Republic of Iraq

Ministry of Higher Education & Scientific Research

Apparatus of Scientific Supervision and Evaluation

Iraqi Engineering Graduate Attributes
IEGAs
مواصفات خريج الـهندسة العراقي
(مسوّدة اولية)

Proposed by;

Quality Improvement Council of Engineering Education in Iraq
QICEEI
مجلس تحسين جودة التعليم الهندسي في العراق

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1.1 Foreword

Engineers make significant contributions to the quality of human life. They solve real-life problems and find the best solutions through the application of their knowledge, experience and skills. Engineers help to define and refine the way of life by providing innovative, higher-performance, safer, cleaner or more comfortable daily-used facilities for human beings. They seek improvements through the processes of invention, design, manufacturing and construction.

The ***Ministry of Higher Education and Scientific Research MOHESR*** in Iraq lunched a comprehensive program for quality assurance of educational programs. This was in 2008, and the engineering education programs were considered with special attention and care. In this context, an extensive work and efforts were made by a large number of engineering programs covered various Iraqi colleges and universities. The experiment now reached a stage that needs an overall and precise assessment and accreditation. One of the most fruitful outcomes of this comprehensive program is the establishment of ***Quality Improvement Council of Engineering Education in Iraq QICEEI***.

The ***Quality Improvement Council of Engineering Education in Iraq QICEEI*** proposed the ***National Criteria for Engineering Education Accreditation NCEEA***, to be the body for accreditation of engineering education programs. ***NCEEA*** is written to ensure a certain ***Graduate Attributes GAs*** which represent general expectations about the standards for the Bachelor of Science (B.Sc.) degree in engineering. The following statements clarify the attributes associated with the award of engineering degrees:

- ***The awards are in accord with the frameworks for engineering education; which ensures the acquirement of knowledge, skills, and attributes by the students upon graduation in order to be successful engineers.***
- ***The engineering degrees address the national, regional, and international expectations.***
- ***The degrees satisfy the ever-changing needs of the society.***

According to the ***Accreditation Board for Engineering and Technology (ABET)***, which is the baseline chosen to be followed by the Iraqi national engineering programs, engineering is the knowledge of the mathematical and natural sciences, gained by study, experience, and practice, applied with judgment to develop ways to economically utilize the materials and forces of nature for the benefit of mankind. It is the ability to initiate and conduct activities associated with engineering processes, systems, problems, opportunities, history, future impacts and ethics with minimal negative consequences. It involves knowledge, ways of thinking, action coordination and capability development. It helps preparing individuals to make well-informed choices whether they act as consumers, workers, citizens or members of the global community.

The ***National Criteria for Engineering Education Accreditation NCEEA*** proposed by the ***Quality Improvement Council of Engineering Education in Iraq QICEEI*** endeavors to be one of the ***Washington Accord WA*** signatories. This accord is a mutual recognition agreement (MRA) which pertains to engineering programs accredited by its signatories in their jurisdictions since 1989. Signatories to the Washington Accord are organizations responsible for accrediting engineering programs in Australia, Canada, Chinese Taipei, Hong Kong, Ireland, Japan, Korea, Malaysia, New Zealand, Singapore, South Africa, Turkey, the United Kingdom, and the United States. The Washington Accord assists in determining if an engineering program in one signatory's jurisdiction is recognized for purposes of licensure and registration, employment, or admission to graduate school in another jurisdiction.

The Washington Accord only recognizes engineering programs accredited within the signatories' own jurisdictions. Signatories to the Washington Accord may accredit programs outside of their jurisdiction, but only those programs accredited within their jurisdictions are recognized by the Accord.

The year in which the signatory joined the Washington Accord determines recognition. For example, ***ABET*** was a founding member of the Washington Accord in 1989. Graduates of U.S.-based ABET-accredited programs beginning in 1989 are covered by the Washington Accord. Other signatories are under no formal obligation to recognize ABET-accredited engineering programs or their graduates prior to 1989; however, individual signatories may recognize graduates prior to 1989 at their own discretion.

The Washington Accord is administrated by the ***International Engineering Alliance IEA***. The ***IEA*** seeks to improve engineering education and competence globally. It fulfills this mission through its constituents: education agreements that are concerned with standards, best practice accreditation processes and mutual recognition of accredited engineering programs and agreements for defining and recognizing professional competence.

1.2 The *ABET* Engineering Criteria

According to ***ABET***, Engineering Departments must demonstrate that all of their graduates have the following eleven general skills and abilities (called ***Student Outcomes SOs***):

(a) An ability to apply knowledge of mathematics, science, and engineering.

(b) An ability to design and conduct experiments, as well as to analyze and interpret data.
(c) 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.
(d) An ability to function on multidisciplinary teams.
(e) An ability to identify, formulates, and solves engineering problems.
(f) An understanding of professional and ethical responsibility.
(g) An ability to communicate effectively.
(h) The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.
(i) A recognition of the need for, and an ability to engage in life-long learning
(j) A knowledge of contemporary issues.
(k) An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

1.3 The Washington Accord *WA* Graduate Attributes

Graduate attributes form a set of individually assessable outcomes that are the components indicative of the graduate's potential to acquire competence to practice at the appropriate level. The graduate attributes are exemplars of the attributes expected of graduate from an accredited program. Graduate attributes are clear, succinct statements of the expected capability, qualified if necessary by a range indication appropriate to the type of program. The Graduate Attributes **GAs** of the Washington Accord ***WA*** are listed below;

1. **Engineering Knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution.
2. **Problem Analysis:** Identify, formulate, research literature and analyze *complex* engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
3. **Design/ development of solutions:** Design solutions for *complex* engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
4. **Investigation:** Conduct investigations of *complex* problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.

5. **Modern Tool Usage:** Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to *complex* engineering activities, with an understanding of the limitations.
6. **The Engineer and Society:** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant professional engineering practice.
7. **Environment and Sustainability:** Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
9. **Individual and Team work:** Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project Management and Finance:** Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Lifelong learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

1.4 Mapping between *ABET* Student Outcomes and *WA* Graduate Attributes

The following table shows the relation between the ***ABET*** student outcomes and ***WA*** graduate attributes.

ABET Student Outcomes		WA Graduate Attributes	
SO#	**Student Outcomes**	**GA#**	**Graduate Attributes**
(a)	An ability to apply knowledge of mathematics, science, and engineering.	1	**Engineering Knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution.
(b)	An ability to design and conduct experiments, as well as to analyze and interpret data.	4	**Investigation:** Conduct investigations of *complex* problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.

©	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.	3	**Design/ development of solutions:** Design solutions for *complex* engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
		6	**The Engineer and Society:** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant professional engineering practice.
(d)	An ability to function on multidisciplinary teams.	9	**Individual and Team work:** Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
	A major design experience based on the knowledge and skills acquired in earlier course work and incorporating appropriate engineering standards and multiple realistic constraints.	11	**Project Management and Finance:** Demonstrate knowledge and understanding of engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
(e)	An ability to identify, formulates, and solves engineering problems.	2	**Problem Analysis:** Identify, formulate, research literature and analyze *complex* engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
(f)	An understanding of professional and ethical responsibility.	8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
(g)	An ability to communicate effectively.	10	**Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
(h)	The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.	7	**Environment and Sustainability:** Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

(i)	A recognition of the need for, and an ability to engage in life-long learning	12	**Lifelong learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.
(j)	A knowledge of contemporary issues.	6	**The Engineer and Society:** Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant professional engineering practice.
(k)	An ability to use the techniques, skills, and modern engineering tools necessary	5	**Modern Tool Usage:** Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to *complex* engineering activities, with an understanding of the limitations.

1.5 Professional Competency Profiles

According to ***IEA***, a professionally or occupationally *competent person* has the attributes necessary to perform the activities within the profession or occupation to the standards expected in independent employment or practice. The *professional competency profiles* for each professional category record the elements of competency necessary for competent performance that the professional is expected to be able to demonstrate in a holistic way at the stage of attaining registration.

Professional competence can be described using a set of attributes corresponding largely to the graduate attributes, but with different emphases. For example, at the professional level, the ability to take responsibility in a real-life situation is essential. Unlike the graduate attributes, professional competence is more than a set of attributes that can be demonstrated individually. Rather, competence must be assessed holistically (as a whole).

To meet the minimum standard of competence, a person must demonstrate that he/she is able to practice competently in his/her practice area to the standard expected of a reasonable Professional Engineer.

The extent to which the person is able to perform each of the elements shown in the following table in his/her practice area must be taken into account in assessing whether or not he/she meets the overall standard.

Professional Competency Profiles

No.	Competency	Character of Professional Engineer
1	Comprehend and apply universal knowledge	Comprehend and apply advanced knowledge of the widely-applied principles underpinning good practice.
2	Comprehend and apply local knowledge	Comprehend and apply advanced knowledge of the widely-applied principles underpinning good practice specific to the jurisdiction in which he/she practices.
3	Problem analysis	Define, investigate and analyze complex problems.
4	Design and development of solutions	Design or develop solutions to complex problems.
5	Evaluation	Evaluate the outcomes and impacts of complex activities.
6	Protection of society	Recognize the reasonably foreseeable social, cultural and environmental effects of complex activities generally, and have regard to the need for sustainability; recognize that the protection of society is the highest priority.
7	Legal and regulatory	Meet all legal and regulatory requirements and protect public health and safety in the course of his or her activities.
8	Ethics	Conduct his or her activities ethically.
9	Manage engineering activities	Manage part or all of one or more complex activities.
10	Communication	Communicate clearly with others in the course of his or her activities.
11	Lifelong learning	Undertake CPD activities sufficient to maintain and extend his or her competence.
12	Judgment	Recognize complexity and assess alternatives in light of competing requirements and incomplete knowledge. Exercise sound judgment in the course of his or her complex activities.
13	Responsibility for decisions	Be responsible for making decisions on part or all of complex activities.

1.6 General Range and Profile Definitions

Range of Problem Solving

Attribute	Complex Engineering Problems
Preamble	**Engineering problems which cannot be resolved without in-depth engineering knowledge, much of which is at, or informed by, the forefront of the professional discipline, and have some or all of the following characteristics:**
Range of conflicting requirements	Involve wide-ranging or conflicting technical, engineering and other issues.
Depth of analysis required	Have no obvious solution and require abstract thinking, originality in analysis to formulate suitable models.
Depth of knowledge required	Requires research-based knowledge much of which is at, or informed by, the forefront of the professional discipline and which allows a fundamentals-based, first principles analytical approach.

Familiarity of issues	Involve infrequently encountered issues.
Extent of applicable codes	Are outside problems encompassed by standards and codes of practice for professional engineering.
Extent of stakeholder involvement and level of conflicting requirements	Involve diverse groups of stakeholders with widely varying needs.
Consequences	Have significant consequences in a range of contexts.
Interdependence	Are high level problems including many component parts or sub-problems.

Range of Engineering Activities

Attribute	Complex Engineering Activities
Preamble	**Complex activities means (engineering) activities or projects that have some or all of the following characteristics:**
Range of resources	Involve the use of diverse resources (and for this purpose resources includes people, money, equipment, materials, information and technologies).
Level of interactions	Require resolution of significant problems arising from interactions between wide-ranging or conflicting technical, engineering or other issues.
Innovation	Involve creative use of engineering principles and research-based knowledge in novel ways.
Consequences to society and the environment	Have significant consequences in a range of contexts, characterized by difficulty of prediction and mitigation.
Familiarity	Can extend beyond previous experiences by applying principles-based approaches.

Knowledge Profile

A systematic, theory-based understanding of the natural sciences applicable to the discipline (e.g. calculus-based physics).
Conceptually-based mathematics, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modeling applicable to the discipline.
A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
Knowledge that supports engineering design in a practice area
Knowledge of engineering practice (technology) in the practice areas in the engineering discipline
Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; the impacts of engineering activity: economic, social, cultural, environmental and sustainability.
Engagement with selected knowledge in the research literature of the discipline.
A programme that builds this type of knowledge and develops the attributes listed below is typically achieved in 4 to 5 years of study, depending on the level of students at entry.

1.7 National Engineering Graduate Attributes

According to the ***ABET*** outcomes and ***WA*** attributes outlined above, the general expectations about the qualifications, attributes and capabilities that graduates of the national engineering programs should be able to demonstrate are re-formulated as listed below.

1.7.1 Knowledge and Understanding

The graduates of the engineering programs should be able to demonstrate the knowledge and understanding of:

a. Concepts and theories of mathematics and sciences, appropriate to the discipline.
b. Basics of information and communication technology (ICT).
c. Characteristics of engineering materials related to the discipline.
d. Principles of design including elements design, process and/or a system related to specific disciplines.
e. Methodologies of solving engineering problems, data collection and interpretation.
f. Quality assurance systems, codes of practice and standards, health and safety requirements and environmental issues.
g. Business and management principles relevant to engineering.
h. Current engineering technologies as related to disciplines.
i. Topics related to humanitarian interests and moral issues.
j. Technical language and report writing.
k. Professional ethics and impacts of engineering solutions on society and environment.
l. Contemporary engineering topics.
m. Understanding the national and patriotism issues and believe in their importance.

1.7.2 Intellectual Skills

The graduates of the engineering programs should be able to:

a. Select appropriate mathematical and computer-based methods for modeling and analyzing problems.
b. Select appropriate solutions for engineering problems based on analytical thinking.
c. Think in a creative and innovative way in problem solving and design.
d. Combine, exchange, and assess different ideas, views, and knowledge from a range of sources.
e. Assess and evaluate the characteristics and performance of components, systems and processes.

f. Investigate the failure of components, systems, and processes.
g. Solve engineering problems, often on the basis of limited and possibly contradicting information.
h. Select and appraise appropriate ICT tools to a variety of engineering problems.
i. Judge engineering decisions considering balanced costs, benefits, safety, quality, reliability, and environmental impact.
j. Incorporate economic, societal, environmental dimensions and risk management in design.
k. Analyze results of numerical models and assess their limitations.
l. Create systematic and methodic approaches when dealing with new and advancing technology.

1.7.3 Practical and Professional Skills

The graduates of the engineering programs should be able to:

a. Apply knowledge of mathematics, science, information technology, design, business context and engineering practice integrally to solve engineering problems.
b. Professionally merge the engineering knowledge, understanding, and feedback to improve design, products and/or services.
c. Create and/or re-design a process, component or system, and carry out specialized engineering designs.
d. Practice the neatness and aesthetics in design and approach.
e. Use computational facilities and techniques, measuring instruments, workshops and laboratory equipment to design experiments, collect, analyze and interpret results.
f. Use a wide range of analytical tools, techniques, equipment, and software packages pertaining to the discipline and develop required computer programs.
g. Apply numerical modeling methods to engineering problems.
h. Apply safe systems at work and observe the appropriate steps to manage risks.
i. Demonstrate basic organizational and project management skills.
j. Apply quality assurance procedures and follow codes and standards.
k. Exchange knowledge and skills with engineering community and industry.
l. Prepare and present technical reports.

1.7.4 General and Transferable Skills

The graduates of the engineering programs should be able to:

a. Collaborate effectively within multidisciplinary team.
b. Work in stressful environment and within constraints.
c. Communicate effectively.
d. Demonstrate efficient IT capabilities.

e. Lead and motivate individuals.
f. Effectively manage tasks, time, and resources.
g. Search for information and engage in life-long self-learning discipline.
h. Acquire entrepreneurial skills.
i. Refer to relevant literatures.

Appendix A: Terminology

<u>Note:</u> The following definitions apply to the terms used in this document which are equivalent to the terms used in other engineering education standards.

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

Complementary (Contextual) Knowledge: Disciplines other than engineering, basic and mathematical sciences, that support engineering practice, enable its impacts to be understood and broaden the outlook of the engineering graduate.

Continuing Professional Development CPD: the systematic, accountable maintenance, improvement and broadening of knowledge and skills, and the development of personal qualities necessary for the execution of professional and technical duties throughout an engineering practitioner's career.

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

Engineering Design Knowledge: Knowledge that supports engineering design in a practice area, including codes, standards, processes, empirical information, and knowledge reused from past designs.

Engineering Discipline: synonymous with *branch of engineering.*

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

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

Engineering Problem: is a problem that exists in any domain that can be solved by the application of engineering knowledge and skills and generic competencies.

Engineering Practice Area: a generally accepted or legally defined area of engineering work or engineering technology.

Engineering Specialty or Specialization: a generally-recognized practice area or major subdivision within an engineering discipline, for example Structural and Geotechnical Engineering within Civil Engineering; the extension of engineering fundamentals to create theoretical frameworks and bodies of knowledge for engineering practice areas.

Engineering Technology: is an established body of knowledge, with associated tools, techniques, materials, components, systems or processes that enable a family of practical applications and that relies for its development and effective application on engineering knowledge and competency.

Formative Development: the process that follows the attainment of an accredited education program that consists of training, experience and expansion of knowledge.

Manage: means planning, organizing, leading and controlling in respect of risk, project, change, financial, compliance, quality, ongoing monitoring, control and evaluation.

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

Natural Sciences: Provide, as applicable in each engineering discipline or practice area, an understanding the physical world including physics, mechanics, chemistry, earth sciences and the biological sciences,

Practice Area: *in the educational context:* synonymous with generally-recognized engineering specialty; *at the professional level:* a generally recognized or distinctive area of knowledge and expertise developed by an engineering practitioner by virtue of the path of education, training and experience followed.

Solution: means an effective proposal for resolving a problem, taking into account all relevant technical, legal, social, cultural, economic and environmental issues and having regard to the need for sustainability.

Subdiscipline: Synonymous with *engineering specialty*.

Substantial Equivalence: applied to educational programs means that two or more programs, while not meeting a single set of criteria, are both acceptable as preparing their respective graduates to enter formative development toward registration.