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Disparity between College Preparation and Career Demands for Graduating Engineers*

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The engineering profession has traditionally been a technical field based on theoretical and scientific discipline. In addition to the technical knowledge and hard skills, engineers must acquire sufficient soft skills in personal and interpersonal behavior to meet current employment market standards. This research identifies learning deficiencies that hinder the effectiveness of practicing engineers. Based on the ABET (Accreditation Board for Engineering and Technology) criteria, three categories of skills were tested: technical, interpersonal, and personal indicators. Research questions were as follows: Did engineers acquire these skills before graduation? How important are these skills to them as practicing engineers? Are there any differences in their perceptions of gender, work experience, or work location? A sample of 188 engineers who graduated from universities in Lebanon completed an online survey assessing their proficiencies before graduation and after starting their profession. Fifteen engineers were interviewed to gather information about the skills necessary for their career. Although participants reported that they possessed adequate theoretical knowledge and technical skills, noticeable weaknesses in creativity and innovation were found. Interpersonal and personal skills in leadership, management, and multidisciplinary teamwork were the most overlooked aptitudes in college despite their importance in work settings.

Keywords: college preparation; engineering practice; soft skills

1. Introduction

Several considerations motivate students to enroll in engineering colleges. Although personal interest in the subject matter may be one of the leading influences, other motivational criteria include professional, financial, social, and personal growth [1]. By investigating these reasons for enrolment, Baytiyeh and Naja [1] demonstrated that students are driven largely by their desires for a satisfying job that provides opportunities for professional growth, creativity, earning potential, and advancement. However, when graduates enter the workforce, they face the realities of sustained full-time work [2]. On the one hand, the work may involve environmental constraints, administrative tasks, and job security. On the other, specific skills and knowledge are necessary for company productivity and performance.

Trevelyan [3] calls for a general classification for engineering practice. Some researchers believe that engineering is a ''design process'' [4], and others focus on technical problem solving [5]. With the objective of revising engineering education, Solomon and Holt [6] took an ethnographical approach to mechanical engineering. Other researchers studied engineering practice from the social perspective, discussing society and the work place rather than the profession *per se* [7–9] or examined gender roles in the engineering profession [10].

Using a qualitative approach, Sageev and Romanowski [11] demonstrated that recent graduates spend approximately 64% of their time on written or oral communication, reflecting the need to acquire strong communication skills. In this line of thought, Martin *et al.* [12] demonstrated that communication, teamwork, and interpersonal skills should be taught in their technical context.

In response to the question ''What is engineering practice?'' Sheppard *et al.* [13] interviewed engineering faculty and students, and concluded that engineering work is a social process. Trevelyan (2007) argued that coordination is another dominant factor in the engineering field, involving discussing the project status, developing a network of contacts, and supervising colleagues. Tang and Trevelyan [14] interviewed fifteen engineers in Brunei and revealed that the range of engineering tasks and social issues in engineering practice contribute to the gap between engineering education and engineering practice.

Using a quantitative approach, other researchers have rated the skills, attributes, and competencies necessary for the engineering profession [15–17]. Deans [15] studied graduate and undergraduate mechanical engineering students and found that the acquisition of soft skills was valued much more than the acquisition of engineering knowledge; that is, management and interpersonal skills were more important than manual skills. Johnston [18], who lamented the scarcity of literature on employment from the perspectives of graduates, called for additional research on the experiences of graduates regarding their working conditions and

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employee culture during their early employment years, such as job expectations, satisfaction, and commitment. Using a longitudinal study to investigate the transition from education to working life, Dahlgren *et al.* [19] compared three master's programs: political science, psychology, and mechanical engineering. The results indicated that the psychology program provided the generic skills necessary for professional work, whereas the other two programs contained elements that emphasized traditional roles rather than preparing graduates for the modern workplace. Sagen *et al.* [20] investigated the career preparation of 1012 baccalaureate graduates one month after graduation and found that internships, work experiences related to career goals, advanced courses in communication, and participation in student organizations were key factors in their learning and development.

Investigating the gap between engineering education and practice in the Arab Gulf States, Akili [21, 22] examined vital issues that have been neglected and called for collaboration between industry and colleges of engineering. Akili argued that academia is not putting sufficient effort into establishing a connection with the engineering firms to determine where curricula need to be reformed.

Most studies have focused on the engineering profession's dissatisfaction with graduates, demonstrating a gap between education and the professional practice [23–25]. Most findings have demonstrated the importance of soft skills such as communication, team coordination, and planning in the engineering profession. However, the extent to which training in these criteria is implemented as experiential learning in the engineering colleges remains unknown.

2. Theoretical framework

Dewey [26] asserted that there are two types of learning: "learning about" is learning the subject, and "learning to be" is learning to become a professional practitioner. In the engineering field, students need to be well-rounded practitioners, working together to develop and test new products, find solutions for problems, and work on inventions. No matter what type of community engineers may represent, engineering colleges compete to produce the best graduates possible. However, although colleges are teaching the subject, we must ask whether they are preparing future engineers to implement the full practice.

The Accreditation Board for Engineering and Technology (ABET) provides specific criteria to ensure that graduates of accredited engineering programs are qualified to start professional work [27, 28]. Therefore, academic institutions are expected to maintain specific educational objectives to deliver the desired ABET outcomes, ranging from intellectual capabilities to interpersonal skills. In this study, the criteria examined reflected technical, interpersonal, and personal skills. Technical indicators are the hard skills and knowledge attained for both professional development and career advancement, including all types of learning opportunities, from theoretical knowledge to creativity and innovation [29]. In the soft skills, interpersonal indicators are related to interaction, such as the ability to work as part of a group or team, openness to new ideas, and verbal/nonverbal communication skills [30], and personal indicators refer to management, negotiation, and conflict resolution skills, ranging from business policies to time management and planning [31].

Taking into consideration these three indicators, this study explores the gap between academic learning and engineering practice by answering the following questions: Did engineers acquire technical, interpersonal, and personal skills before graduation? How important are these skills to them as practicing engineers? Are there any differences in their perceptions of gender, work experience, or work location?

3. Context of the study

Lebanese engineers were the study population for this research. After World War I, colleges of engineering were founded in Egypt and Lebanon; in the Arab Gulf States, similar institutions were established in the 1960s [21, 22]. Higher education institutions in Lebanon constitute a prosperous source of fresh engineers for the Arab Gulf States. Engineering education in Lebanon began in 1913 with the French Engineering School of Saint Joseph's University and the Faculty of Engineering at the American University of Beirut. These two institutions have framed engineering education in Lebanon [32].

The targeted population includes graduate engineers from three top ranked universities in Lebanon: the American University of Beirut, Lebanese University, and Balamand University. These three universities have been chosen because their engineering curricula are based on the American educational system. The American University of Beirut, established in 1849 by American Protestant missionaries, opened its school of engineering in 1951 and is ranked the first in the nation. Lebanese University, established in 1951 and the only state-operated university, opened its college of engineering in 1980. Balamand University, founded by the Greek Orthodox Church in 1988, established the faculty of engineering in 1993 and offers engineering

specialties not provided by other institutions, such as aerospace and chemical engineering. The curricula in these three universities are guided by American standards, but the Lebanese University does not require general education courses in the program. It is important to note that these universities vary in their teaching styles. In fact, the majority of faculty members of the American University of Beirut and Balamand University are graduates of United States universities, whereas the Lebanese University faculty members are largely graduates of European universities.

4. Method and data collection

A mixed method approach [33] with a sequential explanatory design was used to identify the gap between schooling and practice in engineering. The e-mail addresses of engineers were collected from the universities' alumni lists. An online Likert-scale survey was sent to the engineers for whom contact e-mail addresses were available (N = 1032). Out of the 1032 emails, 139 were returned as undeliverable, and 188 respondents completed the survey, yielding a 21% response rate. The survey was based on previous studies in the literature relating to engineering practice using quantitative and/or qualitative approaches [15, 16, 23, 34]. The survey included questions about participants' gender, age, and specialization. Three categories for technical, interpersonal, and personal skills were represented through tables with nine indicators for each category. Participants were asked to rate the 27 indicators on a scale of 5 indicating how well they thought they had been trained in these skills before graduation (1 = poor, 5 = excellent) and the importance of those skills for their professional success (1 = not necessary, 5 = extremely necessary).

At the end of the survey, 29 participants expressed interest in participating in an interview by providing their contact information. After quantitatively analyzing the skill indicators, 15 of the 29 engineers were randomly selected for interviews. The purpose of the interviews was to obtain a better understanding of their college preparation for an engineering career. Six telephone interviews were conducted with participants who were abroad, and the other respondents were interviewed face to face. The questions focused on job responsibilities and technology use, as well as the importance of technical, interpersonal, and personal skills. The participants were asked about the ways in which the school had or had not prepared them for their future career. After transcribing the interviews, data were analyzed inductively using the constant comparative method [35, 36]. Data were coded for the key points and patterns related to questions about the main skills that engineers view as necessary for the engineering profession. The authors conducted interobserver agreement checks on the answers provided by engineers. Answers were rated independently using keys, and an agreement was defined as both raters' recording that the same answer was under the same key. Coders reached a level of 80% interobserver agreement on each of the themes. Themes that emerged include "Continuous learning," "Technology expertise," and "Managerial and teamwork skills."

5. Findings

The majority of the participants (82%) was male, and only 18% were female (see Table 1). Participants were distributed among the following specializations: Civil (34%), Mechanical (25%), Electrical (23%), Computer (11%), and Engineering Management (7%).

Most of the participants (68%) were young engineers practicing for less than five years. The majority of the engineers (62%) are working abroad, in the Arabic Gulf (31%), Europe and North America (16%), and Africa (15%).

Surprisingly, 27% of these engineers work in management although only 7% of the sample specialized in Engineering Management. Most of the remaining engineers are distributed between design and consulting related duties, 25% and 15%, respectively. Interestingly, 20% of the participants revealed that they would not study engineering if they had the chance again.

Participants were asked to rate the 27 indicators for how well they were trained in these skills before graduation and how important those skills have proven to be for their professional success. The Likert-scale items revealed a Cronbach's alpha reliability of 0.834 for the technical skills, 0.855 for the interpersonal skills, and 0.858 for the personal skills. The difference of means was calculated for the indicators related to the investigated skills before starting their career and after practicing engineering. Skills rated below average appear in bold in Table 2; mean before graduation = Mb, and mean after starting career = Ma.

5.1 Technical skills

The findings indicate that among all the measured technical indicators, "Creativity and innovation skills" has the lowest mean (Mb = 2.91, SD = 1.1), but it was rated high for the engineering profession (Ma = 3.99, SD = 0.92). Moreover, we note that the "Learn a new subject on your own" indicator has the highest mean among all the technical skills acquired during college (Mb = 3.90, SD = 0.96), and it is also the highest rated skill as necessary for

Table 1. Participants' demographics

		Frequency	Percent
Gender	Male	154	82
	Female	34	18
Major	Civil	64	34
	Mechanical	48	25
	Electrical	43	23
	Computer	20	11
	Management	13	7
Years of work	Less than 2 years	44	23
	2–5 years	84	45
	Over 5 years	60	32
Location	Lebanon	72	38
	Gulf region	58	31
	Europe & North America	30	16
	Africa	28	15
Position title	Sales	6	3
	Planning	3	2
	Production	3	2
	Maintenance	15	8
	Consulting	28	15
	Design	47	25
	Site	19	10
	Management	50	27
	Other	17	9
Choose to study engineering again	Yes	152	81
	No	36	19

Table 2. Technical, Interpersonal, and Personal skills indicators on a scale 1–5 (skills rated below average appear in bold)

	Before starting career		After practicing engineering		
	Mb	**SD**	**Ma**	**SD**	**Mb–Ma**
Technical skill indicators					
Theoretical knowledge	3.68	0.85	3.39	1.0	–0.29
Transforming knowledge to product	3.04	0.96	3.88	0.98	0.84
Learn a new subject on your own	3.90	0.96	4.45	0.73	0.55
Conduct experiment on your own	3.23	0.94	3.52	1.1	0.29
Using technological tools	3.19	1.0	3.86	1.0	0.67
Model and formulate problems	3.60	0.89	4.03	0.90	0.43
Possessing computational skills	3.76	0.89	3.86	0.98	0.1
Solving engineering problems	3.70	0.92	4.12	0.90	0.42
Creativity and innovation skills	**2.91**	1.1	3.99	0.92	1.08
Interpersonal skill indicators					
Presentation skills in foreign language	3.23	1.0	4.27	0.76	1.04
Written communication in foreign language	3.37	1.0	4.43	0.74	1.06
Oral communication in foreign language	3.24	1.1	4.44	0.77	1.2
Make decision and accept responsibility	3.20	1.0	4.55	0.59	1.35
Confidence in dealing with others	3.27	1.0	4.48	.66	1.21
Ability to effectively work in a team	**2.86**	0.97	4.48	0.68	1.62
Openness to new ideas	3.61	0.97	4.13	0.79	0.52
Motivate others for a given task	**2.94**	1.1	4.12	0.83	1.18
Be willing to take risk	**2.87**	1.1	3.60	1.1	0.73
Personal skill indicators					
Leadership and managerial skills	2.51	1.0	4.12	0.86	1.61
Knowledge of business and public policies	**2.19**	0.97	3.77	0.99	1.58
Ability to work under pressure	4.14	0.85	4.51	0.67	0.37
Preparedness for continued learning	3.79	0.89	3.94	0.85	0.15
Ability to manage your time	3.47	1.0	4.49	0.65	1.02
Planning skills	3.11	1.1	4.32	0.77	1.21
Flexibility in dealing with others	3.36	0.96	4.18	0.81	0.82
Ability to be goal oriented	3.32	1.0	4.14	0.80	0.82
Possessing professional ethics	3.68	1.0	4.08	0.97	0.4

their engineering career (Ma = 4.45, SD = 0.73). The "Computational skills" indicator has a mean of Mb = 3.76, SD = 0.89, and a mean of Ma = 3.86, SD = 0.98, for their engineering practice. However, "Theoretical knowledge" has a high mean in college (Mb = 3.68, SD = 0.85) compared with the mean after starting their engineering career (Ma = 3.39, SD = 1). Participants rated "Conduct experiment on their own" with a mean of Mb = 3.23, SD = 0.94, during college and Ma = 3.52, SD = 1.1, for their career. All the other technical indicators have a mean of M > 3.0 both before graduation and after starting the engineering career.

5.2 Interpersonal skills

Regarding interpersonal skills, the "Ability to effectively work in a team" skill was poorly rated during college (Mb = 2.86, SD = 0.97) but had the highest rating for the profession. Other poorly rated interpersonal skill indicators were "Willing to take risks" (Mb = 2.87, SD = 1.1) and "Motivate others for a given task" (Mb = 2.94, SD = 1.1). These two skills were also the lowest rated as necessary for their engineering profession with Ma = 3.60, SD = 1.1, and Ma = 4.12, SD = 0.83, respectively. Engineers did acquire the remaining interpersonal skills to succeed in their career (M > 3.2). It is worth noting that no deficiency was found in "Presentation," "Written communication," and "Oral communication" skills in foreign languages with Mb = 3.23, 3.37, and 3.24, respectively, because Lebanese engineering colleges require their students to be fluent in Arabic, French, and English.

5.3 Personal skills

The personal skills indicators' results reveal that participants gave the lowest rating to "Knowledge of business and public policies" (Mb = 2.19, SD = 0.97), whereas it was rated as necessary for their profession (Ma = 3.77, SD = 0.99). The second lowest rated skill indicator learned during school is "Leadership and managerial skills" (Mb = 2.51, SD = 1.0), which was rated as highly necessary for an engineering career (Ma = 4.12, SD = 0.86). Another important personal skill for engineers is the "Ability to work under pressure," which was the highest rated for preparedness at the school level (Mb = 4.14, SD = 0.85) and also rated as the highest necessary for the engineering profession (Ma = 4.51, SD = 0.67). The other personal indicators demonstrate a sufficient level of academic preparation (M > 3.1).

5.4 Comparing the three sets of skills

A comparison was applied to the three sets of skills as a full group entity before and after graduation. Three variables were computed on the basis of the mean of the items falling under each set of skills before graduation (see Table 3). Cronbach's alpha was calculated for each of the sets, resulting in the Technical skills with 0.846, the Interpersonal skills with 0.896, and the Personal skills with 0.856. However, students may be prepared differently in these skills during college. To investigate any disparity between the skills that participants acquired before graduation, a one-way repeated measures ANOVA was applied to the set of skills and indicated significant differences among the three set scores during college: ($F(2,374) = 15.58$, $p < 0.001$). For the set of skills examined after starting a career, three variables were also computed based on the mean of the items falling under each set of skills. Cronbach's alpha was calculated for each group resulting in the Technical skills with 0.774, the Interpersonal skills with 0.790, and the Personal skills with 0.807. However, graduating engineers may have different values for these skills depending on their actual job's needs. Therefore, a one-way repeated measures ANOVA was applied to the set of skills after starting their profession and indicated significant differences among the three set scores after starting their engineering career, ($F(2,374) = 47.75$, $p < 0.001$). The post hoc tests using the Bonferroni technique indicated that all differences are significant ($p < 0.05$) except for the interpersonal and personal skills before graduation, which are nearly equal.

A paired-samples t-test was also applied to compare each one of the three sets of skills as rated by engineers before graduation and after starting a career. Figure 1 demonstrates significance for the three sets, mainly in the Interpersonal skills with a mean of ($\mu = 3.27$ before graduation) compared with ($\mu = 4.28$ after starting a career), and the Personal skills with a mean of ($\mu = 3.28$ before graduation) compared with ($\mu = 4.17$ after starting a career).

Table 4 summarizes the participants' perceptions of the three sets of skills before graduation and after starting their engineering career with regards to gender, years of experience, work location, and school type.

5.5 Gender differences

An independent t-test compared each item (before and after) between the male and female subjects.

Table 3. Mean of the three sets of skills before graduation and after starting career

	Before graduation		**After starting career**	
	Mean	**SD**	**Mean**	**SD**
Technical	3.48	0.63	3.90	0.57
Interpersonal	3.27	0.79	4.28	0.48
Personal	3.28	0.68	4.17	0.52

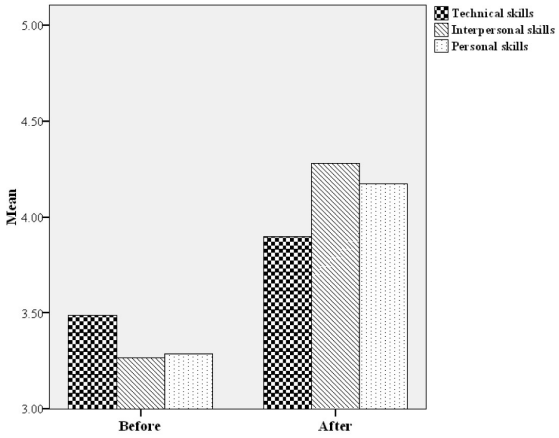

Fig. 1. Comparing the three sets of skills before graduation and after starting a career.

The findings revealed that the interpersonal skill "Motivate others for a given task" and the personal skill "Leadership and managerial skills" were both more highly rated by the male sample group than the female sample group after practicing the career.

5.6 Does the work experience have any influence?

A one-way ANOVA test was applied to the three groups: engineers who have been working for less than two years, those who have between two and five years of experience, and those who have over five years of experience. The results revealed no significant difference in their perceptions before starting their career. However, a significant difference appeared after practicing the engineering profession, largely in the interpersonal and personal skills, where engineers with over five years of experience valued these skills more than did the other two groups.

5.7 Does the location of employment have any impact?

Another investigation compared the views among engineers who are working in different regions. A one-way ANOVA test was applied to four groups by work location: Lebanon, Gulf region, Europe and North America, and Africa. The results revealed that the interpersonal skills "Ability to effectively work in a team," "Motivate others for a given task," and "Be willing to take risk" were rated higher by engineers working in the Gulf region and Africa. The personal skills "Leadership and managerial skills" and "Knowledge of business and public policies" were also rated higher by engineers working in the Gulf region and Africa.

5.8 What is the effect of institution on the preparation level?

An investigation was undertaken to discover any differences in the perceptions between practicing engineers who had graduated from the private institutions and those who had graduated from the public university. An independent t-test was applied to compare each item between the public and private samples. The interpersonal skills before graduation were rated significantly differently between the two groups, largely through the communication indicators. The indicators "Presentation skills in foreign language," "Oral communication in foreign language," and "Written communication in foreign language" were poorly rated by engineers who had graduated from the public university.

5.9 What do engineers suggest for a successful engineering profession?

To obtain a better understanding of engineers' perceptions about the relationship between school-

Table 4. Summary of the mean of the three sets of skills with regards to gender, work location, years of experience, and school type

	Mean before graduation			Mean after starting career		
	Technical	**Interpersonal**	**Personal**	**Technical**	**Interpersonal**	**Personal**
Gender						
Male (154)	3.5	3.3	3.3	3.9	4.3	4.2
Female(34)	3.3	3.2	3.3	3.9	4.1	4.0
Years of experience						
< 2 years (44)	3.5	3.3	3.2	3.7	4.2	4.0
2–5 years (84)	3.6	3.4	3.4	4.0	4.3	4.2
>5 years (60)	3.3	3.0	3.1	3.9	4.4	4.2
Work location						
Lebanon (90)	3.5	3.3	3.4	3.9	4.2	4.1
Gulf region(65)	3.6	3.3	3.2	4.0	4.4	4.3
Europe & North America (21)	3.2	3.0	3.0	3.7	4.2	4.0
Africa(12)	3.4	3.1	3.4	3.7	4.4	4.4
School type						
Public (60)	3.2	2.8	3.1	4.0	4.2	4.1
Private (128)	3.6	3.5	3.4	3.9	4.3	4.2

ing and practice, fifteen engineers were interviewed. The three coded themes "Continuous learning," "Technology expertise," and "Managerial and teamwork skills" are expanded below using illustrative quotes and excerpts from the participants' comments.

5.9.1 *Continuous learning*

The most frequent theme found in engineers' answers was the learning aspect embedded in their profession. The majority of participants (85%) expressed the importance of continuous learning in their field. Joseph, an electrical engineer working in Lebanon stated:

> Learning is the most needed in our work; each project is [a] new learning experience and a challenge. Engineering is a continuous sequence of learning.

Participants also expressed confidence in learning on their own; Dona, a mechanical engineer working in France declared:

> We don't expect school to teach us everything because the engineering profession keeps changing with new technologies and applications, but at least school helped me to learn on my own and under pressure. However, I think that we should have been exposed to more experiments and maintenance/laboratory courses that help students being more innovative and creative.

5.9.2 *Technology use*

The majority of participants also stressed the value of knowing how to use software packages and applications. A common theme found in engineers' answers was the need for familiarity with the latest computer applications. A typical comment was offered by Walid, a structural engineer working in the Arabic Gulf:

> My job requires the use of different software regarding structural engineering and management. I learned some of these packages at school, and I used them in my final project. The way college has integrated the use of these software [applications] in [the] classroom was very helpful for my job today.

5.9.3 *Managerial and teamwork skills*

Participants valued the importance of managerial and teamwork skills as extremely necessary for the engineering profession. All fifteen participants agreed about weaknesses in such skills. Nicolas, a civil engineer working in the Arab Gulf region, observed:

> I believe that the main skills that school didn't prepare me for are management, planning, financial issues, teamwork, insurance, [and] dealing with human resources. For example, I note that we are responsible about the safety of all [laborers] on site, and we did not learn about safety standards in our college.

6. Discussion

The results demonstrated, interestingly, that 20% of the participants would not study engineering if they had the chance again. Previous research has demonstrated that students who enroll in engineering programs are largely driven by their desires for professional growth, creativity, earning potentials, and advancement [1]. Our finding reveals that a fifth of the practicing engineers were disappointed in their profession or had not received adequate orientation regarding the actual career before enrolling in engineering programs.

6.1 *Technical, personal, and interpersonal skills*

The findings indicated that among all the measured technical indicators, "Creativity and innovation skills" has the lowest mean as a learned skill during college, but it was rated as highly necessary for a creative engineering profession. Such a difference in the mean reflects a feeling of deficiency in creative skills. It appears that the engineering programs in Lebanon are traditional in their curricula as well as in the teaching styles, where creative behavior may be absent. To improve such skills, curricula should implement innovative thinking activities with approaches to problem solving that enhance creativity and visualization skills at an earlier educational stage rather than focusing only on theoretical concepts.

It is interesting to note that the "Learn a new subject on your own" indicator has the highest mean among all the technical skills acquired during college and it is also the highest rated skill as necessary for the engineering career, indicating the importance of the self-learning ability for the engineering profession. The "Computational skills" indicator seems to be well covered during college studies and is deemed essential for engineering practice. This skill indicator has the second highest mean in school preparedness level, indicating that engineering colleges in Lebanon provide an adequate background in math-related subjects. However, the "Theoretical knowledge" indicator implies that programs put more emphasis on theories that engineers find unnecessary for practice. Engineers also appear confident in their ability to "Conduct experiments on their own" in their career on the basis of their college training. Looking at the other technical indicators, the findings reveal an adequate academic preparation for a successful career in engineering.

Highly significant differences were found in the mean scores for all the interpersonal skills indicators between the preparedness in college and the necessity in practice. The "Ability to effectively work in a team" skill was the highest rated by

participants reflecting its extreme importance for their profession. However, they rated their preparedness in this regard during college poorly, and this deficiency implies that colleges do not emphasize teamwork practice in activities and projects. Other poorly rated interpersonal skill indicators were "Willing to take risks" and "Motivate others for a given task," which were also the lowest rated skills as necessary for the engineering profession. Unexpectedly, the "Openness to new ideas" skill was the highest rated indicator in school preparedness, which might be a natural consequence of the rich cultural diversity of Lebanese society. Overall, it appears that engineers did acquire the remaining interpersonal skills for success in their career. It is noteworthy that no deficiency was found in "Presentation," "Written communication," and "Oral communication" skills in foreign languages because Lebanese engineering colleges require their students to be fluent in Arabic, French, and English.

Looking at the personal skills indicators, the results demonstrate that participants gave the lowest rating to "Knowledge of business and public policies" although they rated it as necessary for their profession. This result was expected because most engineering programs in Lebanon provide no business or public policy courses. Therefore, elective courses should be offered in these fields. Surprisingly, the second lowest rated skill indicator learned during school is the "Leadership and managerial skills" indicator, which was rated as highly necessary for an engineering career. This finding is deeply disappointing because the engineering profession requires this expertise for long-term professional success and sustainability. A related concern is that 27% of the surveyed engineers work on managerial tasks. One indicator deemed an important personal skill for engineers is the "Ability to work under pressure," which was the highest rated for both school level preparedness and engineering profession necessity. This suggests that rigorous and competitive engineering programs challenge students through tough requirements and demanding exams.

6.2 The three sets of skills

Although several of the individual skills were rated as non-significant before graduation and after starting an engineering career, the three sets of skills before and after graduation were compared as a full group entity. Students may be prepared differently in these skills during college, whereas graduating engineers may have different values for these skills, depending on their actual job requirements. Cronbach's alpha is the reliability coefficient that measures the inter-correlation of items. Although there is a decrease in the Cronbach's alpha value between the set of skills before graduation and after starting the engineering profession, the alpha values remain above 0.70, indicating internal consistency of the items in the scale. This variation reveals that the extent to which item responses obtained at the same time for the skills before graduation correlate more closely with each other than with the skills after starting the engineering career. The *post hoc* Bonferroni tests indicated that all differences are significant except for the Interpersonal and Personal skills before graduation, which are nearly equal. The significant difference in the ANOVA test reflects an obvious emphasis on the technical skills, whereas the interpersonal and personal skills were neglected in college. Although engineers considered the technical skills as important after starting their career, interpersonal and personal skills are deemed indispensable for their professional growth. This comparison reveals the importance of interpersonal and personal soft skills in the engineering profession, suggesting that these skills should be integrated into academic studies.

6.3 Gender

Between 2005 and 2010, the enrolment of females in Lebanese engineering programs fluctuated between 15.2% and 18.2% with a mean of 16.5%, as revealed by the Center for Educational Research and Development [37]. Although female engineers comprised only 18% of the sample, the findings elucidate women's perceptions and reveal differences between male and female engineers' evaluation of their skills.

Males and females seem to agree on their academic preparation for engineering careers and the importance of the same items for a successful engineering career. Only two items were rated significantly different after practicing the engineering profession. The interpersonal skill "Motivate others for a given task" and the personal skill "Leadership and managerial skills" were both more highly rated by the male sample group than the female sample group after practicing the career. These findings may imply that Middle-Eastern women in the engineering field do not see themselves moving into managerial positions. We can also note that among the 34 females, only six had risen to management positions but none had specialized in Engineering Management.

6.4 Work experience

Work experience is an important factor in the transition from college to career, and hence we sought any disparity in perceptions between freshly graduated engineers working for less than two years, engineers with two to five years' experience, and engineers with over five years' experience.

Although no significant differences were found in

the perceptions of the groups before starting their career, some significant differences appeared after practicing the engineering profession, primarily in the interpersonal and personal soft skills where engineers with over five years' experience valued these skills more than did the other two groups. The personal skill "Leadership and managerial skills" appeared to be the most significant item, suggesting that experienced engineers may have been assigned more managerial tasks and therefore value such skills as very essential for their long-term career. This finding is not surprising because previous research has confirmed that a large portion of engineers have become managers by the age of 45–50 [38–40].

6.5 Location

After investigating the perceptions of engineers working in different locations, engineers working in the Gulf region and Africa had different perceptions from those in Europe/North America. The interpersonal skills "Ability to effectively work in a team," "Motivate others for a given task," and "Be willing to take risk" were rated higher by engineers working in the Gulf region and Africa. The personal skills "Leadership and managerial skills" and "Knowledge of business and public policies" were also rated higher by engineers working in the Gulf region and Africa. These values reflect that engineers in the Gulf region and Africa are more likely to hold leadership positions that require these professional skills. It is interesting to note that among the 34 women, 25 of them work in Lebanon, 5 in the Gulf region, and 4 in Europe/North America. None of the female participants work in Africa.

6.6 Universities

Approximately two-thirds of the participants had graduated from the two private universities, and the rest obtained their degree from the Lebanese University, the only state-operated university. Because it charges no tuition fees, the acceptance into the Lebanese University engineering program is extremely competitive, and only the most qualified students can excel in its rigorous program. Therefore, to avoid the pressure of such a curriculum, students who have not been admitted to the Lebanese University engineering program usually enroll in private institutions where the success rate is relatively high. When comparing the perceptions of engineering graduates from the private institutions to those of graduates from public university, the results demonstrated that both groups agree on their technical and personal preparation. In addition, participants seem to agree on the importance of the same items for a successful engineering career. Nonetheless, the interpersonal skills before graduation were rated significantly different between the two groups, primarily in the communication indicators: "Presentation skills in foreign language," "Oral communication in foreign language," and "Written communication in foreign language" were poorly rated by engineers graduated from the public university. In fact, the curriculum in the Lebanese University greatly emphasizes scientific and engineering core courses while neglecting the soft skills courses. The curriculum offers no communication courses, and students are expected to develop these skills on their own. Therefore, students find themselves compelled to focus on the core courses to successfully advance in their program.

6.7 The interviews

The objective of the interviews was to give the engineers an opportunity to express their opinions in their own words, and they were especially beneficial for understanding the engineers' perceptions about the relationship between schooling and professional practice. The themes that emerged were "Continuous learning," "Technology expertise," and "Managerial and teamwork skills." Consistent with the quantitative results, participants expressed the importance of continuous learning in their field. The "Learn a new subject on your own" indicator had the highest mean among all the technical skills acquired during college and also as necessary for the engineering career. Participants also stressed the value of expertise in using software packages and applications, regarded as a necessary means for learning technological tools and implementing these skills at work. The participants' comments confirmed the quantitative results for the measured item "Using technological tools," which was highly ranked before and after practicing the profession. Finally, participants valued the importance of managerial and teamwork skills as extremely necessary for the engineering profession, a finding consistent with the quantitative results where "Knowledge of business and public policies" was among the most necessary skills.

7. Limitations

The online survey was a convenient means of gathering information from participants scattered around the world. Interviews gave participants the opportunity to express their perceptions in their own words.

Although participants were engineers working in different social and multicultural settings, the fact that the data were collected from graduates of one country in the Middle East is one limitation of this study. As such, engineers who graduated from other universities in the region, especially from institu-

tions that do not follow the American curriculum may have different perceptions regarding the same skills.

Another limitation of the study is that it is based on student and young professional self-reports, not on their employers' or professors' evaluations, which could be perceived as more objective. Future studies should collect the opinions of professors and employers who will definitely add value to this investigation. Interviews with employers would confirm the findings and reveal the real gaps that engineers face in practicing their profession. Greater research emphasis should also be placed on the gender issue regarding the Engineering Management specialization and positions.

8. Conclusions

This study analyzed indicators that are essential for improving engineering practice for new graduates and identified certain skill deficits that may hinder the effectiveness of practicing engineers. Specific criteria were tested to assess college preparations and work proficiencies in technical, personal, and interpersonal skills.

The Likert-scale data suggested that colleges of engineering provide their students with sufficient theoretical and technical skills while neglecting certain personal and interpersonal skills. It appeared that these skills in leadership, management, and multidisciplinary teamwork were the most overlooked aptitudes in college although they are crucial in work settings. In addition, the results demonstrated that the participants were weak in creativity and innovation.

The interviews, wherein participants could express their perceptions in their own words, confirmed the quantitative results. Participants stressed the importance of continuous learning in the field of engineering, the need for software package and application usage expertise, and the value of managerial and teamwork skills.

These findings suggest that there is a need for instruction in the currently neglected but necessary skills to bridge the gap between schooling and practice. Therefore, the academic environment is responsible for producing well-rounded practitioners of the engineering profession by teaching not only the subject but also the soft skills required of the current and future generations of engineers.

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