جمهورية العراق

Republic of Iraq

وزارة التعليم العالي والبحث العلمي

Ministry of Higher Education & Scientific Research

جهاز الاشراف والتقويم العلمي

Apparatus of Supervision & Scientific Evaluation

# Attributes and Professional Competencies of the Graduates of Iraqi Engineering BSc Programs

المجلس العراقي لاعتماد التعليم الهندسي

Iraqi Council of Accreditation
for Engineering Education

Rabie I, 1443 December, 2020

# ATTRIBUTES AND PROFESSIONAL COMPETENCIES OF THE GRADUATES OF ENGINEERING BSC PROGRAMS

## 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 in the context of sustainability.

Since 2015, the Ministry of Higher Education and Scientific Research in Iraq (MOHESR) had lunched a comprehensive project entitled "Rehabilitation of Iraq's Higher Education System - Towards Quality Improvement of Engineering Programs in All Iraqi Universities". The Project was aided by the UNISCO (Iraq Office) and the Network of Iraqi Scientists Abroad (NISA).

The first package of training workshops included the Engineering Colleges in Iraq, in which many engineering programs had received special attention in this context. Furthermore, a Council for Quality Improvement of Engineering Education has been also established in 2015 in order to ensure the continuity of the project.

The Council started to set National Accreditation Criteria for Engineering Education (included BSc degrees in engineering at first). The first step in this endeavor was to set the **Graduate Attributes and Professional Competencies** being essential as a starting line. Therefore the Council had issued this document to fill the gap.

As soon as the National Accreditation Criteria for Engineering Education was set in 2018, the Council for Quality Improvement of Engineering Education was developed to be the Iraqi Council of Accreditation for Engineering Education (ICAEE).

**Prof. Dr. Zeyad S. M. Khaled**
**ICAEE Chairman**

# 1. INTRODUCTION

This document is compiled according to the International Engineering Alliance (**IEA**) valid issue in this context and solely based on what it says.

**Engineering** is an activity that is essential to meet the needs of people, economic development and provision of services. It involves purposeful application of mathematical and natural sciences and engineering knowledge in order to produce solutions whose effects are predicted to the greatest degree possible in often uncertain contexts. While bringing benefits, it has potential adverse consequences, therefore it must be carried out responsibly and ethically, use available resources efficiently, be economic, safeguard health and safety, be environmentally sound and sustainable and generally manage risks throughout the entire lifecycle of a system.

The development of an **engineering professional** is an ongoing process with three identified stages. The first stage is the engineering education graduate stage in which the fundamental purpose is to build a knowledge base and attributes to enable the graduate to continue learning and to proceed to formative development that will develop the competencies required for independent practice. The second stage is the professional registration after a period of formative development in which the fundamental purpose is to develop the competencies required for independent practice where the graduate works with engineering practitioners and progresses from an assisting role to taking more individual and team responsibility until competence can be demonstrated at the level required for registration. Once registered, the practitioner must maintain and expand competence. A third stage is to qualify for the international register held by the various jurisdictions. In addition, engineers are expected to maintain and enhance competency throughout their working lives.

According to the Accreditation Board for Engineering and Technology, currently known worldwide as (**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 Iraqi Council of Accreditation for Engineering Education (ICAEE) aim at joining 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 countries all over the world, from Japan in the far east to the United States in the far west. 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 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

The International Professional Engineers Agreement (**IPEA**) provide mechanisms to support **the recognition of a professional** registered in one signatory jurisdiction obtaining recognition in another. The Washington Accord (WA) signatories have formulated consensus competency profiles for the registration and these are adopted in this document in addition to the signatories' consensus on the attributes of graduates. The distinctive competencies, together with their educational underpinnings are defined in sections of this document.

# 2. GRADUATE OUTCOMES ACCORDING TO ICAEE

The followings are the "Graduate Outcomes" adopted by ICAEE. These outcomes are compatible to the "Student Outcomes" adopted by ABET. Every program must make sure that its graduates do acquire these outcomes at the time of graduation.

i. An ability to distinguish, identify, define, formulate, and solve engineering problems by applying principles of engineering, science and mathematics.
ii. An ability to produce engineering designs that meet desired needs within certain constraints by applying both analysis and synthesis in the design process.
iii. An ability to create and carry out proper measurement and tests with quality assurance, analyze and interpret results, and utilize engineering judgment to make inferences.
iv. An ability to skillfully communicate orally with a gathering of people and in writing with various managerial levels.
v. An ability to perceive ethical and professional responsibilities in engineering cases and make brilliant judgments taking into account the consequences in worldwide financial, ecological and societal considerations.
vi. An ability to perceive the continual necessity for professional knowledge growth and how to find, assess, assemble and apply it properly.
vii. An ability to work adequately on teams and to set up objectives, plan activities, meet due dates, and manage risk and uncertainty

# 3. GRADUATE ATTRIBUTES BACKGROUND

The following background explains the meaning of "Graduate Attributes", purpose, limitation, role, scope, interpretation, application and organization. The full set of graduate attribute definitions is given in the section of graduate attributes.

## Meaning of Graduate Attributes

The graduate attributes are exemplars of the expected attributes that form a set of individually assessable outcomes or indicators of the graduate's potentials to acquire competence to practice at the appropriate level. They are clear, succinct statements of the expected capability and qualified by a range indication appropriate to the type of program.

## Purpose of Graduate Attributes

The graduate attributes are intended to assist in developing outcomes-based education and accreditation criteria as well. They also serve to identify the distinctive characteristics as well as areas of commonality between the expected outcomes of the different types of programs.

## Limitation of Graduate Attributes

Programs are not expected to have identical outcomes and content but rather produce graduates who could enter employment and be fit to undertake a program of training and experiential learning leading to professional competence and registration. The graduate attributes provide a point of reference to describe the outcomes of substantially equivalent qualification.

## Role of Graduate Attributes

The Graduate Attributes are assessable outcomes, supported by level statements, developed to give confidence that the educational objectives of programs are being achieved. The quality of a program depends not only on the stated objectives and attributes to be assessed but also on the program design, resources committed to the program, the teaching and learning process and assessment of students, including confirmation that the graduate attributes are satisfied.

## Scope of Graduate Attributes

The attributes are chosen to be universally applicable and reflect acceptable minimum standards and be capable of objective measurement. While all attributes are important, individual attributes are not necessarily of equal weight. Attributes are selected that are expected to be valid for extended periods and changed infrequently only after considerable debate. Attributes may depend on information external to this document, for example generally accepted principles of ethical conduct.

## Contextual Interpretation

The graduate attributes are stated generically and are applicable to all engineering disciplines. In interpreting the statements within a disciplinary context, individual statements may be amplified and given particular emphasis but must not be altered in substance or individual elements ignored.

## Best Practice of Application

The attributes are defined as a knowledge profile, an indicated volume of learning and the attributes against which graduates must be able to perform. The requirements are stated without reference to the design of programs that would achieve the requirements. Providers therefore have freedom to design programs with different detailed structure, learning pathways and modes of delivery. Evaluation of individual programs is the concern of related national systems.

## Organization of Graduate Attributes

The graduate attributes are organized using twelve headings shown in the section of graduate attributes. Each heading identifies the differentiating characteristic that allows the distinctive roles of engineers to be distinguished by range information. The range qualifier in several attribute statements uses the notions which are defined in the section of program knowledge profile.

# 4. PROFESSIONAL COMPETENCIES BACKGROUND

The following background explains the meaning of "Professional Competence", purpose, limitation, scope, interpretation and organization. The full set of professional competency profiles is given in the section of professional competency profiles.

**Meaning of Professional Competence**

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.

**Purpose of Professional Competency Profiles**

A professional must have the attributes necessary to perform the activities within the profession 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.

**Scope of Professional Competency Profiles**

Demonstration of competence may take place in different areas of practice and different types of work. Competence statements are therefore discipline-independent. Competence statements accommodate different types of work, for example design, research and development and engineering management by using the broad phases in the cycle of engineering activity: problem analysis, synthesis, implementation, operation and evaluation, together the management attributes needed. The competence statements include the personal attributes needed for competent performance irrespective of specific local requirements: communication, ethical practice, judgment, taking responsibility and the protection of society.

## Limitations of Professional Competency Profiles

As in the case of the graduate attributes, the professional competency profiles are not prescriptive in detail but rather reflect the essential elements that would be present in competency standards. The professional competency profiles do not specify performance indicators or how the above items should be interpreted in assessing evidence of competence from different areas of practice or for different types of work.

Each national system may define performance indicators that are actions on the part of the candidate that demonstrate competence. For example, a design competency may be evidenced by the following performances:

i. Identify and analyze design/ planning requirement and draw up detailed requirements specification
ii. Synthesize a range of potential solutions to problem or approaches to project execution
iii. Evaluate the potential approaches against requirements and impacts outside requirements
iv. Fully develop design of selected option
v. Produce design documentation for implementation

## Contextual Interpretation

The professional competency profiles are stated generically and are applicable to all engineering disciplines. The application of a competency profile may require amplification in different regulatory, disciplinary, occupational or environmental contexts. In interpreting the statements within a particular context, individual statements may be amplified and given particular emphasis but must not be altered in substance or ignored.

## Organization of Professional Competency Profiles

At the professional level, a classification of engineering activities is used to define ranges and to distinguish between categories. Each profile consists of thirteen individual elements that are formulated around a differentiating characteristic using a stem and range modifier as shown in the section of engineering activities. Like their counterparts in the graduate attributes, the range statements use the notions defined in the section of program knowledge profile.

# 5. PROGRAM KNOWLEDGE PROFILE

A program 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.

**Natural Sciences:** A systematic, theory-based understanding of the natural sciences applicable to the discipline.

**Mathematics:** Conceptually-based mathematics, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modeling applicable to the discipline.

**Engineering Fundamentals**: A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.

**Specialist Knowledge:** 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.

**Design**: Knowledge that supports engineering design in a practice area.

**Technology:** Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.

**Comprehension:** 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.

**Research**: Engagement with selected knowledge in the research literature of the discipline.

## 6. PROBLEM SOLVING

Complex Engineering Problems have characteristic of the followings in the context of both Graduate Attributes and Professional Competencies:

**Depth of Knowledge Required:** Cannot be resolved without in-depth engineering knowledge of one or more of the program knowledge profile which allows a fundamentals-based, first principles analytical approach.

**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.

**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:** Involve diverse groups of stakeholders with widely varying needs.

**Interdependence:** Are high level problems including many component parts or sub-problems.

In addition, in the context of the Professional Competencies

**Consequences:** Have significant consequences in a range of contexts.

**Judgment:** Require judgment in decision making.

## 7. ENGINEERING ACTIVITIES

Complex engineering activities mean 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.

## 8. GRADUATE ATTRIBUTES

The Graduate Attributes adopted by the Council of Quality Improvement of Engineering Education in Iraq are the same as the IEA Graduate Attributes explained in the following:

**Engineering Knowledge:** Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution.

**Problem Analysis:** Identify, formulate, research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.

**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.

**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.

**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.

**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.

**Environment and Sustainability:** Understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.

**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.

**Individual and Team work:** Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.

**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.

**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.

**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.

# 9. PROFESSIONAL COMPETENCY PROFILES

To meet the minimum standard of competency, an engineer must demonstrate the ability to practice competently in the corresponding practice area to the standard expected of a reasonable Professional Engineer. The extent to which the engineer is able to perform each of the following elements must be taken into account in assessing whether to meet the overall standard or not.

**Comprehend and apply universal knowledge:** Comprehend and apply advanced knowledge of the widely-applied principles underpinning good practice.

**Comprehend and apply local knowledge:** Comprehend and apply advanced knowledge of the widely-applied principles underpinning good practice specific to the jurisdiction of practices.

**Problem analysis:** Define, investigate and analyze complex problems.

**Design and development of solutions:** Design or develop solutions to complex problems.

**Evaluation:** Evaluate the outcomes and impacts of complex activities.

**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.

**Legal and regulatory:** Meet all legal and regulatory requirements and protect public health and safety in the course of activities.

**Ethics:** Conduct activities ethically.

**Manage engineering activities:** Manage part or all of one or more complex activities.

**Communication:** Communicate clearly with others in the course of activities.

**Lifelong learning:** Undertake CPD activities sufficient to maintain and extend competence.

**Judgment:** Recognize complexity and assess alternatives in light of competing requirements and incomplete knowledge. Exercise sound judgment in the course of complex activities.

**Responsibility for decisions:** Be responsible for making decisions on part or all of complex activities.

## 10. PRACTICAL AND PROFESSIONAL SKILLS

The graduates of the engineering programs should be able to:

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

## 11. ADDITIONAL GRADUATE ATTRIBUTES

The following additional graduate attributes are adopted by the Iraqi Council of Accreditation for Engineering Education in addition to the IEA Graduate Attributes already explained:

**Knowledge**

i. Technical English and report writing.
ii. Global contemporary issues.
iii. National and patriotism issues.

**Intellectual Skills**

i. Use of lateral thinking in problem solving.
ii. Think in creative and innovative way.
iii. Combine, exchange, and assess different ideas from different sources.

**General Skills**

i. Practice neatness and aesthetics in every approach.
ii. Exchange knowledge with the engineering community and industry.
iii. Search for information and engage in life-long self-learning discipline.
iv. Acquire entrepreneurial skills.

**Transferable Skills**

i. Collaborate effectively within multidisciplinary team.
ii. Work in stressful environment and within constraints.
iii. Lead and motivate individuals.
iv. Communicate effectively.
v. Demonstrate efficient IT capabilities.
vi. Effectively manage tasks, time, and resources.
vii. Refer to relevant literatures.

## 12. DEFINITIONS OF TERMS

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:** 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.

**Forefront of the professional discipline/branch:** defined by advanced practice in the specializations within the discipline.

**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.

**Sub-discipline:** 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.