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Comparison of Civil Engineering Curricula in the Arab World*

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The Arab World countries are facing major challenges in Civil Engineering professional registration standardization due to the significant differences in the undergraduate curricula in these countries. This paper compared undergraduate civil engineering curricula in Arab countries. A review of the course requirements at 31 universities located in 19 countries was presented. Only universities that follow the American credit hour system are included in the study. Specifically, the study addressed degree requirements related to science, mathematics, general education, free electives, English language, engineering fundamentals, computer proficiency, required civil engineering courses, and technical electives. The study showed that the considered curricula took either 4 or 5 years to complete. The number of credit hours was found to be as little as 131 and as large as 204 credits. The humanities, social science and foreign language requirements at traditional universities were usually very low, whereas the same requirements were almost a full-year of study at Western-style universities located in the same region. Some universities followed a track system, which provided for specialization in one of the various civil engineering disciplines. As a result, the curricula of such universities were loaded with a large number of obligatory technical courses. The Western style universities, on the other hand, were heavy on fundamentals, but gave the student more choices with regard to technical and free elective courses.

Keywords: civil engineering; curriculum development; education; general education; professional registration; technical electives

1. Introduction

Civil engineering is a professional field that addresses the planning, design, construction and maintenance of the built environment. Real-life application lies in the works of buildings, bridges, tunnels, roads, railways, canals, dams, and water and waste water treatment facilities. In its broadest definition, civil engineering includes many sub-disciplines such as structural engineering, geotechnical engineering, transportation engineering, environmental engineering, water resources engineering, materials engineering, coastal engineering, surveying, and construction engineering and management. Compared to other engineering disciplines, civil engineering is the oldest engineering discipline. Remains of ancient feats, such as the Egyptian pyramids, Greek temples, Roman road systems, and Islamic dams and mosques are based on civil engineering principles.

The core courses in a civil engineering curriculum reflect the fact that this field focuses to a large extent on the study of the built environment. In general, civil engineering students start their education with basic physics, chemistry and calculus courses. This is followed by courses on surveying principles, mechanics, construction materials, geology and structural analysis. A civil engineering curriculum is usually rounded out with courses on hydrology, concrete and/or steel structures, foundation design, highway design, sanitary engineering, and construction management. Depth in a particular area is often achieved through technical electives in the program.

The Arab world has a population of about 280 million people and consists of 22 countries that are part of the Arab League, extending from the Atlantic Ocean in the west to the Arabian Sea in the east, and from the Mediterranean Sea in the north to the Horn of Africa and the Indian Ocean in the south-east [1]. The Arab states are mostly developing economies and derive their export revenues from oil and gas, or the sale of other raw materials. Recently, significant economic growth in the Arab World has been observed due to an increase in oil and gas prices and efforts by some states to diversify their economic base, particularly in the construction sector. The major economic organizations in the Arab World are the Gulf Cooperation Council (GCC), comprising the states in the Persian Gulf, and the Union of the Arab Maghreb (UMA), made up of North African States. In recent years, a new term has been used to define a greater economic region: the MENA region, standing for Middle East and North Africa.

Historically, formal engineering education in the Arab world did not exist before World War I. In 1913, St. Joseph University in Beirut, Lebanon, founded the French School of Engineering, which became the Higher Institute for Engineering in 1948 [2]. Between 1925 and 1950, seven other universities

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started to cover engineering education in Algiers, Cairo, Alexandria, Baghdad, Aleppo, and Khartoum. By 1955, about 8500 students were enrolled in various engineering departments, this number reached over 40,000 by 1970, and is estimated to have reached over 100,000 in 2010 [3]. The most recent establishment of engineering education programs have been in the Palestinian Territories in 1978 [4].

With regard to the field of Civil Engineering, departments of such field are among the largest units in many colleges and schools of engineering in universities located in the Arab countries. This is because the construction industry and civil infrastructure building greatly dominate the economies of countries in this region. A close inspection of the civil engineering undergraduate curricula in the various Arab countries shows considerable differences in the number of years of study, number of credit hours, science and mathematics courses, technical courses, nontechnical courses, and internship requirements. These differences in curriculum requirements are due to local accreditation demand, quest for international accreditation, origin of the educational system within the country, and pressure (or lack of it) for curriculum development. While some differences in degree requirements from one regional country to another are healthy and expected, significant changes in curricula in neighboring countries can lead to many problems. Discrepancies in degree requirements can cause pressure on students to obtain degree equivalency or take extra credits, possibility of rejection of a foreign degree by the local engineering syndicate, and reduced work opportunities abroad.

This paper compared undergraduate civil engineering curriculums in 31 universities in 19 Arab countries located in Western Asia, Arabian Peninsula and North Africa. Universities from Tunisia, Algeria and Morocco were excluded from the study because they follow European system of credits; thus, it was difficult to combine their requirements with those universities that follow the American system of credit hours. A review of the courses and laboratories from representative universities in each country was presented. Specifically, the study addressed requirements related to science, mathematics, statistics and probability, general education, free electives, English language, engineering fundamentals, computer, required civil engineering courses, and technical electives.

2. Literature review

Curriculum development and continuous search for improvement to avoid reaching a steady state situation in a study program are goals of many institutions of higher education and accrediting agencies. As a result, there have been extensive research efforts devoted to investigation of differences in engineering curricula and the motives behind these variations around the world. Some of the factors that affect curriculum development and new challenges faced by the engineering community and educators (such as curriculum integration, freshman design, sustainability, computer usage, distance learning, teaming, university-industry coordination, etc.) were discussed in a number of studies [5–10]. While many studies have focused on curricula within a particular region with the same culture or geographical relation, recent studies have extended the scope to cover countries in different continents [11, 12].

For instance, in the United States (US), Russell and Stouffer [13] conducted a survey of about 40% of the civil engineering programs in the United States. In their analysis, they considered three major sets of courses covering the areas of basic math and science, general education and engineering courses. As a result of this survey, they examined the satisfaction of the curriculum to American Board of Engineering and Technology (ABET) accreditation requirements. In conclusion, they found out that the Civil Engineering curriculum is highly technical and lacks focus in other areas, such as liberal arts, professional skills, and systems thinking. In contrast to the conclusions reported by Russell and Stouffer, Sparling and Kells [14] showed that the general trend of reducing the number of credits in Civil Engineering programs and increasing the breadth in covering Civil Engineering basics have created an argument that the technical competency gained in a four-year Bachelor degree is not adequate for the practical work. The impact of accreditation and professional societies in the US on curriculum content and structure was investigated by Bardet et al. [15]. In their study, they considered the performance assessment of Civil Engineering curriculum as part of the ABET and American Society of Civil Engineers (ASCE) requirements. They have proposed a systematic approach to evaluate the student performance across the overall curriculum when considering the ABET accreditation requirements and the Body of Knowledge (BOK) of the ASCE. They have developed direct assessment methods that result in some quantitative measures of student performance without significantly affecting faculty work load in preparing these documents.

Outside of the US, there have been a number of studies on civil engineering education in Europe, Australia, and Japan. For example, Tsuji and Nanni [16] reported on efforts at the undergraduate and graduate levels in Japan to improve the curricula to

better prepare the graduates for the global market place. They found out that differences between the civil engineering system in Japan and other countries are mainly due to the differences in values and traditions. For example, as the Japanese society discourages individualism, poorly performing students are tutored to achieve minimum standard instead of failed during their compulsory education, and bright students are not allowed to skip grades. A major revision of the civil engineering curriculum at a university in Australia was recently reported by Airey et al. [17]. The changes were driven by rationalization of course offerings, expectations from industry, integration with combined degrees, moves toward a common freshman engineering year, student expectations and abilities, and greater integration of teamwork and generic skills within the courses. The broad modifications were consistent with the objectives set out by the ASCE in their BOK for the 21st century, and with statements by the European Civil Engineering Education and Training (EUCEET). In Europe, Angelides and Loukogeorgaki [18] called for a new strategic approach to address the European challenges imposed by the world-wide trends in education, the requirements of the employers of civil engineering students, and several pertinent societal constraints and drivers inherent to Europe.

With regard to research on engineering education in the Middle East region, the literature search has revealed few studies on the subject. Some research focused on accreditation issues in civil, electrical and chemical engineering disciplines in the United Arab Emirates [19–21]. Others investigated the quality and sustainability of engineering education at universities in the Middle East and North Africa regions [22, 23]. Engineering graduates' areas of strengths and weaknesses in the Palestinian territories' universities compared to their counterparts in universities abroad were examined by Abu-Eisheh [4]. The challenges associated with the development of new engineering programs in the region were studied by Thomson [24] and Abu-Faraj [25]. Assessment of environmental and transportation engineering education at different universities in the Middle East was addressed by Jassim and Coskuner [26] and Hamad et al. [27], respectively. Nontechnical course requirements related to humanities and social sciences within engineering curricula in the GCC were discussed by Webb [28].

The literature search also showed that there have been a number of recent studies on the challenges facing the educational system in the Arab World. These studies have addressed challenges related to the curricula, quality of graduates, and educators. The challenges concerning engineering educators are associated with lack of textbooks on local codes of practice, quality assurance mandates are increasingly being based on international standards with little attention to regional issues, and reduced interest of women in the field of engineering [29]. In the curriculum area, the challenges are due to lack of unified engineering educational system, influence of language of instruction on curriculums, and minimal emphasis on research [30]. With regard to the quality of graduates, challenges have been identified in relation to lack of creativity, deficiency in critical thinking, weak communication skills, inefficient use of time and resources, and inexperience in working in teams [31].

3. Professional registration challenges

One of the major difficulties facing civil engineering graduates in the Arab countries is professional registration. Throughout the world, regulation of the engineering profession has been established by some jurisdictions to protect the safety and well-being of the general public. With vast non-uniformity in curricula, some engineering graduates from Arab universities abroad may not qualify for professional registration in their home countries.

In order to practice engineering in Lebanon, the engineer has to be registered in The Lebanese Order of Engineers and Architects [32], which has special requirements for registering engineers who graduate from foreign universities. These requirements include holding an engineering degree awarded by a university or an institute approved by the Lebanese government and that the program of study leading to the engineering degree is equivalent to the program at the Université Libanaise, the state university in Lebanon. Study schedule at the Faculty of Engineering in the Lebanese state university is a full 5 years program and the degree is a Bachelor of Engineering, not Bachelor of Science [33]. For those graduates who do not satisfy the Bachelor degree requirements, the Lebanese Order of Engineers and Architects has been requiring a Master's degree in Engineering as condition for registration. As prerequisite for the practice of engineering in their countries, both the Syrian Syndicate of Engineers [34] and the Jordan Engineers Association [35] require engineering degree from a university approved by the local ministry of higher education with a minimum of four years of study. In case the Bachelor degree is based on a 3-year program, the Jordan Engineers Association necessitates additional post-graduate 30-credit hours of study in the field.

Similarly, the Sudanese Engineering Society requires that the degree should be equivalent to the BS degree in Civil Engineering at University of Khartoum, which requires 5 years of study [36]. The

Egyptian Syndicate of Engineers requires a bachelor degree that is approved by the Supreme Council of Universities. In addition to quality in curriculum and course content, engineering degrees in Egypt require a five years program in order to be accredited by the Supreme Council of Universities [37]. Currently, there are 37 programs from public universities and 36 programs from private universities in Egypt accredited by the Council.

In the GCC region, the Society of Engineers in the United Arab Emirates [38], the Society of Engineers in Kuwait [39], Bahrain Society of Engineers [40], Saudi Council of Engineers [41], Oman Society of Engineers [42] and Qatar Society of Engineers [43] all require a Bachelor degree in engineering that is accredited by the local Ministry of Higher Education. Such entities accept all the accredited degrees from other Arab countries without any specific requirements with regard to the number of credit hours or the number of years of the study. However, the registration in the Society of Engineers is not a requirement for practicing engineering in these countries.

4. Methodology

In an attempt to investigate Civil Engineering curricula in the Arab countries, this paper focused on the civil engineering curriculum as it is currently being offered to undergraduate students in the region at institutes of higher education. It presented the results of an analysis of 31 of the region's undergraduate civil engineering programs. Public, private and semi-private institutions from the considered countries were investigated, but graduate programs were excluded. Information on the curricula was obtained either from the University's web site or personal contacts with the university.

The countries from the Arabian Peninsula that were considered in the study included the United Arab Emirates, Saudi Arabia, Oman, Bahrain, Qatar, Kuwait, Iraq and Yemen. The considered countries from Bilad Al Sham region were Lebanon, Syria, Jordan, and Palestine. From Africa, only Egypt, Sudan and Libya were selected since civil engineering curricula in Tunisia, Algeria and Morocco follow the European system, where the offered courses are assessed by the European Credit Transfer and Accumulation System [44] of credits. The major difference between the ECTS and the US College Credit system together with the unconventional format of the Bachelor degree, which requires a 2-year program of mathematics and science prior to a 3-year civil engineering specific program, made it difficult to include universities from Tunisia, Algeria and Morocco in the analysis. Table 1 shows the considered universities in the study with their associated countries.

The obtained information was classified into the following fifteen categories: (1) General information, (2) Science requirement, (3) Mathematics, (4) Statistics and/or probability, (5) General education, (6) Free electives, (7) English language and communication skills, (8) Engineering fundamentals, (9) Computer literacy, (10) Required civil engineering courses, (11) Laboratory course requirements, (12) Civil engineering elective courses, (13) Capstone

Table 1. Arab universities considered in the study

Region	Countries	Universities
Arabian Peninsula	United Arab Emirates	American University of Sharjah, University of Sharjah, Abu Dhabi University, United Arab Emirates University, American University of Dubai
	Saudi Arabia	King Fahd University of Petroleum and Minerals, King Abdulaziz University, King Saud University, King Faisal University
	Oman	Sultan Qaboos University
	Bahrain	University of Bahrain
	Qatar	University of Qatar
	Kuwait	Kuwait University
	Iraq	Baghdad University
	Yemen	Sanaa University, Yemen University of Science & Technology
Bilad Al Sham	Jordan	University of Jordan, Jordan University of Science and Technology
	Lebanon	American University of Beirut, Lebanese American University, Beirut Arab University
	Syria	Damascus University
	Palestine	Birzeit University, Al-Najah University
Northeast Africa	Egypt	Ain Shams University, Cairo University, Alexandria University, Assiut University, American University of Cairo
	Libya	University of Al-Jabal Al-Gharbi
	Sudan	University of Khartoum

design, (14) Professional training or internship, and (15) Other requirements.

The analysis described the composition of undergraduate education as well as particular course sequence and requirements. It outlined the common areas of education and points of diversion among the civil engineering curricula. The minimum, maximum, and mean number of credit hours in each of the above subjects were determined and discussed.

5. Results and discussion

This investigation showed that all the considered civil engineering programs in the Arab region were based on the semester system. The Western-style universities gave the students the flexibility to choose their courses from the study plan, whereas the traditional universities had rigid curricula with annual offering of courses. The title of the degree was either Bachelor of Science (B.S.) or Bachelor of Engineering (B.E.) in Civil Engineering. About one-half of the programs required 4 years to complete, while the remaining programs required 5 years. The total number of credits hours needed for completing the degree varied significantly from one country to another, and even within the same country. The minimum number of credits hours to earn the degree was 131 and the maximum was 204, with a mean value of about 161.

5.1 Nontechnical course requirement

The nontechnical course requirement consists of courses related to science, mathematics, statistics, probability, humanities, social sciences, free electives and English language. The study showed that this requirement was not uniform among the considered programs, as shown in Fig. 1.

All but one program required explicit courses in science. For the programs that mandated science courses, the requirement varied between 2 and 16 credits, with a mean value of 10.9. For most programs, science included physics and chemistry, but for a few programs either the chemistry was waived or biology was added to physics and chemistry. The universities that did not require explicit science subjects or had a small number of credits assigned to science covered such topics within the fundamental engineering courses on an 'as-needed' basis. The mathematics requirement included courses in calculus, differential equations, linear algebra and numerical analysis. As expected, most programs had heavy emphasis on calculus, compared with other fields. The number of credit hours of mathematics varied between 8 and 23 credits, with a mean value of 15.3. While only six programs did not require statistics and/or probability, the rest obliged either 2 or 3 credits on the subject. Among the areas that had the most non-uniformity among the programs was the general education requirement, which included courses in humanities, social sciences, Arabic language and religion. In general, this requirement at traditional universities was very low, whereas the same requirement was almost a full-year of study at Western-style universities located in the same region. The study showed that the number of general education credit hours ranged between 0 and 41, with a mean equal to 13.8. Eighty percent of the curriculums did not include free electives, defined as courses that a student chooses to take because he/she is interested in the subject matter covered in the courses. Such courses could be related to the major or could be totally unrelated. For the considered programs that included free elective courses in their curriculums, the credit requirements ranged between 4 and 12. The English language requirement included courses in communication, technical writing and/or public speaking. Four out of the 31 considered curricula did not require such a subject for degree completion. For the other curricula, the number of credit hours of English varied between 2 and 16 credits, with a mean value of 7.5. As expected, the universities that follow the Western system of education required more English courses than the other universities.

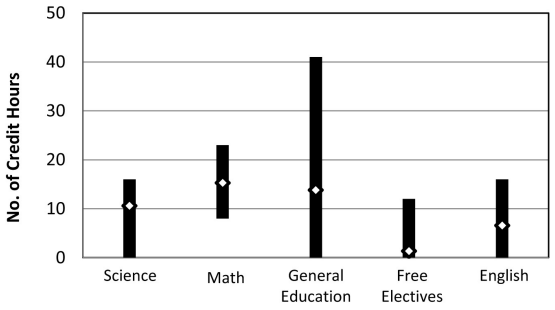

Fig. 1. Credit hour range and mean for nontechnical courses in Civil Engineering curricula.

5.2 Technical course requirement

The technical course requirement consists of courses related to engineering fundamentals and applications. Again, the study revealed that this requirement varied considerably among the considered programs, as shown in Fig. 2.

In this study, 'Engineering Fundamentals' are defined as courses related to engineering mechanics (solid and fluid), material science, surveying, graphics, and engineering geology. Other courses offered by an engineering college/school to freshman or sophomore students, such as 'Introduction to Engineering' or 'Introduction to Civil Engineer-

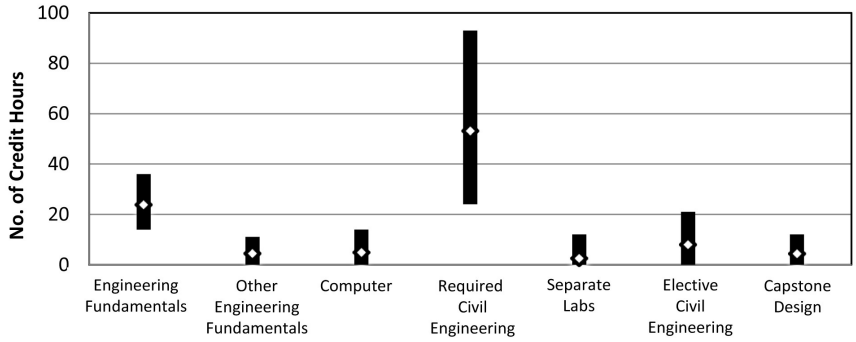

Fig. 2. Credit hour range and mean for the technical courses in Civil Engineering curricula.

ing', are also a part of this category. The study showed that the number of credit hours of courses in Engineering Fundamentals varied between 14 and 36 credits, with a mean value of 23.8. The category of 'Other Engineering Fundamentals' refers to courses in thermodynamics, electrical circuits, engineering economy and architecture engineering. It was found that all but 5 programs required courses in this area. Specifically, the number of credit hours of courses in 'Other Engineering Fundamentals' varied between 0 and 11 credits, with a mean value of 4.5. With regard to computer literacy, almost all programs included courses in computer programming or software use. The credit requirement ranged between 0 and 14, with a mean of 4.8. While the majority of considered programs had laboratory components embedded in related courses, there were some curricula which had separate labs. These labs were related to fluid mechanics, construction materials, soil mechanics, etc., with credit hours ranging 0–12, with a mean value of 2.5.

All programs covered most of the specialty areas of civil engineering through required analysis and design courses. Such courses included construction materials, structural analysis, reinforced concrete design, steel design, soil mechanics, foundation design, hydrology, hydraulics/water resources, water/waste water treatment, environmental engineering, construction management, quantity surveying/cost analysis, and/or highway design. The number of credit hours of required civil engineering courses varied between 24 and 93 credits, with a mean value of 53.1. The technical elective course requirement included advanced courses in the various civil engineering disciplines. In the considered programs, 9 out of the 31 curricula did not have technical electives. For the rest, the number of credit hours in the technical electives area varied between 6 and 21, with a mean value of 12. The programs that mandated a large number of technical electives often had a small number of required courses; thus, their curricula could be considered track-based. This was particularly true for departments with large number of faculty and students, which offered their students the opportunity to specialize in one or two areas within civil engineering.

With regard to the capstone design project, often referred to as senior graduation project, all but one program explicitly required course(s) in the subject. For such programs, the credit hours significantly varied among the programs from as little as 3 to as high as 12, with a mean of 4.5.

With regard to professional training or internship, about one-half of the programs did not require such an element for degree completion. For the other half, the credits hours associated with professional training or internship was not consistent, ranging between 0 and 15.

The majority of differences in curriculum requirements discussed above are mainly due to the fact that each university follows the local accreditation and professional registration requirements, in the absence of regional governing bodies. However, the study showed that some of the considered programs, particularly those which follow the ABET accreditation standard, do have some common requirement in their curricula.

6. Summary and conclusions

This study compared 31 undergraduate civil engineering curricula in 19 Arab countries. Arab universities that followed the European Credit Transfer and Accumulation System were excluded from the investigation. The research addressed degree requirements related to science, mathematics, statistics and probability, general education, free electives, English language, engineering fundamentals, computer proficiency, required civil engineering courses, and technical electives. The findings of the study indicated that there are no consistent requirements for professional registration and practice for civil engineers in the various

considered countries in the Arab World. Also, civil engineering undergraduate curricula in the Arab Middle-East countries showed considerable differences in the number of years of study, number of credit hours, science and mathematics requirements, technical courses, nontechnical courses, capstone design project, and internship. Furthermore, the humanities, social science and foreign language requirements at traditional universities were usually very low, whereas the same requirements could be almost a full-year of study (about 30 credit hours) at Western-style universities located in the same region. In addition, some Arab universities, particularly those with large number of faculty, followed a track system, which provided for specialization in one of the various civil engineering disciplines. As a result, the curricula of such universities were loaded with several technical courses, of which many were obligatory. The Western style universities, on the other hand, were heavy on fundamentals, but gave the student more choices with regard to technical and free elective courses. The differences in curriculum requirements were mainly due to lack of regional accreditation body, local accreditation demand, quest for international accreditation, origin of the educational system within the country, and pressure (or lack of it) for curriculum development. The study also revealed that significant differences in curricula in neighboring countries could lead to pressure on students to obtain degree equivalency or taking extra credits, possibility of rejection of a foreign degree by the local engineering syndicate, and reduced work opportunities abroad.

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