For Engineering Excellence

REVIEW OF SOME REQUIREMENTS FOR REGISTRATION OF ENGINEERS

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1.0 Introduction.

According to Paul Wright, 2000, engineering is a profession in which knowledge of the mathematics and natural sciences, gained by study, experience, and practice, are applied with judgement to develop ways to utilize, economically, the materials and forces of nature to the benefit of mankind. Engineers figure out how things work and find practical uses for scientific discoveries. Scientists and inventors often get the credit for innovations that advance the human condition, but it is engineers who are instrumental in making those innovations available to the world.

In his book, "Disturbing the Universe" (Sloan Foundation, 1981), physicist Freeman Dyson wrote, "A good scientist is a person with original ideas and a good engineer is a person who makes a design that works with as few original ideas as possible".

The field of engineering has also been defined by the Engineers Council for Professional Development, in the United States of America (USA), as the creative application of "scientific principles to design or develop structures, machines, apparatus, or manufacturing processes, or works utilizing them singly or in combination; or to construct or operate the same with full cognizance of their design; or to forecast their behavior under specific operating conditions; all as respects an intended function, economics of operation and safety to life and property."

Standards of engineering practice are maintained through the efforts of professional societies, usually organized on a national or regional basis, with all members acknowledging a responsibility to the public over and above responsibilities to their employers or to other members of their society.

All engineering definitions as described in the preceding paragraphs agree that engineering requires; i) in-depth knowledge of mathematics and natural sciences, and ii) preparation for professional practice by involving them in extensive training in the application of that knowledge.

2.0 Problem statement

Persons without first degrees in engineering but who later acquire post graduate engineering degrees have been applying to register as engineers but their applications have been turned down on grounds that their first degrees are not in engineering. Some of these persons have studied mathematics and natural sciences in their first degrees and added post graduate qualifications in engineering related fields (specialization), have had practical experiences in their fields of specialization, but still their applications to register as engineers have been rejected.

There is another category of applicants who did not follow the normal education progression, that is, direct entry for holders of A-Level and Mature Age Entry, both of which join into the first year and take four years (eight semesters and three recess periods of Industrial Training) but used the Diploma Entry into the first year or second year and third year depending upon the level and class of diploma. Some of these too have been denied registration.

This paper has been prepared to shed light on this predicament- rejection to register as engineers on grounds of first degree not in engineering, and either or exempting one year or two years in the engineering course, analyze engineering functions, analyze the minimum requirements for one to register, look at training of engineers in Uganda, non-traditional engineering fields, and to propose and make recommendations to ERB and UIPE, and prayers thereto.

3.0 Engineering Functions

Problem solving is common to all engineering work. The problem may involve quantitative or qualitative factors; it may be physical or economic; it may require abstract mathematics or common sense. Of great importance, however, is the process of creative synthesis or design, putting ideas together to create a new and optimum solution.

Although engineering problems vary in scope and complexity, the same general approach is applicable. First comes an analysis of the situation and a preliminary decision on a plan of attack. In line with this plan, the problem is reduced to a more categorical question that can be clearly stated. The stated question is then answered by deductive reasoning from known principles or by creative synthesis, as in a new design. The answer or design is always checked for accuracy and adequacy. Finally, the results for the simplified problem are interpreted in terms of the original problem and reported in an appropriate form.

In order of decreasing emphasis on science, the major functions of all engineering branches are the following:

i. *Research*. Using mathematical and scientific concepts, experimental techniques, and inductive reasoning, the research engineer seeks new principles and processes.

ii. *Development*. Development engineers apply the results of research to useful purposes. Creative application of new knowledge may result in a working model of a new electrical circuit, a chemical process, or an industrial machine.

iii. *Design*. In designing a structure or a product, the engineer selects methods, specifies materials, and determines shapes to satisfy technical requirements and to meet performance specifications.

iv. *Construction*. The construction engineer is responsible for preparing the site, determining procedures that will economically and safely yield the desired quality, directing the placement of materials, and organizing the personnel and equipment.

v. *Production*. Plant layout and equipment selection are the responsibility of the production engineer, who chooses processes and tools, integrates the flow of materials and components, and provides for testing and inspection.

vi. *Operation*. The operating engineer controls machines, plants, and organizations providing power, transportation, and communication; determines procedures; and supervises personnel to obtain reliable and economic operation of complex equipment.

vii. *Management and other functions*. In some countries and industries, engineers analyze customers' requirements, recommend units to satisfy needs economically, and resolve related problems.

The current structure of the technical report requires the applicant to prepare a report that has functions from design through to commissioning. This is applicable in part to civil engineering projects where one goes through the stages of design, construction, commissioning and maintenance. In electromechanical area, an engineer may be employed in the operations or production functions only right from the university without ever getting involved in other functions of say research, development, design, etc. However, it has been demanded that the applicant must include the functions of design through to commissioning and maintenance when preparing a technical report.

The applicants in trying to fulfil this requirement - of including functions of design, construction, operations, etc, - have attempted in their technical reports to include all these functions. Because some of these functions have not been part their routine, the engineers' involvement in these functions in the technical report have been wanting and therefore a source of rejections of technical reports.

There are two modes of reports, the project mode and the systems mode. In the project mode, the individual may be involved in many functions, say from design, implementation, commissioning, etc. In the systems mode, the individual is involved in one function say, design, or production, or operations.

The cure to this predicament - of including the many functions in the technical report even where the applicant has not been personally involved - is to have a technical report only on functions where the applicant has been involved – the systems mode. If the applicant is involved in the operations function, then the technical report should include all the components of operations and should therefore be evaluated on those grounds. If the

applicant is in production, then the report should include all components of production, like it is the case in research function where the applicant's technical report includes only components of research and is evaluated on those grounds.

4.0. Requirement for Registration of Engineers in Uganda

All registrations are undertaken by the Engineers Registration Board which is a statutory body established through an Act of the Ugandan Parliament in 1969 revised in 1977. The board was given the responsibility of regulating the activities and conduct of practicing engineers in accordance with the functions and powers conferred upon it by the Act. Under Cap 271 of the Laws of Uganda, it is illegal for an engineer to practice or call himself or herself an engineer if not registered with the Board. Registration with the Board is thus a license to practice engineering in Uganda.

A candidate qualifies to register as an engineer, R.Eng., if he/she is a holder of a minimum four years post-secondary engineering education and a minimum of four years of postgraduate work experience.

Section 20 of the Engineers Registration Act 1969 gives qualifications required for registration of engineers and entitlements for one to register.

1) A person shall be entitled, on making an application to the Board in the prescribed manner and on payment to the Board of the prescribed fee, to be registered under this Act and to have his or her name entered in the register if he or she is;
    a. a corporate member of the Uganda institution of Professional Engineers (UIPE), the membership of which is recognized for the time being by the Board as furnishing a sufficient guarantee of academic knowledge of, and practical experience in, engineering; or a person who has attained the age of twenty-five years and who; b) is the holder of a degree of a university or school of engineering which may be recognized for the time being by the Board as furnishing a sufficient guarantee of an adequate academic training in engineering; (c) has had at least two years' adequate postgraduate practical training as an engineer and has had at least two years' experience in a position involving responsibility as an engineer; but the board may, at its discretion, accept any additional period in a position of responsibility as an engineer in excess of two years in substitution for the two years' practical training; and is a member of the Institution.
2) The Board may require an applicant for registration under this Act to satisfy that his or her professional and general conduct has been such as, in the opinion of the board, to make him or her a fit and proper person to be registered under this Act, and the Board may direct the registrar to postpone the registration of an applicant until so satisfied.
   From the foregoing, there is no mention in this Act of the **first** degree in engineering. The understanding is that the degree may be the first, second or third as long as it is an

engineering degree accompanied by minimum of four years of postgraduate work experience. However, in practice, the first degree in engineering has been preferred.

5.0. Teaching Engineering Programmes

Engineering education is the activity of teaching knowledge and principles to the professional practice of engineering. It includes an initial education and any advanced education and specializations that follow. Engineering training in Uganda is typically provided by the universities and technical institutes. Engineering is one of the cornerstones of STEM education, an interdisciplinary curriculum designed to motivate students to learn about science, technology, engineering and mathematics. Engineering education is typically accompanied by additional post-graduation supervised training as the requirements for a professional engineering certificate.

All engineering programmes in universities are accredited by the National Council for Higher Education (NCHE) after involving the professional body (a Joint accreditation committee of UIPE and ERB). The engineering programme curriculum document should, as a minimum, include sections on the introduction, enrollment in the programme, structure of the programme, examinations, assessment and grading, progression, programme matrix, and course units description, graduation requirements including minimum credits to qualify for graduation, among others.

The introduction section should clearly indicate among others, the background, the programme rationale, programme goal, programme objectives, learning outcomes, and employment opportunities. The enrollment into the programme section should clearly indicate requirements for admission. The section on structure of the programme should clearly indicate programme duration, programme composition, and industrial collaboration among others. The examination, assessment and grading section should clearly show how a student is assessed in both course work and research/dissertation, industrial collaboration, and grading of marks among others. The progression section should clearly show normal progress, probational progress, retaking courses and programme trajectory among others. The programme structure section should clearly show the course coding and course weighting.

The programme matrix section should clearly indicate course unit code and name, the Lecture Hours (LH), Tutorial Hours (TH), Practical Hours (PH), Field work Hours (FH), Contact Hours (CH) and Credit Units (CU). It should indicate the total CU at semester level, academic year level as well as the total graduation load i.e.CH, and CU. The courses should be arranged chronologically starting with Year One, Semester One through to the last year, Semester Two.

The course description section should clearly indicate the course units description, courses objectives, and courses learning outcomes, and detailed descriptions for each course showing the topics for each course and their total lecture hours, tutorial hours, practical hours and field work hours, mode of delivery and mode of assessment among others.

With these details provided, one can ably evaluate whether the applicant has in-depth knowledge of mathematics and natural sciences, and professional extensive training in the application of that knowledge to practice engineering.

5.1 Entry into the Faculty of Engineering, A case of Kyambogo University

i. Kyambogo University gives the opportunity to people who dropped out of school for reasons other than the academic ability to develop their full potential.

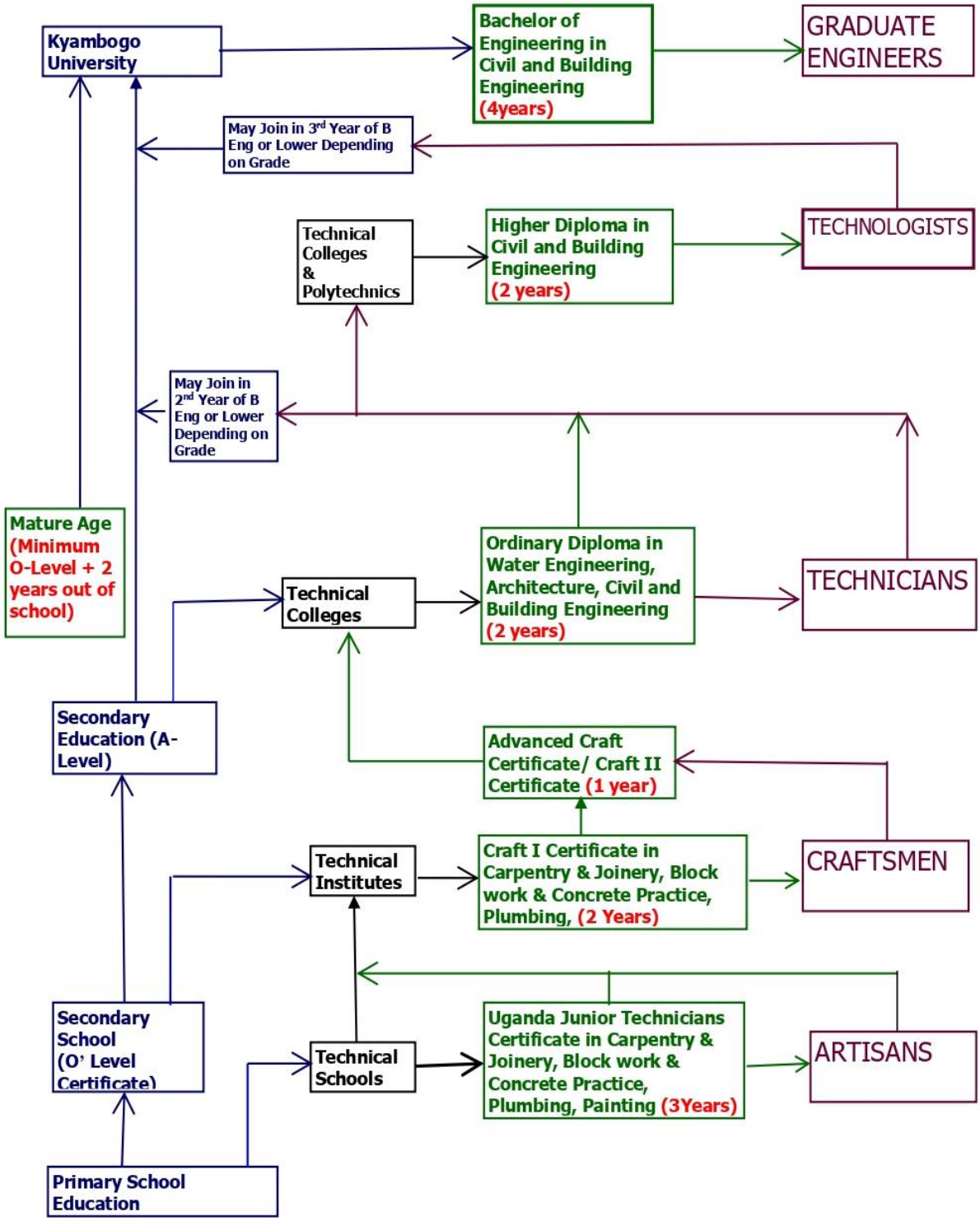
   For example, Figure 1 shows the routes available for one to acquire a bachelor's degree in civil and building engineering at Kyambogo University. In engineering profession, upward movement from lower cadre to higher cadre is allowed provided the concerned engineering personnel has attained higher qualifications and satisfies the professional body's requirements.

ii. There are three basic routes to joining the programme. The Direct Entry for holders of A-Level and Mature Age Entry both of which join into the first year and take four years (eight semesters and three recess periods of Industrial Training).

iii. The Diploma Entry into the first year, second year and third year depending upon the class of diploma. Someone with a Credit or Upper Second-class Higher Diploma in Civil Engineering may be admitted into the 3rd year of the B.Eng, while one with a Credit or Upper Second-class Diploma may be admitted into the 2nd year. According to Kyambogo University, the Diploma Programmes of Kyambogo University have been structured in such a way that a graduate with a Diploma covers all course units in the 1st year of the B.Eng in addition to trades and skills needed in the field to practice as a Technician. A graduate of Higher Diploma in Civil and Building Engineering covers all the courses covered in the second year of B.Eng in addition to other professional course units and skills needed in the field to practice as a Technologist. From figure 1, one may start as an artisan and progressively attain a Bachelor of Engineering of Kyambogo University.

iv. NCHE has piloted and approved a one-year bridging certificate for candidates who did not perform well at the UACE to obtain two principle passes to get admitted in the university for a degree programme, but obtained one principal pass. These are admitted for a degree programme if thy pass.

Figure 1: Faculty of Engineering Entry Structure (Adopted from Kyambogo University)



5.2 Emerging Engineering programmes

The relentless change in technology and environment has witnessed emerging engineering programmes like Biosystems engineering, Biomedical engineering and other programmes in information, communication and technology industry. The emergence of new programmes has redrawn the boundaries of engineering industry. The expansion of the engineering industry boundary to accommodate the emerging fields of engineering has inevitably expanded influence and the outlook of engineering.

The rapid emergence of these engineering fields has, somehow, made the engineering industry more complex and variegated. The complexity and variation in the engineering industry has inevitably steadily depreciated the existing Engineers Registration Board's and UIPE's intellectual capital to sufficiently evaluate and regulate the expanded engineering Industry. To bring the Board and UIPE up to speed and keep up with this rapid change and expansion in the engineering industry, the two organs have to create, within themselves, a reasonable proportion of these new engineering fields. One way to introduce more intellectual variety is to have new members from the new fields of engineering to cross-breed with the existing members.

The Act allows the Board to coopt members on its committees. The cooption in this case is more relevant to the Panels that finally review the applicants' submissions to the board for approval. However, knowing that each applicant that reaches the Board Panels has already passed some reviews previous and has been presold and more or less preapproved, the Board and the UIPE pre-reviewing Committees (JAC, MET, and Assessors) have to coopt members from the new engineering fields to introduce the required intellectual variety.

Enlarging intellectual capital depends, more than anything else on curiosity and humility. The Board and UIPE therefore have to become curious and humble enough and delve into the new fields of engineering and find appropriate professionals to coopt on the Board Panels and UIPE pre-reviewing committees.

The relentless environmental and technological changes that have necessitated the emergency of new engineering fields has blurred the boundaries of engineering and other technologies. The blurring of the boundaries between engineering and other technologies therefore in part calls for flexibility while evaluating candidates' submissions for admission to UIPE as corporate members and registration with ERB respectively.

5.3 A case of a new field of engineering

A Masters in Biosystems engineering programme will be offered by Gulu University, Faculty of Agriculture Engineering and Environment. In that programme, one of the specializations is Food and Agro process engineering. In this programme, one of the requirements is that the applicant shall possess an Honours Bachelors' degree in the fields, among others, in Science (Chemistry, Physics and Mathematics, Geology). However, critical analysis of the masters' programme core and elective course units in the programme matrix, and the detailed courses description contained in the course description section show enough engineering content. This would have been missed if one only looked at the course units indicated in the programme matrix that are normally indicated on the academic transcript (Programme for the Degree of Master of Science in Biosystems Engineering, 2017, Gulu Uiversity).

Professor Banadda's case was ably handled by Prof. Lating (appendix 1). It was found out the Bachelors' degree programme in the B. Sc in Food Science and Technology was lacking in engineering content. The Masters' programme courses description were judged also to be lacking in engineering Content. Prof. Banadda obtained a Doctor of Engineering degree from Katholieke Universiteit, Leuven, Belgium in July 2006, Chemical Engineering option. The assumption is that if he is to register, he should apply to register as a Chemical Engineer because it is not clear to which discipline, he was interested in.

As in the case of Gulu University's Programme for the degree of Master of Biosystems Engineering, critical analysis of Prof. Banadda's masters' and PhD's programmes core and elective courses in the programme matrix, and the detailed courses description contained in the course description section should be critically analyzed to determine engineering content. This will require obtaining the detailed courses description contained in the course description section to determine engineering content. It is understood that Prof. Banadda's case was concluded but either it could be re- reviewed or moving forward, the proposed critical analyses should be undertaken on similar cases that may present themselves to UIPE and the Board respectively.

From the foregoing therefore, the relentless environmental and technological changes that have necessitated the emergence of new engineering fields has blurred the boundaries of engineering and other technologies. The blurring of the boundaries between engineering and other technologies calls for flexibility while evaluating candidates' submissions to UIPE for corporate membership and ERB for registration respectively.

UIPE and the Board have already built the quality assurance advantages in their reviews of applications for admission to corporate membership and registration as engineers respectively. However, this alone is not sufficient. It is important to also build speed (reduced cycle time of the registration process) and flexibility advantages- in exemptions of courses, one or two years of the engineering programme depending on level and class of diploma, and having the first degree not in engineering- atop the quality advantage to satisfy the applicants that present themselves for admission as corporate members of UIPE and registration with ERB respectively.

6.0 Career progression of applicant

A career report gives a chronology of one's professional development precisely showing positions occupied, degrees of responsibility assigned, the supervisor under whom the applicant trained, and details the tasks undertaken indicating the value, the challenges, encountered and how they were addressed. It guides the evaluator to determine the professional experience gained by the applicant in application of engineering.

According to Marcus Buckingham (1999), in his book "First, Break All the Rules", for one to excel in a role requires three things namely, knowledge, skill and talent. The in-depth knowledge - what you are aware of - can be evaluated from the engineering programme. According to Buckingham 1999, there are two kinds of knowledge; factual knowledge – things you know; and experiential knowledge -understandings you have picked along the way. The skill (experiential knowledge)- experience gained from doing the right thing over time or - the how – to's of a role-, can be evaluated from the career report. Again, Marcus Buckingham defines talent as "a recurring pattern of thought, feeling or behavior that can be productively applied". The emphasis here is on the word "recurring". Your, talents, he says are the behaviors you find yourself doing often.

From the career report therefore the skills and talents (recurring behaviors) can be sufficiently adduced from the tasks undertaken, the challenges encountered and how they were successfully addressed.

7.0 Conclusion

1. The Diploma Entry into the first year, second year and third year depends upon the class and level of diploma. Someone with a Credit or Upper Second-class Higher Diploma in Civil Engineering may be admitted into the 3rd year of the B.Eng, while one with a Credit or Upper Second-class Diploma may be admitted into the 2nd year. The exemptions for courses, one year or two years to the engineering programme are made after studying the submitted documents for admission to the programme by respective departments who then make recommendations to the University Senate to effect the exemption.

2. Technical reports presented by applicants for admission to corporate membership of UIPE and registration by ERB respectively could be evaluated based on any or in combination, where necessary, of the engineering major **functions** of the engineering branches namely research, development, design, construction, production, operations, and management and other functions.

3. The engineering programmes course outline or curriculum satisfactorily indicate whether the applicant has in-depth knowledge of mathematics, physical and natural sciences, and professional extensive training in the application of that knowledge to practice engineering.

4. From the career report, one should ably evaluate the skills and the talents from the tasks undertaken, the challenges encountered and how they were successfully addressed.

5. It wouldn't be advisable for a person who wants to become an engineer to first major in mathematics or other sciences like physics, geology, etc. with the view to deviating at a later date toward engineering. It is true that a lot of mathematics principles apply in the world of engineering, but engineering is far more practical and 'hands-on' and one could not major in mathematics and expect to secure employment right away as an engineer. If, however, one has majored in mathematics or sciences and finds himself / herself looking thereafter to pursue a career in engineering, he/she is certainly ahead of someone who has majored in something completely unrelated. There are some specialized areas of engineering in which a mathematician could work, but one will still have to undergo further training and obtain the relevant qualifications.

6. UIPE and the Board have already built the quality advantage in their reviews for admission to corporate membership of UIPE and registration with ERB respectively. However, this alone is not sufficient. It is important to also build speed and flexibility advantages atop

the quality advantage to improve satisfaction of the applicants that present themselves for admission to corporate membership of UIPE and registration with ERB respectively.

8.0 Recommendations

i. The evaluators should critically interrogate the applicants' documentation to satisfy themselves that the applicants have had sufficient in-depth knowledge of mathematics, physical and natural sciences and that the applicants have had adequate preparation for professional practice by involving them in extensive training in the application of that knowledge.

ii. For persons whose first degree is not in engineering, critical analysis of the post graduate programmes core and elective courses in the programme matrix, and the detailed courses description contained in the course description section should be carried out to determine engineering content. This will therefore require obtaining the detailed courses description contained in the course description section of the applicant's degree programme.

iii. For the applicants who have used the diploma entry scheme, each case (applicant) should be handled on its own merit by evaluating the educational path and the attainments thereto that qualifies them to be exempted for either courses, one year or two years accordingly from the engineering programme rather than having a blanket rejection on looking at number of years that have been spent on the engineering programme only. NCHE allows exemptions up to 40% of the courses in the programme.

iv. Technical reports presented by applicants for registration could be based on any or in combination of the engineering major **functions** namely research, development, design, construction, production, operations, and management and other functions.

v. The blurring of the boundaries between engineering and other technologies calls for flexibility while evaluating candidates' submissions for admission to corporate membership of UIPE and registration with ERB respectively.

vi. It is important to also build speed and flexibility advantages atop the quality advantage to satisfy the applicants that present themselves for admission to corporate membership of UIPE and registration with ERB respectively.

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