# A Comparison of EC and ABET Accreditation Criteria

Arif A. Anwar, Ph.D., P.E., M.ASCE[[1]](#footnote-1) and David J. Richards, Ph.D., C.Eng. [[2]](#footnote-2)

**ABSTRACT**

The Washington Accord is one of seven mutual recognition agreements managed by the International Engineering Alliance. Signatories to the Washington Accord recognize the substantial equivalency of programs accredited by the signatory bodies. Signatories to the Washington Accord agree to make every reasonable effort that licensing bodies in respective countries recognize this substantial equivalency. Despite 25 years of the Washington Accord, only a minority of US state licensing boards acknowledge the Washington Accord in their statutes. This paper compares Engineering Council guidelines for accreditation with ABET criteria – both are signatories to the Washington Accord. This paper concludes that there are substantial similarities in the accreditation criteria of the Engineering Council and ABET. This should give confidence to US state licensing boards to acknowledge Engineering Council accredited programmes in their statues explicitly if not through the Washington Accord. A number of key differences in the accreditation criteria of Engineering Council and ABET are also highlighted. Both ABET and Engineering Council accredit programs at various level. This paper recommends the International Engineering Alliance clarifies the correspondence between the various levels of accredited programs of the signatories.

**Keywords:** Education & training, Accreditation, Professional Qualifications, Washington Accord

## INTRODUCTION

The Washington Accord is one of seven international agreements administered by the International Engineering Alliance (IEA). The Washington Accord also referred to as an international mutual recognition agreement (MRA) has, as of Dec. 2016, 19 signatory bodies with full rights and 5 signatory bodies with provisional status. ABET and Engineering Council (EC) UK are amongst the six founding signatory bodies of the Washington Accord (IEA 2014). “*Through the Washington Accord, ……… the signatories recognise the substantial equivalence of such programmes in satisfying the academic requirements for the practice of engineering at the professional level..* IEA (2017a) This is further qualified by jurisdiction (ABET 2016a) in that “*The Washington Accord only recognizes engineering programs accredited within the signatories’ own jurisdictions”*. ABET define jurisdiction for the purposes of the Washington Accord as the U.S. (presumably all U.S. territories) whereas EC (EC 2016a) states that their jurisdiction for the purposes of the Washington Accord *“… applies to programmes accredited at universities in England, Scotland, Wales and Northern Ireland only”*. Therefore British Overseas Territories and Crown Dependencies such as; Gibraltar, Jersey, Guernsey, Isle of Man etc. are excluded. The Washington Accord is also significant in the International Professional Engineers Agreement (IPEA). This agreement supersedes the Engineers Mobility Forum of 1997 (IEA 2017b). IEA (2017b) lists the EC as member of the IPEA and also the United States Council for International Engineering Practice - but not ABET. The IPEA (IEA 2017b) states that “*….. if the organization accrediting engineering degrees in a jurisdiction holds signatory status of the Washington Accord, the above-mentioned requirement for the academic achievement will be deemed to have been met in full”*.

ABET accredits four categories of programs

1. Associate (typically two-year degree)
2. Baccalaureate (typically four-year degree).
3. Master’s (typically two-year degree).
4. Integrated Baccalaureate-Master’s

ABET organizes itself into four commissions; Applied and Natural Science Accreditation Commission (ANSAC); Computing Accreditation Commission (CAC); Engineering Accreditation Commission (EAC); and, Engineering Technology Accreditation Commission (ETAC). The CAC and ANSAC do not accredit engineering programmes. The EAC focuses on engineering programs and the ETAC on engineering technology programs. Not all ABET commissions necessarily accredit all four categories of programs listed above. For example the EAC does not accredit Associate programs. Furthermore Associate programs are not recognized in the Washington Accord but rather are recognized in the Sydney Accord

The EC has a larger categorization (referred to as sections in EC terminology) of programs and accredits (EC 2014)

1. Bachelors Degrees accredited for Incorporated Engineer (IEng) registration.
2. Bachelors (Honours) Degrees accredited for IEng registration.
3. Bachelors (Honours) Degrees accredited as partially meeting the educational requirement for Chartered Engineer (CEng).
4. Integrated Master’s of Engineering (MEng) Degrees.
5. Master’s Degrees other than the MEng Degrees.
6. Engineering Doctorate (EngD).

Unlike ABET, the EC does not conduct accreditation itself. Rather the EC licenses a number of professional engineering institutions to carry out the process of accreditation. Four professional institutions namely; Institution of Structural Engineers, Institute of Highway Engineers; Chartered Institution of Highways and Transportation; and, Institution of Civil Engineers have formed the Joint Board of Moderators (JBM) to assess and make recommendations on the accreditation and approval of relevant educational programs. The JBM (JBM 2016a) lists eight categories of accreditation.

The EC (EC, 2016a) further elaborates that only graduates of an EC accredited Bachelor of Engineering (BEng) degree programs (accredited in the CEng section) who enrolled after 1989 and before 1999, or graduates of an EC accredited MEng programs who enrolled after 1989 are recognized by the Washington Accord. Furthermore, a graduate of an EC accredited BEng program (accredited in the CEng section) who enrolled on or after 1999 who has also either graduated from an EC accredited Master of Science in Engineering (MSc) program or an EC accredited EngD program, this combination is also recognized by the Washington Accord. It is therefore evident that even within the jurisdiction of England, Scotland, Wales and Northern Ireland, not all the programs accredited by the EC are recognized by the Washington Accord. This is also confirmed by Lloyd-Roach (2013) and Pritchard (2013).

The Washington Accord recognizes “…*the substantial equivalency of programs…”* and “…*Washington Accord signatories have agreed to make every reasonable effort to ensure that the engineering licensing and registration bodies in their countries recognize the substantial equivalence of engineering programs accredited by the other signatories”* (ABET 2016, Hanrahan 2008). This is also restated in IEA (2014) as “*Signatories agree to grant (or recommend to the relevant national registration body, if different) graduates of each other’s accredited programmes the same recognition, rights and privileges as they grant to graduates of their own accredited programmes…..”*

The IEA does not provide any elaboration or definition of the term substantial equivalency. ABET has discontinued substantial equivalency evaluations, but provide a definition of substantial equivalency as *“Substantial equivalency” means that a program is comparable in program content and educational experience, but may differ in format or method of delivery”*  and further that substantial equivalency *“...evaluations followed policies and procedures similar to those used for accreditation...*”(ABET 2016c). Although ABET has discontinued substantial equivalency evaluations, ABET continues to recognize substantial equivalency through the Washington Accord. The Accord refers to substantial equivalency of programs, and ABET elaborates on that identifying content and student experience as similar amongst substantially equivalent programs and that evaluations uses policies and procedures similar to those used for accreditation. Milligan (2011) provides an interpretation, whereby “*Substantial equivalency means that the accreditation systems have comparable standards, outcomes, and processes, though they may not be absolutely identical”*. which is similar to the interpretation by ABET (ABET 2016c).

It is unclear what “reasonable effort” ABET as a Washington Accord signatory has made towards ensuring programs under the Washington Accord are recognized by US state licensing boards. Anwar and Richards (2015) showed that despite 25 years since the Washington Accord was founded only 3 of 54 US state licensing boards explicitly acknowledge the Accord in their statutes; Texas Board of Professional Engineers, Idaho Board of Licensure of Professional Engineers and Professional Land Surveyors, and South Carolina Department of Labor, This suggests that limited progress has been made in 25 years in ensuring US state licensing boards recognize programs under the Washington Accord. Anwar and Richard (2015) observed that on the other hand there are four US state licensing boards that explicitly acknowledge the Canadian Engineering Accreditation Board even though the Canadian Engineering Accreditation Board is also a signatory to the Washington Accord.

This paper explores substantial equivalency in this context of accreditation systems of two Washington Accord signatories; EC, and ABET. Although there are 16 other full signatories and 6 provisional signatories to the Washington Accord, this paper is limited to EC and ABET where the authors have direct experience. The motivation of this work is

1. To demonstrate that the accreditation criteria of the EC for MEng programs is at least substantially equivalent to the ABET accreditation criteria which should give confidence to US state licensing boards to explicitly acknowledge the EC accredited (MEng) programs in their statutes.
2. To provide insight to ABET, and the EC on some of the differences in their accreditation systems that could be of concern to third parties such as US state licensing boards.

The EC requires …“Students starting Washington Accord programmes from  July 2015 onwards will be required to demonstrate learning to European Master's level when applying for Chartered Engineer registration.”. (EC 2017). To put this in the context of this paper, this implies that although an ABET accredited baccalaureate degree is substantially equivalent to a UK MEng degree (as defined by the Washington Accord), a graduate of an ABET accredited baccalaureate program would need to demonstrate the learning at the ABET accredited baccalaureate programme is equivalent to European Master’s level to apply for Chartered Engineer (C.Eng) registration! There is a degree of inconsistency in this EC statement. Hence the analysis in this paper is asymmetric in the sense that it uses ABET criteria as a reference against which EC criteria and guidelines are compared but not vice versa.

For engineering professionals, the UK does not have licensing boards unlike the US. The EC itself is responsible for both accreditation and professional licensure of engieners. The EC admits individuals to its register of Chartered Engineers upon fulfilling specified criteria. The C.Eng professional qualification is broadly comparable to the Professional Engineer in the US. The requirements for receiving a C.Eng professional qualification varies between the various professional institutions, however the requirements are generally

1. Educational requirements – typically Baccalaureate and Master’s degree or an Integrated Master’s degree.
2. Qualifying work experience (also called initial professional development)
3. Professional Review.

Some important distinctions are that the UK requires a Master’s level qualification – this is comparable to what is suggested in Policy Statement 465 (ASCE 2017). Further distinctions are that there is no UK equivalent to the Fundamental of Engineering examination for graduates of an EC accredited programs. Furthermore the professional review is a review of a written submission, record of continuous-professional development (CPD), interview and an assessment of written (sic) skills. There is no formal test equivalent to the Principles and Practice of Engineering (PE) exam. It is beyond the scope of this work to debate the merits and demerits of these two licensing approaches but Llyod-Roach (2013) provides an interesting personal perspective on the US PE licensure examinations.

## MATERIALS AND METHODS

This research uses publicly available material including but not limited to reports, websites, newsletters issued by ABET, EC, JBM along with published research papers. Since the EC licenses various professional institutions to undertake accreditation on its behalf – and four such professional institutions have formed the JBM, for the purposes of this paper no distinction is made between EC and JBM.

The research explores the question of substantial equivalency from an ABET perspective i.e. each of the eight ABET Engineering Accreditation Commission (EAC) General Criteria for Baccalaureate Level Programs. (ABET 2016b) is examined in turn against comparable EC criteria for MEng programs. The ABET EAC Program Criteria for Civil Engineering Programs are also considered as one of the four institutions that constitute the JBM is the Institution of Civil Engineers.

## ANALYSIS

## ABET Criterion 1. Students

ABET criterion 1 requires student performance to be evaluated and mentored in both academic and professional matters, and policies and documented procedures to ensure graduates meet all graduation requirements. The EC has guidelines similar to this criteria for student assessment and progression and professional mentoring.

ABET requires that the program have and enforce policies for accepting new and transfer students. The EC provides very specific guidance on the policy for accepting new students and although not mandatory expects to see evidence of special measures where a program departs from this guideline. The EC expects student accepted on an engineering program to have UK high-school level mathematics. Although the EC does require Departments/Schools to report on the number of transfer students accepted, the EC does not require an explicit policy on transfer students. However this practice is probably justified for the UK context given there are far fewer transfer students between UK universities as compared to US universities. The EC provides more specific guidance on transfer students between Bachelor of Engineering (3 year undergraduate programs) and Master of Engineering (4 year integrated masters programs).

## ABET Criterion 2. Program Educational Objectives

ABET, under criterion 2 requires that a program has published Program Educational Objectives whereas the EC does not require that a program have published educational objectives. This ABET criteria also requires that the objectives are; consistent with the mission of the institution; meet the needs of the constituents; and, are periodically and systematically reviewed. Whereas ABET expects programs to identify the constituents, the EC does not require a program to identify the constituents. The JBM Accreditation Submission Document (JBM 2016a) akin to the ABET Self-Study Questionnaire asks for details of any “*input to the civil engineering activity in the School/Department from the construction industry*”. Hence in contrast to ABET, the EC anticipates the construction industry as a constituent, input from this constituent is not specific to program educational objectives but rather includes; staff development and support; student learning; research activity and consultancy; sponsorship; program development and review. The EC also asks where a School/Department has an Industrial Advisory Board to report on the contribution of this Board, the frequency of meetings etc. but again the role of the Industrial Advisory Board in articulating and reviewing Program Educational Objectives is not an explicit criterion or guideline.

## ABET Criterion 3. Student Outcomes

ABET 2016b defines Student Outcomes as the skills, knowledge, and behaviors that students are expected to acquire over the course of the program. ABET Criterion 3 requires an accredited program to document student outcomes listed in Appendix A alongside any others as articulated by the program. The EC (EC 2014) has 40 learning outcomes listed in Appendix B grouped into six broad areas of learning. A comparison of the 11 ABET Student Ouctomes and the 40 EC learning outcomes shows a significant degree of overlap. Table 1 shows a mapping of each of the ABET Student Outcomes against the EC areas of broad learning outcomes (in the interest of brevity all 40 EC learning outcomes are not listed in Table 1). This mapping shows how the ABET Student Outcomes are covered by the EC areas of broad learning.

## ABET Criterion 4. Continuous Improvement

Under this criterion ABET requires that the program has documented processes for assessing and evaluating the extent to which Student Outcomes are being attained and that this evaluation is used for continuous improvement of the program. The EC uses the terminology learning outcomes and expects “*the process of accreditation will include an assessment of whether graduates are achieving these outcomes”* and does not specify continuous improvement. ABET and the EC both ask for programs to report changes since the last visit. Whereas ABET expects to see explicit evaluation of each Student Outcome and how such evaluation is used for continuous improvement of the program, the EC (JBM 2016a) expects programs to “…. *demonstrate through their teaching and assessment methods that graduates have reached the desired threshold level of each of the Output Criteria..”.* Hence whereas ABET has a distinct criteria (Criterion 1 for student/graduate assessment) and Criterion 4 for Student Outcome assessment leading to continuous improvement, the EC does not make this strong distinction.

## ABET Criterion 5. Curriculum (and Program Criteria for Civil Engrg. Programs)

ABET in the general criteria for engineering programs, does not prescribe specific courses. The EC in it’s guidelines specifies two groups of core subjects (courses) shown in Table 2. The EC expects programs to be “constructed” around at least five of these core subjects (JBM 2016b). ABET Program Criteria for Civil Engineering does specify that the curriculum must prepare graduates to “*…..analyze and solve problems in at least four technical areas appropriate to civil engineering….”*. Hence ABET is less prescriptive in the technical areas than the EC. The EC expects 33% of the total curriculum to be devoted to the core subjects listed in Table 2. This is comparable to the 1-1/2 years specified by ABET for engineering topics which for a typical 4 year engineering degree program in the US constitutes 37.5% of the total curriculum.

The EC and ABET both specify that mathematics forms part of the curriculum. ABET specifies one year of a combination of mathematics and basic sciences, the EC guidelines require mathematics and engineering sciences (not basic sciences) constitute 50% (two years) of the program. The EC does not provide any specific guidance on basic sciences. ABET expects a general education component in the program which complements the technical content of the curriculum. Similarly the EC expects broadening subjects outside of core engineering to form an important part of accredited programs.

ABET expects a program to culminate in a major design experience which in practices is the capstone project. The EC have a slightly different take and describe design as a “thread” that is to be weaved throughout the curriculum and also provide explicit guidelines for design. The EC expect students to undertake a major investigative project within the penultimate or ultimate year of a program that is not of routine nature such that there is scope for individual creativity and innovation.

## ABET Criterion 6. Faculty

Both ABET and the EC expect Faculty to be of sufficient number and hold qualifications both academic and professional such that they have the competence to cover all curricular areas of the program and also to provide counselling and mentoring. Again both ABET and the EC expect programs to report on the number of faculty, their qualifications, professional licensure, and experience in order to judge faculty competence. ABET and the EC also expect reporting on some indicator of the workload e.g. courses taught, student:faculty ratio. Whereas ABET has abandoned the requirement that a proportion of faculty or faculty teaching design must be licensed professional engineers, the EC have moved in the opposite direction requiring as of 2015 “…*50% of all academic staff designated as delivering the accredited degree programmes must be professionally qualified “* JBM (2016b). The EC reporting requirements also expect Department/Schools to report on their research activity, any evaluation of their research, and provide a list of up to four published research papers per faculty member – although the EC does not have any specific research related criteria for accreditation of undergraduate degree programs.

## ABET Criterion 7. Facilities

ABET Criterion 7 requires facilities to be adequate “*to support attainment of student outcomes*” and include; classrooms; laboratories; computing; library facilities with particular emphasis on the latter two. This criterion also requires that guidance on the use of tools and facilities is available. The EC does not have an explicitly stated criterion or guideline on facilities. EC like ABET does expect Departments/Schools to provide details on the facilities available for delivery of the program.

## ABET Criterion 8. Institutional Support

This ABET criterion requires “*Institutional support and leadership must be adequate to ensure the quality and continuity of the program.*” This includes institutional support and leadership; budget and financial support; staff (as opposed to faculty); faculty hiring and retention and faculty development. The EC does not have a comparable guideline or criteria. However both ABET and the EC expect Department/Schools to provide details on staff (support staff in the EC terminology) and faculty training and development.

## CONCLUSIONS AND RECOMMENDATIONS

This evaluation shows that there is similarity between ABET criteria for accreditation of engineering programs and the EC guidelines. However there are a few notable differences. The EC does not require explicit Program Educational Objectives nor does the EC express how these should be developed, reviewed etc. The EC unlike ABET does not make a strong distinction between evaluating the program against achieving Student Outcomes and evaluating individual performance. On the criterion of curriculum, the EC is considerably more prescriptive than ABET even taking into account ABET Program Criteria for Civil Engineering Programs. The EC have a very comprehensive list of learning outcomes (comparable to ABET Student outcomes). Similarly the EC is more stringent on professional qualifications/licensure amongst faculty than ABET. The EC have less explicit guidelines for facilities and institutional support although EC does expect considerable reporting on these. Overall the evidence supports the view expressed by Mulligan (2011) that “… *the accreditation systems have comparable standards, outcomes, and processes…”*. This should give confidence to US licensing boards to acknowledge EC accredited MEng programmes in their statutes.

The global engineering community look to the Washington Accord as an exemplar of an international mutual recognition agreement as evidenced by the increasing number of signatories. However there is considerable scope and need to improve the clarity of the Washington Accord. The current signatories should clarify “substantial equivalency”. There is a clearly stated spatial scope - US territories for ABET, England, Scotland, Wales and Northern Island for the EC. The EC also provide a program and temporal scope – only certain degrees over certain periods are recognized by the Washington Accord. However which program accredited by one signatory is substantially equivalent to which program of another signatory remains undefined. The relatively recent requirement of the EC (as of July 2015) for graduates to demonstrate learning to European Master’s level sits uncomfortably with the term substantially equivalent.

## REFERENCES

ABET (2016a) ABET website [http://www.abet.org/global-presence/mutual-recognition-agreements/engineering-washington-accord/#inside](http://www.abet.org/global-presence/mutual-recognition-agreements/engineering-washington-accord/" \l "inside) accessed Dec. 29, 2016

ABET (2016b) “Criteria for Accrediting Engineering Programs” available at <http://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2017-2018/> accessed Dec. 29, 2016.

ABET (2016c) ABET website <http://www.abet.org/global-presence/substantial-equivalency-2/> accessed Jan. 05, 2017.

ASCE (2017) <http://www.asce.org/issues-and-advocacy/public-policy/policy-statement-465---academic-prerequisites-for-licensure-and-professional-practice> accessed Sep. 9, 2017.

Anwar, A., & Richards, D. (2013). Is the USA set to dominate accreditation of engineering education and professional qualifications? Proceedings of the Institution of Civil Engineers - Civil Engineering, 166(1), 42-48. doi:10.1680/cien.12.00012

Anwar, A. A., & Richards, D. J. (2015). The Washington Accord and U.S. Licensing Boards. Journal of Professional Issues in Engineering Education and Practice, 141(4). doi:10.1061/(asce)ei.1943-5541.0000246

EC (2014) “"The Accreditation of Higher Education Programmes, UK Standard for Professional Engineering Competence" available at <http://www.engc.org.uk/EngCDocuments/Internet/Website/Accreditation%20of%20Higher%20Education%20Programmes%20third%20edition%20(1).pdf> accessed Sep 27, 2017

EC (2016a) <http://www.engc.org.uk/international-activity/international-engineering-education-accords/washington-accord/> accessed Dec. 28, 2016

EC(2017) [https://www.engc.org.uk/international-activity/international-engineering-education-accords/](https://www.engc.org.uk/international-activity/international-engineering-education-accords/%20) accessed Sep. 27, 2017

IEA (2017) “International Engineering Alliance: Educational Accords” <http://www.ieagreements.org/assets/Uploads/Documents/Policy/IEA%20Rules%20and%20Procedures%20(3%20June%20206).pdf> accessed Sep. 28, 2017.

IEA (2017b) “Competence Agreements” <http://www.ieagreements.org/assets/Uploads/Documents/Policy/Competence-Agreements-July2017-v1.4.pdf> accessed Sep. 28, 2017.

IEA (2014) “25 years Washington Accord” <http://www.ieagreements.org/assets/Uploads/Documents/History/25YearsWashingtonAccord-A5booklet-FINAL.pdf> , accessed Sep. 28, 2017.

JBM (2016a) “Submission for Accreditation for Academic Courses leading to Engineering Council Registration” available at <http://jbm.org.uk/downloads.aspx> accessed Jan. 06, 2017.

JBM (2016b) “Guidance on the JBM Professional Qualifications Policy for Academic Staff” available at <http://jbm.org.uk/downloads.aspx> accessed Jan. 08, 2017.

Lloyd-Roach D. (2013) Discussion “Is the USA set to dominate accreditation of engineering education and professional qualifications?” Proceedings of the Institution of Civil Engineers. Civil Engineering 166(2), 55-57. doi.:10.1680/cien.2013.166.2.55

Milligan M (2011) “Global Economy Requires a Global View on Accreditation” Licensure Exchange, NCEES (15):1;1,10.

Prichard J. (2013) “Discussion to ‘Is the USA set to dominate accreditation of engineering education and professional qualifications?” Proceedings of the Institution of Civil Engineers, Civil Engineering, 166(2): 56. doi.:10.1680/cien.2013.166.2.55

## APPENDIX A: ABET Student Outcomes

The program must have documented student outcomes that prepare graduates to attain the program educational objectives.

Student outcomes are outcomes (a) through (k) plus any additional outcomes that may be articulated by the program.

1. an ability to apply knowledge of mathematics, science, and engineering
2. an ability to design and conduct experiments, as well as to analyze and interpret data
3. an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
4. an ability to function on multidisciplinary teams
5. an ability to identify, formulate, and solve engineering problems
6. an understanding of professional and ethical responsibility
7. an ability to communicate effectively
8. the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
9. a recognition of the need for, and an ability to engage in life-long learning
10. a knowledge of contemporary issues
11. an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

## APPENDIX B: EC Broad learning areas and learning outcomes

1. **Science and mathematics**

Engineering is underpinned by science and mathematics, and other associated disciplines, as defined by the relevant professional engineering institution(s). Graduates will need the following knowledge, understanding and abilities:

* 1. A comprehensive knowledge and understanding of scientific principles and methodology necessary to underpin their education in their engineering discipline, and an understanding and know-how of the scientific principles of related disciplines, to enable appreciation of the scientific and engineering context, and to support their understanding of relevant historical, current and future developments and technologies
  2. Knowledge and understanding of mathematical and statistical methods necessary to underpin their education in their engineering discipline and to enable them to apply a range of mathematical and statistical methods, tools and notations proficiently and critically in the analysis and solution of engineering problems
  3. Ability to apply and integrate knowledge and understanding of other engineering disciplines to support study of their own engineering discipline and the ability to evaluate them critically and to apply them effectively
  4. Awareness of developing technologies related to own specialisation
  5. A comprehensive knowledge and understanding of mathematical and computational models relevant to the engineering discipline, and an appreciation of their limitations
  6. Understanding of concepts from a range of areas, including some outside engineering, and the ability to evaluate them critically and to apply them effectively in engineering projects.

1. **Engineering analysis**

Engineering analysis involves the application of engineering concepts and tools to the solution of engineering problems. Graduates will need:

* 1. Understanding of engineering principles and the ability to apply them to undertake critical analysis of key engineering processes
  2. Ability to identify, classify and describe the performance of systems andc omponents through the use of analytical methods and modelling techniques
  3. Ability to apply quantitative and computational methods, using alternative approaches and understanding their limitations, in order to solve engineering problems and to implement appropriate action
  4. Understanding of, and the ability to apply, an integrated or systems approach tosolving complex engineering problems
  5. Ability to use fundamental knowledge to investigate new and emerging technologies
  6. Ability to extract and evaluate pertinent data and to apply engineering analysis techniques in the solution of unfamiliar problems.

1. **Design**

Design at this level is the creation and development of an economically viable product, process or system to meet a defined need. It involves significant technical and intellectual challenges and can be used to integrate all engineering understanding, knowledge and skills to the solution of real and complex problems. Graduates will therefore need the knowledge, understanding and skills to:

* 1. Understand and evaluate business, customer and user needs, including considerations such as the wider engineering context, public perception and aesthetics
  2. Investigate and define the problem, identifying any constraints including environmental and sustainability limitations; ethical, health, safety, security andrisk issues; intellectual property; codes of practice and standards
  3. Work with information that may be incomplete or uncertain, quantify the effect of this on the design and, where appropriate, use theory or experimental research to mitigate deficiencies
  4. Apply advanced problem-solving skills, technical knowledge and understanding to establish rigorous and creative solutions that are fit for purpose for all aspects of the problem including production, operation, maintenance and disposal
  5. Plan and manage the design process, including cost drivers, and evaluate outcomes
  6. Communicate their work to technical and non-technical audiences
  7. Demonstrate wide knowledge and comprehensive understanding of design processes and methodologies and the ability to apply and adapt them in unfamiliar situations
  8. Demonstrate the ability to generate an innovative

1. **Economic, legal, social, ethical and environmental context**

Engineering activity can have impacts on the environment, on commerce, on society and on individuals. Graduates therefore need the skills to manage their activities and to be aware of the various legal and ethical constraints under which they are expected to operate, including:

* 1. Awareness of the need for a high level of professional and ethical conduct in engineering
  2. Awareness that engineers need to take account of the commercial and social contexts in which they operate
  3. Knowledge and understanding of management and business practices, their limitations, and how these may be applied in the context of the particular specialisation
  4. Awareness that engineering activities should promote sustainable development and ability to apply quantitative techniques where appropriate
  5. Awareness of relevant regulatory requirements governing engineering activities in the context of the particular specialisation
  6. Awareness of and ability to make general evaluations of risk issues in the context of the particular specialisation, including health & safety, environmental and commercial risk.

1. **Engineering practice**

This is the practical application of engineering skills, combining theory and experience, and use of other relevant knowledge and skills. This can include:

* 1. Understanding of contexts in which engineering knowledge can be applied (egoperations and management, application and development of technology, etc)
  2. Knowledge of characteristics of particular equipment, processes, or products,with extensive knowledge and understanding of a wide range of engineering materials and components;
  3. Ability to apply relevant practical and laboratory skills Understanding of the use of technical literature and other information sources
  4. Knowledge of relevant legal and contractual issues
  5. Understanding of appropriate codes of practice and industry standards
  6. Awareness of quality issues and their application to continuous improvement
  7. Ability to work with technical uncertainty
  8. A thorough understanding of current practice and its limitations, and some appreciation of likely new developments
  9. Ability to apply engineering techniques taking account of a range of commercial and industrial constraints
  10. Understanding of different roles within an engineering team and the ability to exercise initiative and personal responsibility, which may be as a team member or leader.

1. **Additional general skills**

Graduates must have developed transferable skills, additional to those set out in the other learning outcomes, that will be of value in a wide range of situations, including the ability to:

* 1. Apply their skills in problem solving, communication, information retrieval, working with others, and the effective use of general IT facilities
  2. Plan self-learning and improve performance, as the foundation for lifelong learning/CPD
  3. Monitor and adjust a personal programme of work on an on-going basis
  4. Exercise initiative and personal responsibility, which may be as a team memberor leader.

## TABLES

Table 1: Student Outcomes, ABET and EC

TABLE 2: EC Core Subjects

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| TABLE 1: ABET Student Outcomes and EC Broad Areas of Learning | | | | | | |
| EC Broad Areas of Learning  ABET Student Outcomes | Science and Mathematics | Engineering Analysis | Design | Economic, legal, social, ethical and environmental context | Engineering practice | Additional general skills |
| 1. An ability to apply knowledge of mathematics, science and engineering. | ✓ | ✓ |  |  |  |  |
| 1. An ability to design and conduct experiments, as well as to analyse and interpret data. |  | ✓ |  |  | ✓ |  |
| 1. An ability to design a system, component, or process to meet desired needs within realistic constraints…. |  |  | ✓ |  | ✓ |  |
| 1. An ability to function on multidisciplinary teams. |  |  |  |  | ✓ | ✓ |
| 1. An ability to identify, formulate and solve engineering problems. |  | ✓ | ✓ |  |  |  |
| 1. An understanding of professional and ethical responsibility. |  |  |  | ✓ |  | ✓ |
| 1. An ability to communicate effectively. |  |  | ✓ |  |  |  |
| 1. The broad education necessary to understand the impact of engineering solutions in a global…… |  |  |  |  | ✓ |  |
| 1. A recognition of the need for, and an ability to engage in life-long learning. |  |  |  |  |  | ✓ |
| 1. A knowledge of contemporary issues. |  |  |  | ✓ |  |  |
| 1. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice. | ✓ |  |  |  |  | ✓ |

|  |  |
| --- | --- |
| TABLE 2: EC Core Subjects | |
| List | Core subject |
| A | Structures |
| Materials |
| Geotechnics |
| B | Fluid Mechanics (Hydraulics) |
| Surveying (Geomatics and measurement) |
| Transport infrastructure engineering |
| Public Health |
| Construction Management |
| Environmental Engineering |
| Architectural Technology |

1. (corresponding author) Principal Researcher – Irrigation and Head IWMI Pakistan, International Water Management Institute (Pakistan Office) 12km Multan Road Thokar Niaz Baig, Lahore, Pakistan 53700 a.anwar@cgiar.org [↑](#footnote-ref-1)
2. Professor of Ground Engineering, Faculty of Engineering and the Environment, University of Southampton, Highfield Southampton SO17 1BJ, UK. D.J.Richards@soton.ac.uk [↑](#footnote-ref-2)