National Academic Reference Standards (NARS)

Engineering

2nd Edition

2018

Foreword

In line with NAQAE's legal mandate as the authority responsible for Quality Assurance of Education in Egypt, and out of its commitment to be a promoter of quality and an agent for change; NAQAAE has developed the 2nd edition of the National Academic Reference Standards (NARS) -Engineering (2018). These standards represent the minimum academic quality requirements, which NAQAAE and the relevant Stakeholders regard as necessary and appropriate to protect the interests of the students, and of the community at large.

It has always been our conviction that quality is primarily the responsibility of the institution itself, and that the academic standards adopted by any institution should support the achievement of its mission. Thus, it is crucial to emphasize that the NARS are meant to be used as reference points that provide guidance in the design, delivery and review of academic programs, and are not intended by any means to represent a national curriculum in the subject. Instead, NAQAAE was keen to ensure that the NARS allow for flexibility and innovation in program design and teaching strategies, within a framework agreed by the subject community.

NAQAAE has always supported the autonomy and academic freedom of educational institutions and acknowledged -and assimilated- the diversity of their missions, hence, institutions are invited to consider adopting other reference points that better reflect their mission if they need to, provided that these adopted academic standards are equal to or higher than the NARS.

Finally, it should be noted that the 2nd edition NARS- Engineering will be effective starting academic year 2019-20.

Youhansen Eid
Chairman of the Board

I. Introduction

According to the law 82-2006, the National Authority for Quality Assurance and Accreditation of Education "NAQAAE " is responsible for Quality Assurance of education as well as for building the confidence in - and ensuring the recognition of - the output of the Egyptian education system, i.e. graduates / qualifications. The law has granted NAQAAE the authority to set standards and policies and to develop the tools needed to fulfill its defined responsibilities.

While recognizing the existence of- and the need for- diverse institutional missions and educational objectives, NAQAAE believes that any Engineering educational program (as any other educational program) must provide assurances that the graduates exhibit general professional competencies that meet the expectations of the community and that serve as the foundation for a process of lifelong learning and professional development of the engineering graduate. To help institutions provide this assurance and to protect the interests of the community and the students themselves, NAQAAE has developed Subject Specific National Academic Reference Standards (NARS) for engineering educational programs as well as for other subject sectors. The NARS-Engineering are meant to express the stakeholders' expectations about the graduate of an engineering school in Egypt, defining (and articulating) the attributes and competencies that holders of the qualification " Bachelor Degree in Engineering" in the different engineering sectors should exhibit.

The bachelor degree in Engineering is a level 5 qualification on the Egyptian National Qualification Framework. According to the Egyptian NQF descriptors, the holder of a level 5 qualification should be able to*:*

- Apply integrated general/ professional knowledge covering a broad spectrum of facts, principles and theories within inter-related domains with specialization in a field of study or work.
- Use analytic critical thinking to solve specialized problems in predictable and non-predictable contexts, while dealing with variation and interfering factors.
- Master a wide spectrum of specialized skills using familiar and less familiar tools.
- Critically evaluate the results of achieved tasks to establish multi-dimensional correlations and build technical expertise.
- Identify occupational hazards and design mitigation measures for them
- Apply cost/effectiveness measures.
- Manage processes in familiar and less familiar contexts.
- Use digital tools and media to deal with academic / professional challenges in a critical and creative manner.

- Work or study autonomously under general systems and rules, assuming full responsibility for own learning and self-development.
- Take informed decisions in familiar contexts.
- Assumes responsibility for own and team performance.
- Evaluate the performance of subordinates and support their development.
- Uses efficiently and develops workplace resources.
- Embrace work ethics.
- Ensures the application of quality assurance standards and procedures, enhancing methodologies and processes.

NAQAAE - being responsible for guaranteeing the quality of qualifications and of education, was keen while developing the NARS-Engineering with different stakeholders to ensure that those standards benchmark with the descriptors of level 5 qualifications on the Egyptian NQF and that they reflect the paradigm shift in Engineering education from time bound to competency based education as will be evident throughout this document.

II. About the NARS

The National Academic Reference Standards (NARS)

- The National Academic Reference Standards (NARS) are external references for designing and upgrading the undergraduate educational program of faculties of Engineering. They also represent general expectations about the standards for the award of Bachelor Degree in Engineering and articulate the attributes and competencies that those possessing such qualification should be able to demonstrate.
- These standards represent the minimum academic quality requirements, which are regarded as appropriate and reasonable in order to protect the interests of the students, the reputation of individual faculties, and the community.
- The first edition of the National Academic Reference Standards was published in 2009 as outcome-based standards. In the last ten years there has been a significant progress -on the international level- in education. NAQAAE, to align with international engineering updated standards, and after consultation with the main stakeholder in Egypt decided to shift the Egyptian NARS from learning outcomes to competency based.
- They originate from the NQF and define graduate attributes according to the corresponding level descriptors

The shift to competency-based engineering education

- Historically, engineering education has been a "Structured Process", based on a learning model that is time and teacher centered, where studying standardized courses, learning skills and participating in a projects and years of training were the determinants of completing an engineering educational program.
- In the recent past a shift occurred to the Learning Outcomes (LO)-based education, where intended learning outcomes were articulated in the form of Knowledge, Skills and Attitudes that a student must achieve. Despite its being a relatively successful student centered and outcome-oriented model for education; the LO based education model worked with a critical assumption that achieving separate learning outcomes (that were often subject-specific) will enable the engineering graduate to reach an

appropriate level of competence to practice with some degree of autonomy. It was also

based on the assumption that all learners would achieve the outcomes within the same time-based model.

- Through the past decade with higher societal expectations from graduates to demonstrate the development of higher competence standards and with the culminating literature supporting the value of integrated learning, the engineering education worldwide responded by a paradigm shift towards a more holistic and integrated approach to education, that is competency-based education (CBE).
- CBE thus emerged out of a need to focus engineering education on developing learners' competencies and engaging them in real life experiences, and to emphasize learners' abilities and foster the good practices of integrated learning.

Methodology for the developing NARS- Engineering 2018

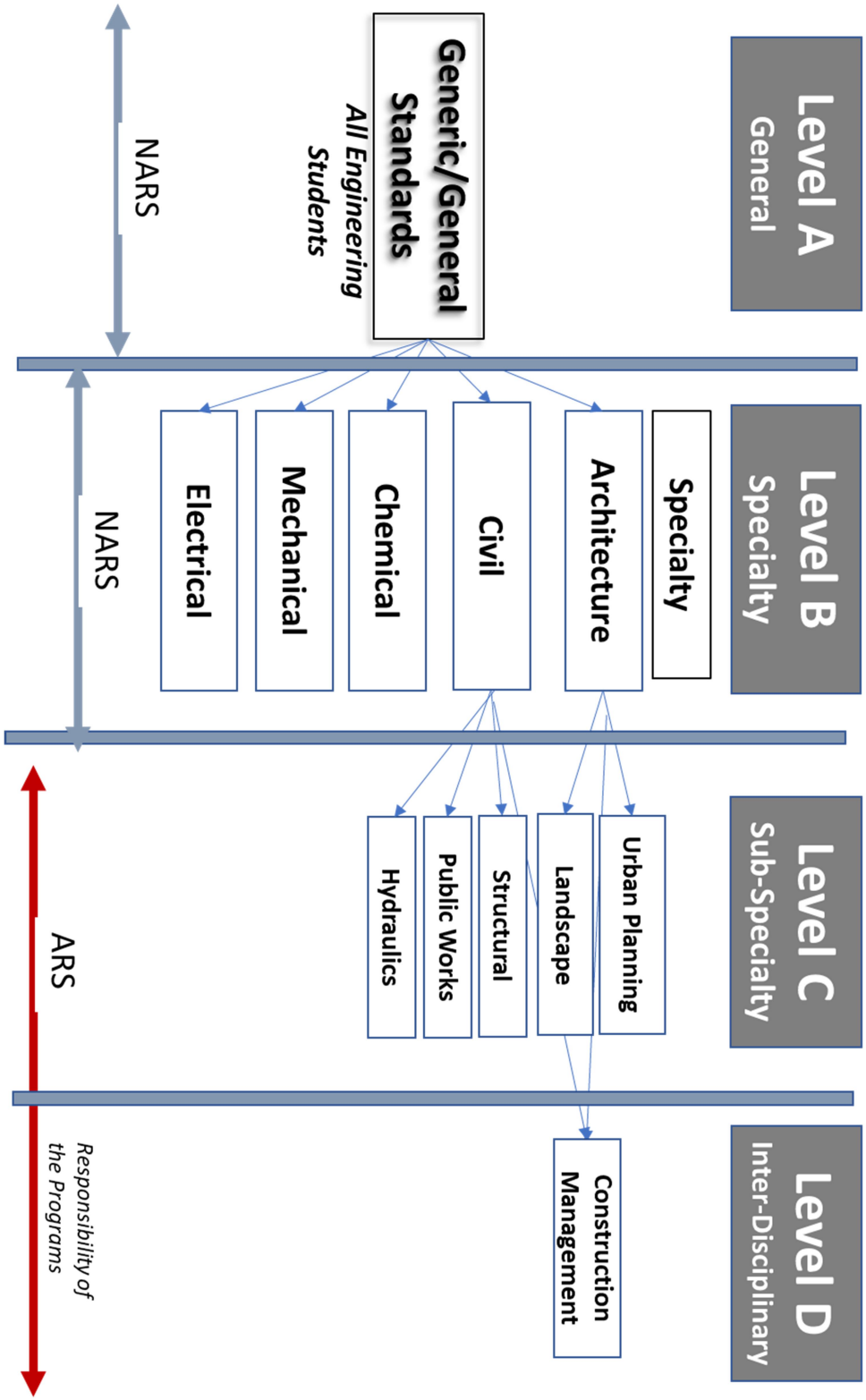
- Under NAQAAE's coordination, NARS-Engineering 2018 have been developed by a group of academics and professionals representing a wide variety of key partners including: Egyptian Universities, the Engineering Sector Committee of the Supreme Council of Universities, the Syndicate of Engineers, Professionals in the field of Engineering, representatives of all engineering sectors.
- The NARS were developed through the following process:
    - Establishment of the "NARS-Engineering" development committee which constitutes a technical task force of experts in Engineering education representing different engineering sectors.
    - Review of the literature regarding developments in engineering education, competency-based education, subject benchmarks for engineering and existing competency frameworks for engineering programs.
    - Analysis of the feedback from Egyptian faculties of Engineering on the NARS 2009, as well as analysis of NAQAAE's external review reports on the faculties of Engineering that went through the accreditation process since the year 2009.
    - Study of the NQF – Egypt to identify the descriptors of a Bachelor degree qualification.
    - Holding brain storming sessions with different stakeholders to define the attributes and competencies of the engineering school graduate.

- Preparing a first draft document of the NARS.
- Holding numerous referee/discussion sessions with stakeholders' representatives to refine the draft document.
- Conducting a series of workshops to present the NARS and explain the planned process for feedback.
- Getting feedback on the developed NARS from a wide base of stakeholders through email surveys.
- Modifying the NARS according to the obtained feedback
- Accreditation of the developed NARS by NAQAAE's board.

Overview of the structure of NARS- Engineering 2018

- The special nature of Engineering Education, prepares graduates in quite different disciplines and who are able to work in varying job markets. Yet they all share commo attributes that are similar and that equip the engineer with critical thinking and problem-solving techniques.
- Engineering education varies from one school to another, and the level of specialization is not the same. Engineering programs are not only multidisciplinary, but they are also inter- and intra-disciplinary, a dilemma that faces Engineering education that tries to cope with and meet the demands of a changing technological arena on a daily basis.
- Thus, the Structure of the NARS-Engineering was developed to reflect the competencies that should be acquired by the engineering graduate, in addition to the competencies of the main sectors.
- It is left to the discretion of the different schools to develop their own inter and intra-disciplinary approaches and design their programs according to their own missions; provided that they meet the minimum standards stipulated by the specialization.
- It was agreed to develop the competency framework of the NARS-Engineering according to seven specializations: Civil – Mechanical - Architectural – Electrical – Chemical – Textile – Petroleum, Mining and Metalurgy.

NARS-Engineering Competency Framework



Structure of the NARS- Engineering 2018

Due to the special engineering education the NARS will be divided as follows:

- Graduate Attributes;
    - The specific qualities that distinguish the graduate engineer
- General (Generic) competencies:
    - General description of the Graduate
    - Common Competencies that signify all graduates
    - All graduates of any engineering faculty should be able to master
    - These compromise the basis for the development of the programs
- Specialized (discipline specific) Competencies:
    - Specific description of the graduates of the different specializations
    - Highly specialized competencies that all graduates of the discipline should be able to master

Schools can design their programs to the level of specialization that comply with their missions. They will need to specify what root discipline they are basing their design and competences on.

Role of Key partners

NAQAAE

The role of NAQAAE is to:

- Coordinate the development of the NARS with wide stakeholders' involvement.
- Approve and Publish the NARS.
- Disseminate the NARS using different means.
- Build the capacity of Engineering schools to enable them to properly apply the NARS.
- Assure the application of the NARS through the conduct of the external reviews.
- Periodically review and develop the NARS, keeping up with developments in engineering education.

The Engineering Sector Committee of the Supreme Council of Universities

- The role of the Engineering Sector Committee is to participate in the development and dissemination of the NARS, and to facilitate its implementation.

Faculties of Engineering

The role of each faculty of enginneering is to:

- Formally adopt the NARS and ensure that they are in compliance with its mission.
- The faculty may opt to adopt other Academic Reference Standards (ARS) (whether these are external or developed by the faculty) that are more consistent with its mission, and in this case the faculty must submit its ARS to NAQAAE to accredit as being equal or higher than the NARS.
- Raise awareness of the faculty members and students about the adopted standards.
- Have an executive plan to successfully implement and monitor the academic reference standards and means to secure and sustain the use of these standards.
- Clearly define the program and course specifications including aims and Learning Outcomes, keeping constructive alignment between learning outcome, teaching modalities, assessment methods and available learning resources.
- Make available all evidences they may wish to present under each of the standards and make this clear in their self-evaluation reports and during external audit.
- Adhere to the Guidelines for application of the NARS presented later in this document.

IV. Attributes of the Graduates of Engineering

The Engineering Graduate must:

1. Master a wide spectrum of engineering knowledge and specialized skills and can apply acquired knowledge using theories and abstract thinking in real life situations;
2. Apply analytic critical and systemic thinking to identify, diagnose and solve engineering problems with a wide range of complexity and variation;
3. Behave professionally and adhere to engineering ethics and standards;
4. Work in and lead a heterogeneous team of professionals from different engineering specialties and assume responsibility for own and team performance;
5. Recognize his/her role in promoting the engineering field and contribute in the development of the profession and the community;
6. Value the importance of the environment, both physical and natural, and work to promote sustainability principles;
7. Use techniques, skills and modern engineering tools necessary for engineering practice;
8. Assume full responsibility for own learning and self-development, engage in lifelong learning and demonstrate the capacity to engage in post- graduate and research studies;
9. Communicate effectively using different modes, tools and languages with various audiences; to deal with academic/professional challenges in a critical and creative manner;
10. Demonstrate leadership qualities, business administration and entrepreneurial skills.

V. Competencies for Engineering Graduates

COMETENCIES OF ENGINEERING GRADUATE

The Engineering Graduate must be able to:

1. Identify, formulate, and solve complex engineering problems by applying engineering fundamentals, basic science and mathematics.

2. Develop and conduct appropriate experimentation and/or simulation, analyze and interpret data, assess and evaluate findings, and use statistical analyses and objective engineering judgment to draw conclusions.

3. Apply engineering design processes to produce cost-effective solutions that meet specified needs with consideration for global, cultural, social, economic, environmental, ethical and other aspects as appropriate to the discipline and within the principles and contexts of sustainable design and development.

4. Utilize contemporary technologies, codes of practice and standards, quality guidelines, health and safety requirements, environmental issues and risk management principles.

5. Practice research techniques and methods of investigation as an inherent part of learning.

6. Plan, supervise and monitor implementation of engineering projects, taking into consideration other trades requirements.

7. Function efficiently as an individual and as a member of multi-disciplinary and multi-cultural teams.

8. Communicate effectively – graphically, verbally and in writing – with a range of audiences using contemporary tools.

9. Use creative, innovative and flexible thinking and acquire entrepreneurial and leadership skills to anticipate and respond to new situations.

10. Acquire and apply new knowledge; and practice self, lifelong and other learning strategies.

VI. Competencies for Engineering Specializations

1. CIVIL ENGINEERING

In addition to the above Competencies for All Engineering Programs the BASIC CIVIL Engineering graduate must be able to:

1.1 Select appropriate and sustainable technologies for construction of buildings, infrastructures and water structures; using either numerical techniques or physical measurements and/or testing by applying a full range of civil engineering concepts and techniques of: Structural Analysis and Mechanics, Properties and Strength of Materials, Surveying, Soil Mechanics, Hydrology and Fluid Mechanics.

1.2 Achieve an optimum design of Reinforced Concrete and Steel Structures, Foundations and Earth Retaining Structures; and at least three of the following civil engineering topics: Transportation and Traffic, Roadways and Airports, Railways, Sanitary Works, Irrigation, Water Resources and Harbors; or any other emerging field relevant to the discipline.

1.3 Plan and manage construction processes; address construction defects, instability and quality issues; maintain safety measures in construction and materials; and assess environmental impacts of projects.

1.4 Deal with biddings, contracts and financial issues including project insurance and guarantees.

2.MECHNICAL ENGINEERING

In addition to the Competencies for All Engineering Programs the BASIC MECHANICAL Engineering graduate and similar programs must be able to:

2.1 Model, analyze and design physical systems applicable to the specific discipline by applying the concepts of: Thermodynamics, Heat Transfer, Fluid Mechanics, solid Mechanics, Material Processing, Material Properties, Measurements, Instrumentation, Control Theory and Systems, Mechanical Design and Analysis, Dynamics and Vibrations.

2.2 Plan, manage and carry out designs of mechanical systems and machine elements using appropriate materials both traditional means and computer-aided tools and software contemporary to the mechanical engineering field.

2.3 Select conventional mechanical equipment according to the required performance.

2.4 Adopt suitable national and international standards and codes; and integrate legal, economic and financial aspects to: design, build, operate, inspect and maintain mechanical equipment and systems.

3. ARCHITECCTURAL ENGINEERING

In addition to the Competencies for All Engineering Programs the BASIC ARCHITECTURAL Engineering graduate and similar programs must be able to:

3.1 Create architectural, urban and planning designs that satisfy both aesthetic and technical requirements, using adequate knowledge of: history and theory, related fine arts, local culture and heritage, technologies and human sciences.

3.2 Produce designs that meet building users' requirements through understanding the relationship between people and buildings, and between buildings and their environment; and the need to relate buildings and the spaces between them to human needs and scale.

3.3. Generate ecologically responsible, environmental conservation and rehabilitation designs; through understanding of: structural design, construction, technology and engineering problems associated with building designs.

3.4 Transform design concepts into buildings and integrate plans into overall planning within the constraints of: project financing, project management, cost control and methods of project delivery; while having adequate knowledge of industries, organizations, regulations and procedures involved.

3.5 Prepare design project briefs and documents, and understand the context of the architect in the construction industry, including the architect's role in the processes of bidding, procurement of architectural services and building production.

4.CHEMICAL ENGINEERING

In addition to the Competencies for All Engineering Programs the BASIC CHEMICAL Engineering graduate and similar programs must be able to:

4.1 Design a practical chemical engineering system, component or process utilizing a full range of chemical engineering principles and techniques including: Mass and Energy Balance, Thermodynamics, Mass Transfer, Heat Transfer, Momentum Transfer, Kinetics of Chemical Reactions, Reactor Design, Instrumentation and Control of Chemical Processes, and Process and Plant Design.

4.2 Engage in the recent technological changes and emerging fields relevant to chemical engineering to respond to the challenging role and responsibilities of a professional chemical engineer.

4.3 Apply numerical modeling methods and/or computational techniques appropriate to chemical engineering.

4.4 Adopt suitable national and international standards and codes to: design, operate, inspect and maintain chemical engineering systems.

5. ELECTRICAL ENGINEERIG

In addition to the Competencies for All Engineering Programs the BASIC ELECTRICAL Engineering graduate and similar programs must be able to:

5.1 Select, model and analyze electrical power systems applicable to the specific discipline by applying the concepts of: generation, transmission and distribution of electrical power systems.

5.2 Design, model and analyze an electrical/electronic/digital system or component for a specific application; and identify the tools required to optimize this design.

5.3 Design and implement: elements, modules, sub-systems or systems in electrical/electronic/digital engineering using technological and professional tools.

5.4 Estimate and measure the performance of an electrical/electronic/digital system and circuit under specific input excitation, and evaluate its suitability for a specific application.

5.5 Adopt suitable national and international standards and codes to: design, build, operate, inspect and maintain electrical/electronic/digital equipment, systems and services.

6. Textile Engineering

In addition to the Competencies for All Engineering Programs the BASIC TEXTILE Engineering graduate and similar programs must be able to:

6.1 Design and operate different processing systems in the textile industries and assess the balance of cost, quality and effects on the environment in production operations.

6.2 Analyze, design and evaluate textile products by applying essential theories, principles, methods and different production technologies in textile manufacturing.

6.3 Engage in the recent technological developments and emerging fields relevant to textile engineering to design textile products, processes and systems.

6.4 Manage resources, plan textile mills and implement quality assurance activities in textile engineering.

7. PETROLEUM, MINING & METALURGY Engineering

In addition to the Competencies for All Engineering Programs the BASIC PETROLEUM, MINING & METALURGY Engineering graduate and similar programs must be able to:

1. PETROLEUM Engineering

7.1.1 Analyze geological data, interpret well-logs, estimate hydrocarbon reserves and evaluate reservoir performance by applying the principles and basic concepts of: geology, geophysics and reservoir engineering.

7.1.2 Plan and construct oil wells, develop oilfield production programs, design early surface facilities plants and field evacuation plans by applying the principles and basic concepts of: drilling engineering, production engineering, phase equilibrium, fluid mechanics and flow through porous media.

7.1.3 Use specialist computer applications and mathematical models to maximize the performance of all petroleum engineering stages.

7.1.4 Apply the concepts of project economics and resources evaluation methods for design and decision making under conditions of risk and uncertainty.

2.MINING Engineering

7.2.1 Design Mining Plants taking into consideration all aspects of the Mine Eco system including: geology, type of ore, exploitation method, materials handling, safety and ground control; and carryout a full Mining surveying campaign both on the surface and the underground.

7.2.2 Design Ore handling and Ore processing plants in consideration of the different types of ores and materials to be handled and extracted.

7.2.3 Apply Engineering Geology related systems to assess and take engineering sound decisions; and apply the concepts of project economics and resources evaluation methods for design and decision making under conditions of risk and uncertainty.

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3. METALURGICAL Engineering

7.3.1 Select and design materials and materials-systems by applying advanced sciences, computational techniques and engineering principles underlying the major elements of the field: structure, properties, processing and performance.

7.3.2 Identify and classify the recent technological developments and emerging fields relevant to materials engineering, systems and metal production; involving: design, implementation and improvement of relevant processes.

7.3.3 Adopt suitable national and international standards and codes to: design, operate, inspect and maintain materials' systems.
