteria – such as curriculum content, resources available and staff profile – to determine whether the programme meets prescribed standards of educational quality or specified minimum standards set by the accrediting body. Accreditation may be institutional or programme specific. Institutional

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 11 of 39

accreditation seeks to broadly evaluate the overall instructional operations of an educational institution, while programme accreditation evaluates the programmes that prepare graduates for specific careers or professions.


Accreditation aims to ensure and certify that graduates from these programmes are qualified and competent. Assuring prospective students and the public that graduates of an accredited institution or programme have achieved a minimum level of competence in their chosen fields of study serves as a form of consumer protection.⁶ Accreditation is also used by institutions providing such programmes as a quality assurance method and by the government for oversight purposes as a substitute for state review of the quality of accredited institutions and programmes.⁷ Finally, the increasing globalisation of manufacturing and service delivery has led to an attendant globalisation of professionals as they increasingly engage in projects around the world, collaborating on multinational teams. For this collaboration to take place effectively, participants need to communicate in a common language and have common levels of understanding. Accreditation is critical in this case as it ensures a common base of measuring and ensuring educational quality across countries. It also streamlines mutual recognition agreements among national accreditation systems in specific professions and allows branch campuses or distance education programmes to function across borders.⁸

The key principle behind accreditation is therefore to ensure that the educational processes produce graduates who are fit for the purpose, technically competent and possess the range of skills required.⁹ By providing standards by which to judge programmes, accreditation also serves to promote the inter-regional mobility of graduates and academic staff who are poised with global competitive advantage.

Professional accreditation can either be regulated or non-regulated. Regulated accreditation is mandatory and is enforced by government on behalf of the public for occupations where the public interest is at stake and needs to be ensured. The accrediting authorities are commonly determined by the government, and institutions and programmes that do not meet required standards face sanctions varying from non-eligibility for government funding/support to refusal to allow students to register for the programmes. In non-regulated accreditation, accreditation is not mandatory and is mainly done at the request

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 12 of 39

of the institution offering the programme. In such cases, non-governmental organisations, usually associations of educational institutions or professional societies may themselves carry out the accreditation as part of their services and operations. The sanction for an institution or programme that fails to meet recognition standards is loss of membership in the organisation, although this may be indistinguishable from situations where the institution simply chose not to apply for recognition. Non-governmental recognition is therefore oriented more towards improvement of standards than towards meeting minimum standards.⁷

An accreditation process needs to map the qualities required from a graduate of a programme to several aspects of the educational programme that produces them. The aspects include the objectives of the programme, the resources and staff in the programme, and its content and delivery methods.

2.2 Accreditation policy considerations

2.2.1 ECSA's policy posture


ECSA's e-series documentation is instructional as to what the current policy posture is on Education platforms and programme Accreditation. E-series documents 01 (defines the accreditation system), 02 (defines the standards for accreditation), 03 (defines the accreditation criterion), 10 (defines the policy of accreditation) and 14 (defines the reporting requirements) have a direct bearing on understanding the consequential impacts of the new and emergent engineering education platforms.

E-10-P provides a foundational starting point that creates space for the expansion of educational platforms to accommodate emerging trends. The policy documents a set of principles that are critical to responding to the objectives of this report, namely (a) determining the critical elements of an engineering education platform to satisfy current accreditation policies and/or proposed amendments informed by research and (b) a gap analysis on ECSA's Engineering programme for Engineering.

The following set of principles on (a) New Programmes, (b) Recognition of Autonomy of education providers, (c) Obligation to provide evidence of compliance with accreditation criteria, (d) Material change during a period of accreditation and (e)

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 13 of 39

Distance education programmes, reveal the posture and extent to which the ECSA accreditation policy can deal with new and emergent trends in engineering education platforms, as follows:

- (a) New programmes – the policy sets out the limits of ECSA’s role to only assist the Higher Education Quality Committee (HEQC) of the Council on Higher Education (CHE). This is an important principle as it delineates between New Programme (CHE responsibility) and existing or approved Programme accreditation (ECSA responsibility).
- (b) Recognition of autonomy of education providers – for the purposes of this report, the critical element in this principle sets out the respect of education providers to determine the design of programmes to satisfy prescribed standards, to develop teaching and learning processes to achieve the required quality and to deploy adequate resources to meet these goals. The development of teaching and learning processes can be graded from level 1 to 5 of blended format/type variations as dealt with in section 2.1.1 On-line education, or classified under synchronous or asynchronous format/type of new and/or emerging engineering education platform.
- (c) Obligation to provide evidence of compliance with accreditation criteria – the responsibility of demonstrating adherence to the accreditation criteria is established to be that of the education service provider. This is essential as it sets out that irrespective of the mode or approach to teaching and learning processes (including new or emergent education platforms, because the choice is the education provider’s to determine) deployed, it must muster compliance with the accreditation criteria.
- (d) Material change during a period of accreditation – within this principle, the policy places the responsibility on the education provider to notify ECSA if the following set of changes occurs in the programme:
 - Programme structure
 - Content
 - Outcome assessed
 - Educational process.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 14 of 39

The latter relates to the manner in which teaching and learning is delivered, and indicates the accommodative posture of the policy to consider the expansion of educational platforms deployed by education providers in an effort to accommodate emerging trends.

(e) Distance education programmes – this principle reiterates the policy position that education programmes must satisfy all accreditation criteria and goes further, singling out Criterion 3 for special consideration as follows by the accreditation team:

1. Assess the effectiveness of the distance delivery platform.
2. Assess the adequacy and effectiveness of face-to-face learning support.
3. Establish the provider's ownership of full responsibility for quality assurance of the programme, including activities at remote sites.


In this policy principle, ECSA's accreditation policy has taken a position on the need for *effective face-to-face learning support* which entrenches the concept of presence that is applied differently by the three types of on-line education platforms. This suggests that the policy is accommodative to two of the three types/formats of on-line education platforms, namely, synchronous and blended, but excluding the asynchronous type/format. It is important to reflect on the point made in section 2.1.1 dealing with the concept of presence under online platforms that sets out a parameter as follows: "*Online learning should never be considered in isolation, but as a component of the overall learning experience*".⁵ This suggests that the synchronous only (fully online) type/format of on-line education platform will also not meet the accreditation policy requirements, alongside the reviewed literature and research outcomes. The blended approach remains the only viable on-line education platform to deliver teaching and learning processes that would satisfy the accreditation policy principles. This acknowledges that the current accreditation policy is silent on on-line education platforms and only extrapolates from the policy principles to establish posture and accommodativeness towards on-line education platforms.

2.2.2 Engineers Australia's accreditation policy posture

The engagement with ECSA's counterpart Engineers Australia (EA) provides a clear sense of the possible; as a member of the Engineering Alliance, it shared its policy, standards

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 15 of 39

and procedures. Engineers Australia's policy posture is more expansive than ECSA's to the extent that its accreditation policy is explicitly accommodative to emergent educational platforms (on-line educational platforms). Under section 9 of its Accreditation Management System – Accreditation Principles – 01 (AMS-POL-01), the policy principle reads as follows;

9 Accreditation of Programmes Delivered Off-Campus

9.1 Background

Engineers Australia recognises that educational techniques are continually advancing. At the same time, students are demanding increasing flexibility in how and when they engage with tertiary education. Some students enrol in combination of on-campus, off campus and on-line courses, where such options are available.

Engineers Australia also recognises that campus-based tertiary education uses an ever-expanding range of on-line technologies for all aspects of the educational process. On-campus students frequently 'attend' classes by watching recordings of lectures, and engage in on-line supported group work. Most assessments are now submitted on-line.

Engineers Australia wishes to encourage and promote new approaches to learning and teaching, limited only by the requirement that knowledge and attributes appropriate for entry to professional engineering practice can reliably be shown to have been attained by all graduates of the program.


Accordingly, Engineers Australia is not unnecessarily prescriptive about particular criteria that might apply to off-campus or on-line education, or any combination of study modes. It does, however, reserve the right to investigate in depth how stated program outcomes are actually achieved in practice.

Engineers Australia will consider for accreditation entry to practice programs offered in any mode of study, or combination of modes. Where there are parallel on-campus and off-campus modes, and a common program award title and content, these will be treated as alternative pathways in a common accreditation process.

9.2 Policy on Accreditation of Programmes delivered Off-Campus

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 16 of 39

Off-Campus study modes may be denoted by such terms as external, distance, on-line, and flexible. Their common aspect is that students are required to spend zero or minimal physical time on a campus of the Education Provider. Nevertheless, off-campus students should have equivalent learning experiences to those of on-campus students, including engagement with fellow students and teaching staff, a full range of experimental and project work, and opportunities to provide feedback on their educational experiences.

Programmes offered in off-campus modes are subject to the same accreditation processes and requirements as campus-based programmes. Each programme and pathway will be considered on its merits against the accreditation criteria.

2.3 Engineering pedagogy


Engineering has been described as the professional art of applying science to the optimum conversion of the resources of nature to the uses of humankind. To borrow from the Engineering Council for Professional Development in the United States, as the creative application of “scientific principles of design or develop structures, machines, apparatus, or manufacturing processes, or work utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behaviour under specific operating conditions; all as respect an intended function, economics of operation and safety to life and property”.¹⁰

This aptly puts into perspective the great body of special knowledge preparation for professional practice involved, requiring extensive training (teaching and learning) in the application of that knowledge.

Recognising the role of pedagogy, it becomes crucial to explore the role of education theory, approaches to engineering pedagogy and experiential learning to have a context for interpreting the various concepts as they interact with the new and emergent engineering education platforms. This will inform the unpacking of the critical elements an on-line engineering education platform should have to meet the accreditation criteria.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 17 of 39

2.3.1 Role of education theory

Education theories born out of educational psychology are made up three basic branches, namely traditional, cognitive and structural theories. The prevailing literature and research have clear instructional outcomes that suggest certain pedagogical approaches (application of a particular education theory) which can deliver effective teaching and learning when using on-line platforms (new and emerging education platforms). considering the policy principles of ECSA's Accreditation Policy (E-10-P) under section 2.2 above, as they deal with the autonomy of service providers to determine and adopt their own teaching and learning approach, there is requirement to provide evidence to compliance to accreditation criteria and as well as to report material changes in their education processes. It therefore becomes pivotal to unpack the choices of teaching and learning the service providers are exercising, appreciate what prevailing literature and research on this affirms which of the pedagogical approaches work in tandem with the new and emerging (on-line) platforms.

Traditional theory (Behaviourist)


Traditional theories, also known as *mental-discipline theories*, advocate that the teaching of anything is not for itself but for what it trains. The mode of learning is based on imitation and memorising with heavy emphasis on the intellectual authority of the teacher. It has been likened to the Socratic method of question and answer. Sub-theories under the traditionalist approach, where the teacher (lecturer) is the centre of the process of teaching and learning, *teacher centred*, are the naturalistic and apperception theories.

Cognitive theory (Constructivist)

Cognitive theory is concerned with knowing and thinking, which advocates that the complete act of thought follows a fairly common sequence, as follows: arousal of intellectual interest; preliminary exploration of the problem; formulation of ideas, explanations or hypotheses; selection of appropriate ideas; and verification of their suitability. The key in this theory is that the process of teaching and learning is *learner centred*. The role of the teacher (lecturer) is to pace development and not outstrip it, firstly by recognising the growth in quality of intellectual activity and capitalisation on

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 18 of 39

the knowledge by organising instruction to anticipate the next stage of development but does not wait for it. Secondly, by performing the function of optimum sequencing and pacing learning.¹² A sub-theory is maturation and readiness, which emphasises the maturation and readiness assessment, which in turn must inform the decision of whether a learner is ready by observing the periods of sensitivity corresponding to certain ages when the learner's interest and mental capacity are best suited to acquiring knowledge. This sub-theory finds expression in prevailing literature and research, without it being explicitly mentioned, on the appropriateness of synchronous and blended on-line platforms being effective for undergraduate engineering programmes.¹¹

Structural theory is concerned with the structural nature of cognitive learning, to the extent that teaching should not be contrived and or artificial. Its pedagogical approach is premised on the structured wholeness of the experience. It affirms that every area of human knowledge has its own knowledge structure, is composed of its concepts and their relationships and has its own basic modes of progress. To this end it is learner, centred, thus physics should be thought of as a physicist views it, at an instructional/teaching level. This theory has not been successfully translated into actual practice.¹²

The two prevailing thrusts in pedagogy centre on traditionalist (behaviourist) and cognitive (constructivist).

The prevailing literature and research on the compatibility of the two prevailing pedagogical thrusts with on-line engineering education platforms present an odd picture where the teacher-centred, traditionalist approach is still dominant, even though research indicates dubious benefits from sticking with the traditionalist approach.¹³ The instructive conclusions are that the constructivist approach is vital for on-line engineering education platforms to deliver against five levels of measurement on the effectiveness of teaching and learning. The performance of constructivist versus traditionalist approach delivers as follows:


Level 1: Reaction and student satisfaction with a course

Level 2: Learning, changes in knowledge, skills and attitude

Level 3: Application, changes in the on-the-job behaviour (from level 3 to 5, please note the bias of application to post-graduate engineering courses)

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 19 of 39

Level 4: Business impact, changes in business impact variables

Level 5: Return on investment and benefits against costs.¹⁴

2.3.2 Experiential learning game theory application

The question of maturity and readiness of students in undergraduate programmes versus postgraduate students, as introduced in the sub-theory under constructivism, is contested in prevailing literature and research. The current and most prolific application of on-line platforms in engineering education, using either synchronous or blended types (approaches), is for post-graduate programmes, certificate programmes¹⁵. This demonstrates the apprehensiveness or not knowing how to deliver effective teaching and learning for undergraduate programme students, who have been characterised as a grouping that will by and large apply minimum effort needed to reach their goals.

The under-graduate question


The available literature and research on this question applied game theory to unpack this question and offer its instructive conclusions. Game theory, which is a branch of applied mathematics, has been successfully applied in Economics and Political Science, while it is seldom used in the pedagogical research as a quantitative tool for analysing and designing effective pedagogical practices. The literature introduced a game theoretical model for modelling the strategic interaction between teacher and students. In short, the literature demonstrated how the uses of mechanism design technique transfer the game equilibrium into one that fosters constructivist experiential learning, using a 2x2 non-cooperative model.

The model affirmed that constructivist pedagogy is a suitable framework for engineering education. The point question on how you move from the problematic disposition of undergraduate students doing the minimum needed to achieve their goal (pass) to a state where they raise their effort levels to match the motivational state (maturity and/or readiness) of postgraduate students, was answered by the Experiential Learning Model (ELG), when it was established.¹⁶

The effort can be raised well above minimum effort, if constructivism, *learner centred*, is adopted and this would resolve the maturity and readiness question.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 20 of 39

The literature and research have mapped a set of parameters and pathways (that become pivotal in determining the critical elements of an on-line programme for accreditation) that would enable effective teaching and learning by adopting a particular approach to pedagogy, while exposing the limitations of the prevailing traditionalist approach for undergraduate students in utilising on-line engineering education platforms.

2.4 Critical elements of an on-line engineering education platform

Regarding ECSA's regulatory function, it becomes paramount to explore and understand what ECSA should consider as the critical elements of on-line platforms. This consideration of prevailing literature and research needs to account for management requirements and remote lab approaches.


2.4.1 Management requirements

The planning, design and delivery of on-line programmes is predicated on having a strong Learning Management System (LMS) that caters for visibility and management of contact details of staff and support; course information; course material; structure of the course; course calendar; assignment scheduling; laboratory scheduling; discussion board submissions, study tips, time and self-management skills; policies and procedures.¹⁷ The literature is emphatic on what constitutes the characteristics of a successful on-line learning programme that is built around the Delphi process.¹⁸ It identifies five broad areas that cover 37 criteria as follows:

1. *Assessment of students* to cover: quick access to grades; tracking of individual responses (such as time and location); provision of rating criteria and scale for discussion board posting thus allowing the instructor to immediately rate a student's contribution; a portfolio of work for each student; allowing for ongoing assessment; easily accessible statistics on student attendance.
2. *Organisational issues*: Clear modifiable structure of the course organisation; ability to break classes into smaller discussion groups; confidentiality; easily accessible repository for instructor to store ongoing

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EEPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 21 of 39

comments of students; collaborative environment within LMS for students to add/modify or delete assignments.

3. *Synchronous features:* Synchronous real-time chat (and web-conferencing) facility for students and instructors; real-time chat facility that can be converted into an asynchronous threaded session in a discussion board.

4. *Multimedia features:* Accessibility (through the LMS) by students of video and audio recordings of presentations, discussions or demonstrations.

5. *Management utilities:* Editing capability; polling facility of students; whiteboard facility accessible by all students and instructors; on-line access to all materials (including textbooks); software assistance with identification of plagiarised documents; on-line facility for use of LMS and other tools.¹⁹

2.4.2. Laboratory work

There is a general agreement in literature that engineering education's practical hands-on, experiential laboratory work is a vital component as an applied Science. The onset of on-line engineering education platforms has brought a focus on just how the pedagogy caters for the requisite hands-on experience. In the context of ECSA's regulatory obligations to fulfil its accreditation function, graduates must have the ability to design, conduct experiments, analyse and interpret data.²


The options available for laboratory work fall into three classifications, as follows:

- Traditional/Classical labs: on location, physical presence and interaction with equipment and substances
- Remote labs: equivalent to the traditional lab environment in using real equipment but situated at a significant distance from the learner
- Simulation labs: Models the process or a learning situation, comprising simulation software running on a host machine, which can be local or remote.

Remote lab work has been demonstrated to be as effective/equivalent as traditional laboratory work²¹, including virtual laboratory work.²²

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 22 of 39

It should be noted that the prevailing literature has an emphasis on the technology required to make it work and system architectural requirements but with little on the Pedagogical implications of remote and simulation laboratories.

In the context of this limitation, this view is expressed by Steve Mackay and Darrell Fisher (2014) in *Practical Online Learning and Laboratories*, page 380; "Rather than having a one-dimensional approach, ultimately, a blended approach with a combination of remote labs, simulations and classical labs is probably the optimum solution". This presents the most realistic and pragmatic approach to extracting the advantages and mitigating the disadvantages of each option.

It is also worthwhile to note that within engineering education, the various disciplines and bodies of specialised knowledge that need to be acquired lend themselves to differing optimal blends among the available laboratory work approaches that can be deployed with on-line engineering education platforms. The observation made in the available literature and research is that the prevalence of successful deployment of both remote and simulation laboratories covered the following disciplines of Engineering:

- Electrical, Electronics and Industrial Automation Engineering
- Mechanical and Manufacturing Engineering
- Chemical and Process Engineering
- Information Technology and Computer Engineering; Nuclear Engineering
- Civil Engineering
- Mining Engineering.


2.5 Policy and Legislative Framework for Accreditation in HE System

The research work conducted by the Council of the Built Environment (CBE), in 2010, in the development of the Accreditation Policy Framework for the Professions, provided insights detailed below which enrich the context of interpretation:

In the context of the South African (SA) higher education (HE) system, accreditation is conceptualised as an element of quality assurance (QA). The Higher Education Quality Committee (HEQC) of the Council on Higher Education (CHE) defines accreditation as:

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 23 of 39

Recognition status granted to a programme for a stipulated period of time after an HEQC evaluation indicates that it meets minimum standards of quality.

The South African Qualifications Authority (SAQA) defines accreditation as:

The certification, usually for a particular period of time, of a person, a body or an institution as having the capacity to fulfil a particular function within the quality assurance system set up by SAQA (www.saqa.org.za)

The International Network of Quality Assurance Agencies in Higher Education (INQAAHE) defines accreditation as follows:

Accreditation is the establishment of the status, legitimacy or appropriateness of an institution, programme or module of study. (www.inqaahe.org)


In this regard, QA in HE in South Africa has to be understood against the backdrop of an ongoing transformation of the HE system, which started with the dawn of democracy in 1994. It is within this context that policy and legislative instruments have been developed which have shaped the HE sector and have provided the conceptual and legal basis for the establishment and work of different role players in higher education quality assurance. A brief contextualisation of the philosophy of quality assurance within the broader policy and legislative issues is therefore worthy of note.

In 1995, the first democratic government appointed a commission to advise government on the transformation of higher education in South Africa. The National Commission on Higher Education (NCHE) released its report called *A Framework for Transformation* in 1996. According to this report, quality and the role of quality assurance in a transformed higher education system were flagged prominently in the recommendations. A comprehensive, development-oriented quality assurance system was seen as central to the creation of a single coordinated higher education system.

The Education White Paper (A Programme for the Transformation of Higher Education, 1997) identified quality as a critical principle for the restructuring of HE. It stated the following:

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 24 of 39

“The pursuit of the principle of quality means maintaining and applying academic and educational standards, both in the sense of specific expectations and requirements that should be complied with, and in the sense of ideals of excellence that should be aimed at. These expectations and ideals may differ from context to context, partly depending on the specific purposes pursued. Applying the principle of quality entails evaluating services and products against a set standard, with a view to improvement, renewal or progress.” (Government Gazette, No 18207)


The White Paper therefore proposed the following:

- The primary responsibility for QA should rest with HEIs. However, an important role is foreseen for an umbrella national authority responsible for quality promotion (QP) and assurance throughout the system.
- The Higher Education Act will provide for the coordination of QA in HE through the HEQC, which will be established as a permanent CHE committee. The CHE will determine the establishment of the HEQC, its registration with SAQA and its modus operandi within the framework and procedural guidelines developed by SAQA.
- The HEQC’s functions will include programme accreditation, institutional auditing and quality promotion. It should operate within an agreed framework underpinned by:
 - the formulation of criteria and procedures in consultation with HEIs
 - a formative notion of QA focused on improvement and development rather than on punitive sanction
 - a mix of institutional self-evaluation and external independent assessment.

The White Paper further indicates that “the CHE will be a major statutory body established to provide independent, strategic advice to the Minister of Education on matters relating to the transformation and development of HE in SA, and to manage QA and quality promotion in the HE sector” through its permanent committee, the HEQC, which would seek delegated authority from SAQA for this purpose. The CHE would make the arrangements it deemed appropriate to operate within the framework and guidelines established by SAQA.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 25 of 39

2.5.1 Accreditation in the built environment

The Built Environment Act, 43 of 2000 assigns the following responsibilities to the CBE:

- Promotion of ongoing human resource development in the built environment
- Promotion of sound governance of the built environment professions
- Promotion and liaison in the built environment in the field of training
- Serving as a forum where the representatives of the built environment may discuss standards of education and training and competence
- Ensuring uniform application of norms and guidelines set by the councils for the professions throughout the built environment
- Ensuring consistent application of policy by the councils for the professions with regard to accreditation, in consultation with the councils
- Obtaining recognition for the councils for the professions as bodies responsible for the establishment of education and training standards in terms of the South African Qualifications Authority Act, 58 of 1995¹
- Promotion of coordination between the CHE and the councils for the professions in relation to the accreditation of educational institutions [of higher learning].


In exercising its mandate, the CBE coordinates the following professional councils, each of which has its own legislation outlining its mandate and regulating its scope of operation:

- (a) The Engineering Council of South Africa (ECSA)
- (b) The South African Council for the Quantity Surveying Profession (SACQSP)
- (c) The South African Council for the Architectural Profession (SACAP)
- (d) The South African Council for the Landscape Architectural Profession (SACLAP)
- (e) The South African Council for the Property Valuation Profession (SACPVP)
- (f) The South African Council for the Project and Construction Management Professions (SACPCMP).

¹ The SAQA Act, 1995 has since been repealed by the NQF Act, 67 of 2008.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 26 of 39

The six professional councils under the ambit of the CBE in general terms have the following statutory responsibilities.

- Setting and auditing of academic standards for purposes of registration through a process of accreditation of programmes at universities and universities of technology.
- Setting and auditing of professional development standards through the provision of guidelines which set out post-qualification requirements for registration.
- Prescribing requirements for Continuing Professional Development (CPD) and determining the period within which registered persons must apply for renewal of their registrations.
- Prescribing a Code of Conduct and Codes of Practice and enforcing such conduct through an Investigating Committee and a Disciplinary Tribunal.
- Identification of work that should be reserved for registered persons by the CBE, after consultation with the Competition Board.
- Advising the CBE and Minister of Public Works on matters relating to the profession and cognate matters.
- Recognition of professional associations, institutes, institutions and societies.
- Publication of a guideline tariff of fees for consulting work, in consultation with government, the profession and the industry.


2.5.2 Engineering Council of South Africa

Established in terms of the EPA, ECSA is among the oldest and most experienced professional councils in South Africa. The EPA gives responsibility over to ECSA to accredit university engineering programmes, subject to the provisions of sections 5 and 7 of the Higher Education Act, 101 of 1997. ECSA started working with the HEQC as soon as the HEQC's establishment in 2001 by inviting it to site visits and other activities.

Discussions were held for ECSA to align its accreditation system with that of the HEQC, a process that started in 2005 and was finalised in 2006, after which a Memorandum of Understanding (MoU) was signed between the two organisations on 7 November 2006.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 27 of 39

ECSCA accreditation system

ECSCA has the following key definitions in relation to accreditation:


- **Accreditation** is awarded through a quality assurance procedure to give formal recognition to an education or training programme that meets criteria laid down for the type of programme.
- **Accreditation criteria** are the requirements that indicate a programme is of adequate quality, including the structure, learning outcomes achieved, educational process and resourcing as well as sustainability. Table 1 below shows the criteria used by ECSCA in assessing and identifying different areas and relevant aspects in meeting the required quality levels.
- **Accredited Programme:** a programme that has been evaluated and recognised by ECSCA as meeting stated criteria.
- **Accredited Qualification:** a qualification awarded on successful completion of an accredited programme.

Table 1: ECSCA accreditation criteria

Criterion no.	Area	Relevant aspects
Criterion 1	Credits, Knowledge Profile & Coherent Design	<ul style="list-style-type: none"> • Total credits specified at appropriate standard. • Knowledge profile defined. • Appropriate purpose of the programme. • Programme designation in line with programme purpose. • Rules of combination with clear vertical and horizontal articulation.
Criterion 2	Assessment of Exit Level Outcomes or Graduate Attributes	<ul style="list-style-type: none"> • Graduates satisfy outcomes. • Documented assessment criteria. • Assessment policies and procedures.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 28 of 39

Criterion no.	Area	Relevant aspects
Criterion 3	Quality of Teaching and Learning	<ul style="list-style-type: none"> • Effective programme coordination. • Teaching and learning strategy in line with programme outcomes. • Effective monitoring of learning progress of students. • Academic development provided. • Independent learning supported by a mix of teaching & learning methods. • Monitoring of student retention and throughputs. • Effective work-based learning and placement programme with mentoring opportunities, where applicable.
Criterion 4	Resourcing and sustainability of the programme	<ul style="list-style-type: none"> • Effective allocation and utilisation of resources. • Equity and diversity of staff and students. • Appropriately qualified and experienced academic staff with relevant research output. • Sufficient physical, IT, financial and human resources. • User surveys, reviews and impact studies. • AD staff qualified.
Criterion 5	Response to previously identified shortcomings	<ul style="list-style-type: none"> • Capacity for improvement. • Programme review.

The contextualisation of the legislative framework above confirmed congruence with ECSA's policy on accreditation, and it allows for the determination on whether the new and emerging (on-line) engineering education platforms can satisfy the accreditation criteria. This will become the focus of the discussion, conclusions and ultimate recommendations for ECSA's consideration.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 29 of 39

3. RESEARCH METHODOLOGY

The research was set out as a combination of both qualitative and quantitative methods in establishing population parameters in South Africa. The research also subjected itself to an ethical clearance process as guided by the Singapore Statement on Research Integrity, adopted in July 2010, at the Second World Conference on Research Integrity. The application and subsequent approval by a competent authority addressed the following five areas:

1. Respecting autonomy

- All participants identified in the random sample size were presented with a cover note informing them of the purpose and freedom to decide on participation, which would be signed off by the CEO of ECSA as a control measure.
- In respect of providing rigorous and appropriate procedure for confidentiality, including anonymization, ECSA's IT platforms protected the identity and anonymity of participants.

2. Maximising benefit


- In respect of effectively and appropriately disseminating the Research, ECSA will reserve the rights of the research product and as the regulator of the Engineering profession within South Africa, will be best placed to effectively and appropriately disseminate the research, as well as approve any recommendation(s) made in order to realise maximum benefit for the Engineering Profession in South Africa.

3. Minimising harm

- In respect of possible Risk(s) the research may raise, and where harm is unavoidable, the research did not present any Risk(s) that will require consideration in terms of appropriateness and acceptability.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 30 of 39

4. Being fair

- The research did not unfairly discriminate against certain groups and/or individuals and/or institution(s). The limitation in respect of the adequacy of the accreditation list being used in ECSA currently, in so far as covering all institutions offering an engineering program, has been ameliorated by sourcing (1) Both schedules of Private and Public institutions offering engineering from CHE and QCTO, (2) Engagements with all affected stakeholders and (3) All identified institutions with viable distribution offering Engineering programme were subjected to a simple random selection technique in a stratified manner recognising the different type of institutions of higher learning in South Africa.

5. Behaving with Integrity (no conflict of interest)

- The research exercise has observed with integrity the various engagements with institutions of higher learning, state actors, interested parties and other regulators, to an extent that they did not interfere with the research process, infer other objectives outside the purpose of the research and unduly influenced the research process. Engagements have been confined to information sharing on the project, observation status and role in the conduct of ECSA's accreditation mandate and no direct, including indirect participation by any of the affected parties in the **Research.**

3.1 Quantitative considerations for the survey


The research used a stratified random sampling in the population of institutions of higher learning offering engineering programmes in South Africa. The stratification was between the public and private institutions and Technical and Vocational Education and Training (TVET) Colleges.

The research placed a premium on having representative samples and as a consequence of this, the sample size variables were as follows:

- The margin of error was set at 5%.
- The confidence level was set at 95%.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 31 of 39

The management and design of the data collection processes went through the following stages:

- Question specification
- Scale specification
- Sampling design
- Population determination, sample size determination
- Data collection decision processes.

3.2 Qualitative considerations from the Literature Review (Chapter 2)

The research focused on explaining concepts and relationships between concepts extracted from the Literature Review.

The research set out to extract empirical observations from the referenced literature and draw correlation deductions, coupled with the Quantitative Survey Sample outcomes to respond to the objects set out by ECSA and ascertain whether the new and emergent platforms (on-line) in engineering education programmes can meet the accreditation criteria.

3.3 Survey responses

The responses were subjected to a statistical significance calculation to establish credibility and usability in the context of the established margin of error and confidence level.


The response rate was poor, with some spoilers. The public institutions' response rate was 17% (3 out of 17), the private institutions' response rate was 0% (0 out of 19) and the TVETs' response rate was 1.7% (6/334).

For the responses to be usable and statistically significant, they need to be equal or less than the 5% margin of error at a 95% confidence level.

The margin of error calculation for public institutions was 52.93% and TVETs was 39.71%, which rendered the results of the survey unusable.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 32 of 39

The implication was that no credible extrapolation could be done from the quantitative survey, which has meant the research had to rely on the qualitative element to draw conclusions and make recommendations for ECSA.

4. DISCUSSION AND CONCLUSIONS

In presenting the discussion, it was important to frame it around the objects ECSA outlined in the commission of this research, to inform conclusions and recommendations on **whether on-line engineering education platforms can meet the accreditation criteria.**

Engineering education platforms

In determining the current emerging engineering education platforms available locally and internationally, the research has established the following:

- There are three types of available platforms: asynchronous, synchronous and blended, which are branded by various services providers; however these constitute the suite of basic descriptors of what is available.
- In being effective for engineering education, the blended approach is advocated by research and literature.
- There are five levels of the blended platform that can be adopted for engineering education, where the use of face-to-face engagement is used. These can be applied with varying levels of synchronous platform adaptation in a progressive manner to the highest level of pure synchronous use, method of which is not advocated. This leaves levels 2 to 4 as acceptable blend adoptions.
- The asynchronous platform is only acceptable as a support platform to both synchronous and traditional face-to-face engagement; it cannot be stand alone.


Critical elements to satisfy current accreditation policy

In determining the critical elements of an Engineering education platform to satisfy the current accreditation policy, the research established the following:

- A constructivist approach (cognitive theory) to engineering teaching and learning delivers the most effective results and is most suited to acceptable on-line engineering education platforms.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 33 of 39


- While the behaviourist approach (traditionalist theory) is the prevailing default teaching and learning process in practice, it cannot translate to effective teaching and learning in under-graduate Engineering programmes which require a constructivist approach to raise the effort levels of undergraduate students to a comparative level to postgraduate students (as demonstrated by the game theory experiential learning research) and address the “Maturity and Readiness” apprehension in the deployment of on-line platforms in undergraduate Engineering programmes.
- The level of adoption, from level 1–5, by an engineering programme would need to be established to be able to assess it against the accreditation policy.
- A Learning Management Systems (LMS) is a critical component in dealing with planning, design and delivery of on-line platforms. The LMS has to have a minimum of five areas of functionality covering: (1) Assessment of students, (2) Organisational management of the platform, (3) Synchronous features, (4) Multimedia functionality, and (5) Management utility.
- Engineering as an applied science needs to have practical hands on experiential laboratory work, even though to differing degrees as dictated by the requirements of the various branches of engineering.
- On-line engineering platforms have mainstreamed remote and simulation laboratories.
- Remote labs have demonstrated to be as effective/equivalent to traditional/classical laboratories.
- However, the research has revealed that the most pragmatic approach requires a blend of remote, simulation and classical laboratories to extract the advantages and ameliorate the disadvantages among the blend of available laboratory formats.

Gap analysis of accreditation policy

The comparative analysis between ECSA’s and EA’s Accreditation policies, both being IEA members, revealed a difference in terms of policy posture on on-line engineering education platforms.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 34 of 39

- EA's policy posture is explicitly accommodative of on-line platforms, while ECSA does not accommodate it explicitly in its accreditation policy.
- The accommodation of on-line platforms does not exempt it from the requirements set out in the accreditation criteria.


Amendments and/or the development of new policies

The proposal of amendments and/or new policy development in line with research has considered gap analysis, critical elements and determination of on-line platforms available. To contextualise the proposals, they will be framed around the accreditation criteria, so the efficacy of accreditation is maintained. The examination of the accreditation criteria and policy principle assert the responsibility of the service providers to demonstrate how the respective programmes meet the accreditation criteria. The conclusion is drawn, on the balance of available literature and research, that section 5 of the accreditation policy is affected, and similarly that accreditation criteria 2 and 3 are affected, as they have a direct relation to *Teaching and Learning processes* as impacted by the emergence of on-line engineering education platforms.

- The policy amendments should extend beyond criterion 3, which has been explicitly singled out for "Distance Education", to include criterion 2.
- Criterion 2 will need to consider the changes brought to bear on assessment tools developed for the assessment of policies and procedures in respect of *Teaching and Learning processes*, so that the commitment to the development and recognition of good practice in engineering education is observed.
- In respect of criterion 3, the same would need to be done and developed for standards and procedures to enable effective assessment of: (1) Programme coordination (i.e.: LMS tools adequacy), (2) Teaching and Learning Strategy in line with outcomes (congruence between adopted teaching and learning approach with adopted level of blended level 2–4 adoption), in particular for under-graduate programmes.
- Not all on-line engineering education platforms can meet the accreditation criteria.
- Only the blended approach, up to level 4 of blended adoption, can meet the accreditation criteria and should be endorsed by the policy.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 35 of 39

- The adoption of a constructivist approach to teaching and learning processes enables effective teaching and learning outcomes.

5. RECOMMENDATIONS

ECSA is enjoined in a process of development and recognition of good practice in engineering education. To this end, it needs to stay abreast of developments, maintain the relevance of its regulatory function and uphold the efficacy of the profession.

The recommendations detailed below are informed by the research, as outlined herein, as follows:


5.1 The accreditation policy E-10-P, under section 5, should be extended to include 5.10 to explicitly cater for on-line engineering education programmes.

5.2 The accreditation policy's recognition of on-line engineering education programmes must be accompanied by a specific set of standards and procedures, including development of training manuals for assessors and service providers that should specifically deal with the following:

- Which type of on-line platforms will be accepted by ECSA, while respecting the autonomy of institutions of higher learning
- Which *“Teaching and Learning processes”* would be encouraged in the use of on-line platforms by institutions of higher learning
- Which mixture of laboratory platforms would be supported among the branches/ disciplines of engineering, if using an accepted on-line education platform.

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 36 of 39

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 37 of 39

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Document No.: N/A	Revision No.: 0	Effective Date: 11 June 2020	
Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 38 of 39

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Engineering Education Programme Accreditation (EIPA) Research Project			
Compiler: MA Dienga	Approving Officer: EL Nxumalo	Next Review Date: N/A	Page 39 of 39

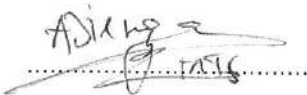
REVISION HISTORY

Revision number	Revision date	Revision details	Approved by
Draft A	30 November 2019	Receipt final draft from the consultant	EL Nxumalo
Draft B	25 January 2020	Customisation to ECSA format and preparation for approval by RPSC	EL Nxumalo
Revision 0	21 May 2020	Consideration and approval	RPSC
Revision 0	11 June 2020	Consideration and approval	Council

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Engineering Education Programme Accreditation (EIPA) Research Project

Revision 0 dated 11 June 2020 and consisting of 39 pages reviewed for adequacy by the Business Unit Manager and is approved by the Executive: Research, Policy and Standards (RPS).



Business Unit Manager

12.06.2020

Date



Executive: RPS

13/08/2020

Date

This definitive version of this policy is available on our website.

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