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Global Approach for Reforming Engineering Education in Iran*

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The aim of this paper is to determine the objectives and standards of engineering education in Iran, adopting a global approach. Eight documents and fourteen models of engineering education were analysed using content analysis. In order to define the objectives and standards of engineering education in Iran, common characteristics of the selected documents and models were identified. With regard to the results of the content analysis of these documents, twenty-four objectives in five categories for engineering education were determined. These categories include: knowledge and reasoning in technical and engineering topics; personal skills and attitudes; professional and ethical skills and attitudes; interpersonal skills and attitudes; and skills for developing system, product, or process. In addition, based on the content analysis of fourteen models derived from international consortia and agreements, seven standards including twenty-seven requirements were identified for engineering education. These standards are: the philosophy and objectives of engineering education; the curriculum; the instructional space and facilities; the teaching–learning process; faculty members; students; and assessment and evaluation.

Keywords: engineering education; educational objectives; standards and requirements; globalization; content analysis

1. Introduction

Globalization, information technology, and the knowledge-driven economy are the most important challenges that have resulted in rapid and uncontrollable cultural, social and economic changes at local, national and global levels [1, 2]. In addition, these challenges and changes have had profound widespread effects on the engineering profession and engineering education.

In 2004 and 2005, the U.S. National Academy of Engineering published two reports, namely, *The Engineer of 2020: Visions of Engineering in the New Century* [3] and *Educating the Engineer of 2020: Adapting Engineering Education to the New Century* [4]. Both reports stress the impact of environmental challenges and changes, including the globalization of engineering practices and the need for engineers to focus on innovation and creative aspects of the profession in order to be globally competitive [5]. These challenges and changes are creating a compelling reason for us to reform engineering education and to rethink the education of future generations of engineers [6, 7].

Historically, engineering curricula have been based largely on an 'engineering science model', in which engineering was taught only after a solid basis in science and mathematics had been built up [6, 8–10]. The engineering science approach, which originated in Europe, was consolidated and developed in the USA after World War II. This was mainly because it was realized that at that time scientists were better prepared to cope with the new technologies, such as radar, than were the engineers. The result was a substantial increase in the scientific and mathematical content of engineering curricula, with a corresponding decrease in the amount of time that students spent on laboratory work and on more specialized professional engineering education [10].

Engineering programmes in many parts of the world that exemplify this tension (the gap between theory and practice) are the products of the evolution of engineering education in the last half century. Throughout those years, programmes moved from a 'practice-based curriculum' to an 'engineering science-based model'. The intended consequence of this change was to offer students a rigorous, scientific foundation that would equip them to address unseen future technical challenges. The unintended consequence of this change was a shift in the culture of engineering education that diminished the perceived value of key skills and attitudes that had been the hallmark of engineering education up to that time [6, p. 2]. As a result, engineering graduates were perceived by industry and academia as being unable to practise in industry because of the change of focus from the practical to the theoretical [8].

Therefore, the constraints on engineering problem-solving today are increasingly not technical

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in nature, but rather lie on the societal and human side of engineering practice. The societal aspect of engineering practice is becoming increasingly important, with constraints on engineering solutions becoming less and less technical and more and more societal, regulatory and human. In addition, society demands that an engineer has a human aspect, seeing technology not only as an instrument of economy but also as the means of improving the quality of life and solving the present and future problems of humans and their environment [10].

Engineering education has changed in the past to adjust to the needs of society; the progress must continue and the required changes must address the needs of the 21st century. We can summarize the major trends in engineering education as follows [11, p. 24].

1. *The 19th century and first half of the 20th century*: 'professional engineer'—As engineering became a distinct profession, early engineering programmes focused on providing their graduates with considerable hands-on training. However, the role of science and mathematical modelling slowly increased and gained acceptance.
2. *The second half of the 20th century*: 'scientific engineer'—By mid-century, technological progress, including the successful harnessing of nuclear energy, as well as geopolitical realities as materialized by *Sputnik*, drove home the need for engineers to be well versed in science and mathematics, and the engineering curriculum adjusted to the changed needs. This structure has, to a large degree, continued until the present time, although 'design' content increased slowly. In the early 1990s it was clear that more than science was needed and many schools started to emphasize non-technical professional skills, such as teamwork and communications.
3. *The 21st century*: 'entrepreneurial/enterprising engineer'—The rapid changes that the world is currently undergoing, as discussed above, coupled with changes in engineering education starting to occur in the 1990s, are likely to result in an extensive re-engineering of engineering education. While the new structure will, almost certainly, continue to be based on a solid preparation in mathematics and sciences, it is likely to emphasize the professional role of the engineer, and then demand new qualifications suited for the new world order.

As for the hitherto historical trend of engineering education, in many engineering schools in many countries instruction focuses on mental development and depends on the presentation of knowledge; instruction is not adequately adapted to the needs of new age and advanced technologies. Also there is no important focus on personal and interpersonal skills, as well as system development skills, namely the engagement in all phases of the lifecycle of a system, product or process [6, 12, 13].

Engineering education in Iran also faces great challenges, since significant progress has occurred in the areas of engineering sciences, technology, and industries at a global level. Therefore, the usual method of educating engineers should be revised and fundamental changes should be made to it [14]. What currently occurs in engineering schools is the presentation of knowledge to students, strengthening their scientific base, and somehow enabling them to acquire new knowledge [15]. Moreover, there is a little focus on the required skills and attitudes for engineering. This important issue, which indicates the necessity for reform and improvement in engineering education, should be taken into consideration in Iran's engineering schools [16].

Any approach to improving engineering education must address two central questions [6, p. 10]:

1. What is the full set of knowledge, skills, and attitudes that engineering students should possess as they leave university, and at what level of proficiency?
2. How can we do better to ensure that students learn these skills?

These are essentially the 'what' and 'how' questions that engineering educators commonly face. The aim of this paper is also to answer these two main questions regarding the global documents and models in the field of engineering education so that we can proceed to reform and improve engineering education in Iran in line with worldwide trends.

2. Methodology

In this qualitative study, the content analysis methodology was used. Since qualitative content analysis can be implemented through several approaches [17–19], in order to answer the above questions two distinct approaches were used:

1. 'Directed content analysis' was used to answer the first research question in which the initial coding starts with a theory or relevant research findings. Then, during data analysis, the researchers immerse themselves in the data and allow themes to emerge from the data. In other words, this approach starts from deductive methodology and then continues to an inductive method [17, 18].
2. 'Summative content analysis' was used to find an answer to the second research question,

which starts with the counting of words or manifest content, then extends the analysis to include latent meanings and themes. This approach seems quantitative in the early stages, but its goal is to explore the usage of the words/indicators in an inductive manner [17, 18].

In order to determine the correlation between the selected objectives and standards of engineering education with the studied documents and models, the objectives and standards that were explicitly in the documents and models were denoted with a black circle (•), indicating a strong correlation between them. Then, the objectives and standards that were implicitly in the documents and models were denoted with a white circle (o), in order to indicate good correlation between them.

3. Findings

3.1 First question: What is the full set of knowledge, skills, and attitudes that engineering students should possess when they leave the university? (Objectives of engineering education)

In developing the models and approaches for engineering education, in addition to having technical knowledge (engineering science) there is a specific focus on skills and attitudes (engineering practice). Hence, the determination of engineering education objectives with regard to the required knowledge, skills, and attitudes for engineers is the basis of many studies in this century [6, 12, 20–22]. In order to answer the first question, eight documents were chosen regarding the objectives of engineering education. These were:

1. Conceive–Design–Implement–Operate (CDIO) Syllabus [6]
2. Taxonomy of Engineering Competencies [23, 24]
3. UK Standard for Professional Engineering Competence (UK-SPEC) [25]
4. Iowa State University (ISU) Workplace Competencies [26, 27]
5. European Accredited Engineer (EUR-ACE) Program Outcomes [28]
6. Washington Accord Graduate Attributes [29, 30]
7. Accreditation Board of Engineering and Technology (ABET) Program Outcomes [31]
8. Attributes of Engineers in 2020 [3]

The numbers of the headings and statements on the objectives of engineering education and the way that they have been categorized differ from document to document. Table 1 shows, in decreasing order, the numbers of headings and statements on the objectives of engineering education in the documents studied.

As specified in Table 1, the CDIO syllabus is currently the most detailed document on the objectives of engineering education. Thus, this syllabus was selected as a basis for extracting the objectives of engineering education. Common characteristics of other taxonomies from the objectives of engineering education were added to this document through open coding. In general, as shown in Table 2, twenty-four objectives were determined for engineering education, these were divided into five categories through axial coding.

A review of the relevant literature showed that several studies have been conducted to validate each of these documents by other documents. In these studies, the CDIO syllabus and the ABET outcomes were valued more. Since these documents were used to determine the objectives of engineering education, the result of their validation can also be used in this study.

Earlier work has compared the CDIO syllabus with the ABET outcomes, the UK-SPEC outcomes, and the Swedish engineering degree requirements. A common finding was that the CDIO syllabus emphasizes encompassing and detailed learning outcomes for engineering education more [32].

According to Crawley's study [33], there is a strong correlation between the CDIO syllabus and the ABET outcomes. In fact, the syllabus is more comprehensive. For example, the ABET outcomes do not explicitly address system thinking, and list

Table 1. Number of headings and statements on the objectives of engineering education in present documents

Present documents	Level of detail				Total number of headings
	First level	Second level	Third level	Fourth level	
1 CDIO syllabus	4	17	73	285	379
2 Taxonomy of Engineering Competencies	7	26	54	–	87
3 UK-SPEC	5	16	65	–	86
4 ISU Workplace Competencies	15	64	–	–	79
5 EUR-ACE program outcomes	6	41	–	–	47
6 Washington Accord Graduate Attributes	12	–	–	–	12
7 ABET program outcomes	11	–	–	–	11
8 Attributes of Engineers in 2020	9	–	–	–	9

only the ability to engage in lifelong learning from among the many desirable personal skills and attitudes of the syllabus. Likewise, the ABET outcomes list only the understanding of professional and ethical responsibility from among several important professional skills and attitudes.

Woollacott's study [23] showed that the taxonomy of engineering competencies addresses around 90% of CDIO syllabus content. Therefore, there is strong correlation between the objectives of engineering education in these two documents.

Brumm *et al.* [27, 34] studied the correlation between ISU workplace competencies and ABET outcomes. Their findings showed that all competencies received an average or better rating, confirming that the associations between the competencies and outcomes were valid.

The CDIO syllabus has been compared with the 2004 version of UK-SPEC. Although UK-SPEC contains more learning outcomes than the ABET outcomes, it still lacks the fine detail of the CDIO syllabus. In addition, UK-SPEC explicitly does not reflect the need for professional competence in all aspects of the system, product, or process lifecycle [6].

Malmqvist's study [32] showed that the CDIO syllabus reflects a more encompassing view of engineering than the EUR-ACE outcomes by considering the full system, product, or process lifecycle, including the implementing and operating life phases.

The comparison of the EUR-ACE outcomes and the Washington Accord graduate attributes showed that there is a strong similarity between the engineering education objectives headings in these two documents. The major difference is that the 'transferable skills' heading in the EUR-ACE outcomes incorporates several of the separate Washington Accord headings. Therefore, the differences between these two documents are more presentational than fundamental [35].

In general, as shown in Table 2, the final extracted objectives of engineering education in this study correlate highly with the present documents, this can be indicative of their validity. In addition, Table 2 shows that:

- The objectives related to the category of knowledge and reasoning of technical and engineering have been excellently supported by the documents studied. The only difference is that the ability to think systematically has not been taken into account in UK-SPEC, the ISU workplace competencies, and the attributes of engineers in 2020.
- The CDIO syllabus, the taxonomy of engineering competencies, and the attributes of engineers in 2020 has given more emphasis to the personal skills and attitudes than other documents. However, recognition of the need for lifelong learning and the ability to engage in it was emphasized in all documents.
- All the documents studied have emphasized professional and ethical skills and attitudes. Nevertheless, the UK-SPEC document fully includes this category of objectives.
- In the category of interpersonal skills and attitudes, the ability to communicate in foreign languages has been considered only in the CDIO syllabus and the EUR-ACE outcomes and has been disregarded in other documents. This may be due to these two documents having more emphasis on the internationalization of engineering education. Other skills and attitudes in this category have been emphasized by the documents studied, except the attainment of management and leadership skills, which was not pointed in the ABET outcomes.
- In the fifth category of objectives, the ability to understand organizations and enterprises and work effectively in them has been less emphasized than other objectives. The skills related to the system, product, or process lifecycle in the global and societal context have been emphasized in majority of documents, which is indicative of the high impact of engineering and engineers on society and the world.

3.2 Second question: How can we do better at ensuring that students learn these skills? (Standards and requirements of engineering education)

According to international consortia and agreements, many models have been developed for engineering education at the national, regional and international levels. These models have posed more or less similar criteria and standards for designing, implementing and evaluating engineering programmes. The analysis of the important and common characteristics of these criteria is a new and effective step toward the determination of the standards and requirements of engineering education with regard to global trends. Hence, three international consortia and agreements in the field of engineering education, including the Washington Accord, the CDIO Approach, and the EUR-ACE Project, have been looked at in this study. The derived models of these consortia were selected as follows:

1. Engineering Council of South Africa (ECSA) [36]
2. Accreditation Board of Engineering and Technology [31]
3. European Accredited Engineer Project [28]

Table 2. Correlation of engineering education objectives with present documents

Objectives of engineering education \ Present documents		1. CDIO Syllabus	2. Taxonomy of Engineering Competencies	3. UK-SPEC	4. ISU Workplace Competencies	5. EUR-ACE Outcomes	6. Washington Accord Graduate Attributes	7. ABET Outcomes	8. Attributes of Engineers in 2020
1. Knowledge and reasoning of technical and engineering	1.1. Knowledge of underlying sciences (mathematics and science)	•	•	•	•	•	•	•	•
	1.2. Knowledge of core engineering concepts and principles	•	•	•	•	•	•	•	•
	1.3. Knowledge of advanced engineering concepts and principles	•	•	•	•	•	•	•	•
	1.4. Ability to reason and solve problems of engineering	•	•	•	•	•	•	•	•
	1.5. Ability to experiment and discover knowledge	•	•	•	•	•	•	•	o
	1.6. Ability to think systematically	•	o			•	o	o	
2. Personal skills and attitudes	2.1. Ability to take risks and be flexible	•	o						•
	2.2. Ability to think creatively and critically	•	o		•	•			o
	2.3. Awareness of one's strengths and weaknesses and ability to manage self	•	•	o	o				
	2.4. Recognition of the need for life-long learning and ability to engage in it	•	•	o	•	•	•	•	•
3. Professional and ethical skills and attitudes	3.1. Perception and behavior based on professional and ethical responsibility	•	o	•	•	•	•	•	•
	3.2. Ability to plan for one's career and stay current on world of engineer	•	o	•	o		o	o	o
	3.3. Ability to innovate and be entrepreneur i.e. effective utilization of new ideas	o	o	•	•	o		o	•
	3.4. Ability to engage on sustainable development	o		•		•	•	o	
4. Interpersonal skills and attitudes	4.1. Attainment of management and leadership skills	•	•	•	•	•	•		•
	4.2. Ability to function on multidisciplinary teams	•	•	o	•	•	•	•	o
	4.3. Ability to communicate effectively (oral, written, graphical, and electronic)	•	•	•	•	•	•	•	•
	4.4. Ability to communicate in foreign languages	•				•			
5. skills for developing system, product, or process	5.1. Ability to understand society and global environment and the impact of engineering on them	•	o	o	o	•	•	•	o
	5.2. Ability to understand organizations and enterprises and work effectively in them	•	o			•			•
	5.3. Ability to conceive a system, product, or process with regard to needs and situations	•	•	o	o	•	•	•	o
	5.4. Ability to design a system, product, or process to meet desired needs	•	•	•	o	•	•	•	•
	5.5. Ability to implement i.e. transform a design to a system, product, or process	•	o	•	•		o	•	
	5.6. Ability to operate a system, product, or process to deliver specified value	•	o	•	•		o	•	
Type of correlation		• Strong correlation				o Good correlation			

4. Engineers Australia [37]
5. Engineers Ireland [38]
6. Institute of Engineering Education Taiwan (IEET) [39]
7. Japan Accreditation Board for Engineering Education (JABEE) [40]
8. Institution of Engineers Singapore (IES) [41]
9. Conceive-Design-Implement-Operate Approach [6]
10. Engineers Canada [42]
11. Accreditation Board for Engineering Education of Korea (ABEEK) [43]
12. Board of Engineers Malaysia (BEM) [44]
13. Institution of Professional Engineers New Zealand (IPENZ) [45]
14. The Hong Kong Institution of Engineers (HKIE) [46]

As shown in Table 3, fourteen models derived from international consortia and agreements were analysed. Criteria and standards that were included in most models and were directly linked to engineering education activities were selected through open coding. These criteria and standards are as follows:

1. Philosophy and objectives of engineering education

2. Curriculum
3. Instructional space and facilities
4. Teaching-learning process
5. Faculty members
6. Students
7. Assessment and evaluation

In this study, criteria related to managerial and support activities have been disregarded. Although these elements are important for quality assurance of engineering education, they are not directly related to engineering education standards [35].

In order to operationalize standards of engineering education, requirements of each standard should be identified so that standards can be encompassed completely. Several components and elements have been considered for each criterion or standard in the studied models which indicate coverage domain of each criterion or standard. Thus, in the present study, each standard was considered as a factor and the statements of each model related to that standard were selected through axial coding. Then, the common characteristics of those statements in variant models were considered as requirements of each standard. Table 3 shows the categorization of requirements of engineering education in relation to different standards.

Regarding the process undergone through this study, as shown in Table 3, the standards and requirements of engineering education highly correlate with the studied models. This correlation can be indicative of validity to the determined standards and requirements. In addition, Table 2 shows that:

- In all the models studied, emphasis was placed on specific and accurate educational objectives and outcomes, as well as the relevance of objectives and outcomes with the required knowledge, skills and attitudes for engineers. That's why these models come under the heading 'outcomes-based models'.
- In these models, curriculum possesses a particular importance and its implementation results in the achievement of educational objectives and outcomes. Hence, curriculum should be relevant to the science and practice of engineering.
- In the engineering education models a particular emphasis was placed on instructional space and facilities so that they result in experiential and practical learning.
- Compared with other standards, the teaching–learning process has not been directly considered in some models. However, the use of effective activities and methods of teaching and learning is necessary in order to implement the curriculum perfectly.
- Since faculty members play an important role in designing, implementing and evaluating engineering programmes, their expertise and competence has been regarded in all studied models.
- Although in the models studied student criterion has been mentioned, most of the models emphasized the admission and enrolment of the students.
- Since the models studied are among the models of quality assurance and accreditation, they place special emphasis on continuous improvement through assessing student learning and evaluating engineering programmes. Thus, assessment and evaluation are among the principal criteria in engineering education models.
- In general, the standards and requirements of engineering education have been emphasized more in: (1) Institution of Professional Engineers New Zealand and Board of Engineers Malaysia; (2) Engineers Australia; (3) Conceive-Design-Implement-Operate Approach; (4) Institution of Engineers Singapore; (5) European Accredited Engineer and Accreditation Board of Engineering and Technology; (6) Engineers Canada and Accreditation Board for Engineering Education of Korea; (7) Engineering Council of South Africa; (8) the Hong Kong Institution of Engineers and Engineers Ireland; (9) Japan Accreditation Board for Engineering Education; and (10) Institute of Engineering Education Taiwan respectively.

4. Conclusions

This study develops a framework for designing, implementing and evaluating engineering programmes in Iran and other countries. Regarding the results of content analysis of the selected documents, twenty-four objectives in five categories were determined for engineering education. These categories were as follows:

- Knowledge and reasoning of technical and engineering;
- Personal skills and attitudes;
- Professional and ethical skills and attitudes;
- Interpersonal skills and attitudes; and
- Skills for developing system, product, or process.

The statements of the present documents also duly supported the specified objectives. Hence, the present documents and studies emphasize the objectives of engineering education with regard to the required knowledge, skills and attitudes for engineers. The correlation between the objectives identified and the present documents showed that the objectives possess the necessary validity. With regard to the globalization of engineering education, these objectives can act as yardsticks in the

Table 3. Correlation of standards and requirements with the studied models

Standards and requirements \ Models of engineering education		1. ECSA	2. ABET	3. EUR-ACE Project	4. Engineers Australia	5. Engineers Ireland	6. IEET	7. JABEE	8. IES	9. CDIO Approach	10. Engineers Canada	11. ABEEK	12. BEM	13. IPENZ	14. HKIE
1. Philosophy and objectives of engineering education	1.1. Simultaneous focus of engineering education on science and practice	o	•	•	•	•	o	o	•	•	o	•	•	•	o
	1.2. Focus of engineering education on the lifecycle of system, product, and process	o	o	o	•	•	o	o	o	•	o	o	o	o	o
	1.3. Having specific and accurate educational objectives and learning outcomes	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	1.4. Focus of objectives on required knowledge, skills, and attitudes for engineers	•	•	•	•	•	•	•	•	•	•	•	•	•	o
2. Curriculum	2.1. Integration of knowledge, skills, and attitudes in curriculum	o	o	o	o	o		o	o	•	o	•	•	•	o
	2.2. Integration of science, technology, engineering, and mathematics in curriculum	o	o	o	o	o		o		•	•	•	•	•	o
	2.3. Having design-implement experiences in curriculum	•	•	•	•	•			•	•	•	•	•	•	•
	2.4. Relevance of content with required knowledge, skills, and attitudes for engineers	•	•	•	•	•	o	•	•	•	o	o	•	•	•
3. Instructional space and facilities	3.1. Relevance of instructional space with experiential and practical learning	•	o	o	•	o		o	o	•		•	•	•	o
	3.2. Equipment of instructional space with modern and necessary engineering tools	•	•	•	•	o	•	•	•	•	•	•	•	•	•
	3.3. Having suitable and up to date computing and information services	•	•	•	•	o	•	•	•	o	•	•	•	•	•
4. Teaching-learning process	4.1. Integration of knowledge, skills, and attitudes in learning activities	o	o	o	•	o			o	•	o		•	•	o
	4.2. Integration of science, technology, engineering, and mathematics in learning activities		o	o	•	o				•	o		o	•	o
	4.3. Using experiential and active methods of teaching and learning	•		o	•			o	o	•	•		o	o	o
	4.4. Having learning activities in accordance with industry and society needs	•	o	o	•	•	o	o	•	•	o		•	•	•
5. Faculty members	5.1. Suitable level of faculty members scholarship		•	•	•	•			•	o	•		•	•	•
	5.2. Competence in required knowledge, skills, and attitudes for engineers	•	•	•	•	•	o	o	•	•	•	•	•	•	•
	5.3. Competence in teaching, learning, and assessment of students activities	•	•	o	o	o		o	•	•	•	•	•	•	o
	5.4. Relationship with industry and professional societies		•	o		•	•		•	•	•	•	•	•	
	5.5. Appropriate relationship with students and guiding them		•		o		•		o		o	•	•	•	
6. Students	6.1. Student admission in accordance with the nature and situations of engineering fields	•		•	•	•		•	•		•	o	•	•	•
	6.2. Increasing interest and thirst of students to engineering learning				o		•	•	o	•			•	o	
	6.3. Giving students academic and occupational counseling	o	•	•	•			o	•		•	•	•		
7. Assessment and evaluation	7.1. Assessment of students learning based on all educational objectives	•	•	•	•	•	•	•	•	•	o	•	•	•	•
	7.2. Determination of students achievement based on reliable and valid data	•	o	•	•	•		•	o	•		•		•	o
	7.3. Evaluation of educational programs to gather data from different stakeholders	o	•	•	•		o	•	o	•	o	o	•	•	o
	7.4. Reform and continuous improvement of engineering education programs based on results of evaluation	•	•	•	•		o	•	•	•	•	•	•	•	•
Type of correlation		• Strong correlation							o Good correlation						

engineering education system of Iran and in subsequent studies.

Based on content analysis of fourteen models derived from international consortia and agreements, seven standards, including twenty-seven requirements, were identified for engineering education. The models studied mainly emphasize the standards related to the philosophy and objectives of engineering education, the instructional space and facilities, assessment and evaluation, curriculum, faculty members, students and the teaching–learning process, respectively. The outstanding points of the studied models were as follows:

- Specific and accurate educational objectives and outcomes
- The focus of engineering education on science and practice (knowledge, skills and attitudes)
- Integrated curricula and learning activities
- Design-implement experiences in the curricula
- Equipped instructional space, suitable for experiential and practical learning
- Focus on society's and industry's needs
- Competence of faculty members
- Student admission and counselling services
- Reform and continuous improvement of engineering programmes.

The majority of the identified standards and requirements have been considered in the engineering education models of different countries. This indicates that highlighting some standards or a particular set of requirements does not represent the totality of an engineering education system. Thus, all standards and requirements of engineering education should be identified in a systematic framework. In addition, interrelations between them can increase our understanding of the system of engineering education.

From a theoretical point of view, since this study has been accomplished based on content analysis of present documents and models in the field, the results join with previous studies. From a practical point of view, this study suggests which, the objectives of engineering education should be determined first, based on the knowledge, skills and attitudes required of engineers, and secondly, the standards and requirements of engineering education should be based on the specified objectives.

In this study, present documents and models derived from international consortia and agreements were used for determining objectives and standards of engineering education. These objectives and standards can be revised, refined, and validated through surveys of the views of engineering education experts; faculty members, students and graduates of engineering schools; as well as employers and labour market key informants.

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