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Students' Enrollment in Engineering: Motivational Factors*

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This study investigates the influences and motives behind students' decisions to choose an engineering major. To learn more about what drives students to enroll in engineering programs, three universities in Lebanon were targeted as a case study. A survey with Likert-scaled items measuring different types of influences and motives were completed by 387 undergraduate engineering students. After rating the potential influence sources, a genuine interest in the field appeared to be the main influence affecting the students' own decision. An exploratory Factor Analysis was applied to the various intrinsic and extrinsic motivational factors and generated four categories: personal growth, professional growth, social growth, and financial growth. One-way repeated measures ANOVA showed that the professional growth including job satisfaction that improves the level of students' creativity in a challenging environment was the leading motivator for choosing engineering.

Keywords: engineering education; engineering enrollment; student motives; Middle East

1. INTRODUCTION

PRIOR TO HIGH SCHOOL GRADUATION, students find themselves in the dilemma of choosing a major to enroll in such as medicine, arts, natural sciences, business, or others. Some students may have some inclinations towards a specific subject, while others may not have any preferences. In fact, a poor choice in this regard may later affect these students and they may either change major or drop out of college. As such, educational choice is the most commonly recognized life regret for Americans [1]. Several factors may particularly impact students' choices such as parents' influence, the prestige of the profession, high earning potential and career prospects, probability of success in the field, or curriculum requirements ([2–4] and [5]).

It is observed that Japan, South Korea and China confer a remarkably large percentage of degrees in science and engineering. In contrast, and in the United States, notable deficiencies were detected in science and engineering enrollment [6]. During the last 5 years, enrollment in engineering programs across the Unites States showed a small rate of increase. The American Society for Engineering Education (ASEE) recently released a report indicating that enrollment in undergraduate engineering decreased 2% between 2004 and 2007 and then rose 4.5% in 2008 over 2007. Undergoing studies focus on the importance of increasing the diversity in science, engineering and technology-related disciplines to attract women and under-represented groups for a sustainable education [7]. In a recent edition of the *Christian Science Monitor*, Mertens [8] argues that the actual recession in the United States drives more students to enroll in engineering programs.

Not far from the United States, the Canadian IT Labor Market Initiative [9] contacted 50 Canadian universities in December 2004 where 17 of them responded to a survey measuring enrollment levels in engineering programs for the academic years 2002–03 to 2004–05. The results differed between the specializations for both undergraduate and graduate levels. For example, the undergraduate computer engineering and electrical engineering decreased by 19% and 11%, respectively, whereas other disciplines such as the civil engineering increased by 23%. The open-ended questions that were used to uncover some steps that should be taken to maintain or increase enrollment levels in these universities suggested that universities, the private sector and the government have important roles to play in enhancing enrollment in engineering programs. At the same time, the respondents stressed the role of secondary schools that can have an important impact such as promoting programs, developing needed skills, offering special presentations to understand the profession, and encouraging female involvement. The above information suggests that enrollment in engineer-

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ing programs in North America are fluctuating about the mean producing either a slight increase or decrease which implies a steady trend of enrollment during the last five years.

Also, in Australia, projections suggest a shortfall in enrollment in engineering studies [10]. Four main factors were identified as influences on poor enrollment in engineering majors: national investment, sources of information, education and perceptions of the profession [11].

On the other side of the globe, the number of students enrolling in engineering programs in the Middle East is increasing. The Arab countries have seen a boost in the number of engineering colleges, engineering students and engineering graduates that has exceeded expectations [12]. For example, during the last five year period, an average enrollment increase is observed at colleges of engineering in Lebanon ranging between 5% and 20%. Such a fact might not be so surprising when we learn that the number of universities offering engineering programs is rising. For instance, the website of the Lebanese Ministry of Education and Higher Education lists forty-one licensed universities and institutions of which 15 offer engineering programs with several concentrations. Not far from Lebanon, a drastic increase of 26.4% was observed in 2006 at King Abdul Aziz University in Saudi Arabia. Also, the Sultan Qaboos University at Oman registered an increase in enrollment of 30.2% in 2007 [13].

Within all this, one question is to be asked: Why is engineering suddenly becoming an attractive major in the Arab world? In other words: what makes students choose engineering majors?

2. THEORETICAL FRAMEWORK

We took two aspects—influences and motives—to inform the design of the survey. Though neither of these aspects directly addresses why students might choose engineering majors, they served as a foundation to guide the development of the survey.

2.1 Theory of Influence

Harvard psychologist, Herbert Kelman [14], posited that social influence occurs when an individual's thoughts or actions are affected by other people, either intentionally or unintentionally. Three types of influences were identified: 'compliance' when a person seems to go with the majority within a group; 'identification' when a person is influenced by well respected or liked people such as celebrities or older family members, and 'internalization' when a person is influenced to agree with something both publicly and privately.

In this study, the sources of influence include individuals, such as parents or relatives, friends or peers, and school teachers [15], who may sway students in their choice of major enrollment. Other types of influences include an interest in the subject, such as an aptitude for the subject, interest in the field, or previous work experience, and the studies' characteristics, such as cost of education, and the number of years required.

2.2 Theories of Motivation

Social researchers have explored theories of motivations and distinguished between intrinsic and extrinsic motivation. *Intrinsic motivation* refers to one's internal desire to perform a task for no definite reward other than personal satisfaction. On the other hand, when someone is motivated by incentives external to his or her interests, the factors are called *extrinsic motivators*. In Self-Determination Theory, an individual's competence and self-determination are strongly connected to emotions and enjoyment [16] where intrinsically motivating activities were defined to be those performed for one's innate satisfaction rather than a consequential recompense. Hence, having fun in exercising an activity is the main idea of intrinsic motivation.

For the purpose of the study, the motives examined focused on four motivational theories: flow, creation, social and financial factors.

2.2.1 Flow factor

Csikszentmihalyi [17] established the concept of 'flow' where enjoyment is maximized by surveying people periodically. He was interested in the activities that people were choosing and to what degree they were engaged in the activity. He proposed that the challenge within an activity is associated with the state of engagement and the perceived ability. Hence, some students might see the engineering profession as a way of achieving satisfaction that will be characterized with an intense focus and concentration, an integration of action and awareness, self-confidence in abilities, and the satisfaction of the activity itself.

2.2.2 Creation factor

Another aspect of motivation is the sense of creativity in completing a task. Amabile [18] theorizes that creativity is a combination of a heuristic task that has no identifiable solution and the conception of a new and suitable solution to a specific task. Amabile has linked this creativity with an objective assessment carried out by expert observers and a subjective self-assessment in order to understand the impact of the creative production. Therefore, students might choose an engineering major hoping for specific opportunities that enable them to show creativity in a challenging environment. Another theory that puts an emphasis on creation is constructionism [19], which asserts that learning is particularly effective when constructing something for others to experience.

2.2.3 Social factor

The third level in Maslow's [20] hierarchy of needs is belongingness, typically provided by

colleagues, family or friends. Similarly, self-determination theory (SDT) includes social aspects such as the desire to belong to a group [16]. Lindenberg [21] also found that part of what motivates people is the desire to socialize when they work and conform to the norms of a group. The opportunity of traveling, working overseas, and meeting new people may provide these students with some of these needs for feeling connected.

The next level of Maslow's hierarchy of needs is esteem, such as the social status and recognition where individuals need to feel important through self-respect and achievement. These students may choose to enroll in engineering for the opportunity of becoming a partner or a director of a company.

2.2.4 Financial factor

Several research studies have discussed the role and effects of financial compensation on job motivation where work rewards can be immediate or delayed, symbolic or tangible, of long or short term. Likewise, students might have some expected outcomes and foreseen benefits that contribute to their attitudes towards the major such as earning potentials, availability of employment, employment security, etc. [22]. These extrinsic rewards may drive not only a desire for high performance but also a desire for increasing social stature, such as potential promotion and the consequent prestige.

3. CONTEXT OF THE STUDY

For the purpose of this research, Lebanon was considered as a case study. Lebanon has one of the best educational systems in the Middle East where higher education institutions provide a prosperous source of fresh engineers for the Gulf region and it is regarded as an engineering educational center in the Middle East [23].

Three ranked universities from the top five in Lebanon are targeted: The American University of Beirut (AUB), The Lebanese University (LU), and Balamand University (BU). The American University of Beirut, established in 1849 by American Protestants missionaries, opened the school of engineering in 1951. The Lebanese University, established in 1951, is the only state operated university. It opened the college of engineering in 1980. Balamand University was founded by the Greek Orthodox Church in 1988; it established the faculty of engineering in 1993 [23]. Table 1 shows the increase in student enrollment in the three targeted universities between 2005 and 2009, where the total average increase exceeds 10%.

4. PURPOSE OF THE STUDY

The main objective of this study is to determine some of the main factors leading to the observed increase in enrollment in engineering majors in the Arab countries. This study examines undergraduate students in three leading universities in Lebanon. Because choosing a college major is a major life decision, the focus of this study is to identify and discuss these motivators by using a Likert-scale survey to understand better what and how 'important' these factors are to students as part of their career decision-making process.

5. METHOD

This study offers response analysis of 387 students in engineering programs who participated in a Likert-scaled survey investigating the factors that had impacted their decisions to choose engineering major. The Likert-scaled items identified influences as well as intrinsic and extrinsic motivational aspects that provided insights into why high school students choose to become members of the engineering community.

5.1 Participants

Undergraduate engineering students from the three universities, AUB, LU, and BU, participated in the survey. As of Fall 2009, the number of students enrolled in engineering programs in the three selected university was 1665, 2519, and 835, respectively. Professors from different disciplines in the targeted universities were contacted and asked to distribute the survey to their students. The survey invites students to voluntary participate while ensuring them of complete anonymity.

5.2 Materials and Procedure

The survey was randomly distributed to the targeted population of 5019 and data collection ended when a sample size of 387 was reached, satisfying the appropriate sample size for the given population [24].

Participants were invited to complete a 30-question survey. The instrument was based on the questionnaires employed in previous studies of major selection [25–28]. Questions included general characteristics such as gender and area of

Table 1. Percentage increase above the mean of the targeted colleges 2005–2009

Academic institution	Academic year					
	2005	**2006**	**2007**	**2008**	**2009**	%
AUB	1329	1360	1445	1576	1665	11
LU	2315	2370	2438	2466	2519	5
BU	557	579	588	713	835	17

specialty. Students were asked to indicate their knowledge and level of awareness of career opportunities in various disciplines when they completed high school before choosing engineering major. Also, participants were asked to rate 28 Likert-scaled items on a scale of 5 that reflects the leading factors that had contributed to their choice of enrolling engineering program (1 being unimportant and 5 being very important). The 28 Likert-scaled questions related to the potential influences and motives revealed a reliability of 0.852. Descriptive statistics were calculated to obtain the measures of central tendency as well as the measures of variability of each of the identified items.

6. FINDINGS AND DISCUSSION

Participants were mostly male (76%) with only 24% female. Such percentages are not surprising since several engineering education studies have discussed the unsatisfactory participation of women in the field [29, 30]. The sample was distributed among Civil (30%), Mechanical (23%), and Electrical (37%) engineers, and others (10%). Using a 5-point scale, students were asked to indicate their level of awareness of career opportunities in various disciplines when they completed high school. Table 2 reflects how knowledgeable students were about the disciplines and shows that the majority of students were not well informed about arts (μ = 2.22), social sciences (μ = 2.3), literature (μ = 2.41) and law (μ = 2.54) prior to choosing their major.

Table 2. Career knowledge level of awareness (1 = Not aware, 5 = Excellently informed)

	Mean	SD
Business	3.01	1.1
Natural sciences	2.59	1.2
Arts	2.22	1.1
Social sciences	2.3	1.1
Literature	2.41	1.2
Engineering	4.03	1.0
Law	2.54	1.2
Medicine	3.12	1.4

Table 3. Source of influences for choosing engineering major (1 = No influence at all, 5 = Strong influence)

	Mean	SD
Advice from parents or relatives	3.1	1.4
Friends' or peers' influence	2.5	1.3
School teacher's influence	2.3	1.3
Close relation with an engineer	2.6	1.5
Family member is an engineer	2.8	1.7
My own decision	4.4	1.0
Cost of education	1.9	1.2
Years of education required	2.4	1.4
Aptitude for subject matter	3.4	1.2
Previous work experience	2.0	1.3
Personal interest in the subject matter	3.9	1.2
High school guidance	2.4	1.3

6.1 Influence Factors

Students were asked to rate the importance of different sources of influence that had impacted their decision in choosing their major (see Table 3). The influence of parents/relatives appears as one of the important factors (μ = 3.1), which has been recognized as a primary determinants of children's career development in previous research studies [31]. For example, Blustein [32] synthesized relevant literature in this field and suggested that the role of the family is an important factor in creating children's career development.

However, the results showed that the highest ranked item is the students' own decision (μ = 4.4) followed by their interest in the subject matter (μ = 3.9). The influence of a genuine interest in the field corresponds to previous research reporting that a student's interest in the subject matter ranks highly in determining the student's selection for a major ([2, 3]).

Nonetheless, it is surprising to find that students have chosen their major based upon their own decision and personal interests. It implies that students had previous knowledge about the skills and abilities required for the engineering major and subsequent jobs. Factors that might provide enough information about the engineering profession for students, such as school teachers, school guidance, and a close relationship with an engineer, are poorly rated. Therefore, it is interesting to know how students have developed their self-assessment to fit in this major as well as their perceptions of the engineering profession.

Another surprising result is the low rate of influence of the school, which suggests that the high school role is almost absent in the students' decision. Obviously, the school has a major role in preparing students to acquire the adequate knowledge for the best challenging jobs. However, one of the main roles of schools is to provide enough guidance and orientation to students for their major enrollment and career choice. It is not clear if such low rate in the findings reveals a failure and a neglect of schools in the guidance process or reflects some disregard from students of such guidance.

6.2 Motivational Factors

In addition, the study investigated the importance of motives—extrinsic and intrinsic—that have impacted on students to enroll in engineering major. Table 4 shows 16 items that reflected the importance of the motives of students.

Though the potential motivators were grouped a priori according to the motivational theories that informed them, we did not expect it to be the case that all items based on a particular motivational theory would have equal importance to respondents. An exploratory Factor Analysis (FA) was employed in order to determine which of the 16 items formed related subsets. FA combines into

Table 4. Motivational factors for choosing engineering major (1 = Not at all important, 5 = Extremely important)

	Mean	SD
Job satisfaction	4.1	0.95
Availability of employment	4.0	1.0
Employment security	3.4	1.1
Prestige of the profession	3.3	1.3
Earning potential	4.0	1.1
Promotion prospects	4.0	1.0
Career flexibility	4.0	1.0
Potential of professional growth	4.0	1.1
Potential to travel	3.4	1.3
Opportunity to work for a large corporation	4.0	1.1
Becoming a partner in a partnership	3.4	1.3
Challenging and exciting profession	3.8	1.2
Opportunity to work overseas	3.4	1.3
Self-employment opportunity	3.4	1.2
Possibility to be a director of a company	3.7	1.2
Opportunity to be creative	4.0	1.1

factors variables that are correlated with one another but largely independent of other subsets of items [33, 34]. This method was used as an expedient way to identify a smaller number of constructs (subsets) that represent the Likert-type items.

As a means of forming the potential factors, FA was applied with principal components extraction, eigenvalues greater than 1.00, and absolute value more than 0.40 [35, 36]. Both results of Kaiser–Meyer–Olkin (KMO) measure of sampling equal 0.839, and Bartlett's test ($p < 0.0001$) showed that using FA is appropriate for this study [37].

The FA with the principal components extraction yielded four factors accounting for 56.7% of the total variance. Table 5 shows the rotated factor loadings, which are the correlations between the variable and the factor. The sizes of the loadings reflect the extent of the relationship between each variable and each factor. The higher the factor loading, the more the particular item contributes to the given factor. For items that were loaded under two factors, only the highest loading was retained. By evaluation of the items loaded under each factor, descriptive names were generated. Factor 1 with a variance ($\sigma^2 = 31.8\%$) was labeled *Financial Growth*, factor 2 ($\sigma^2 = 9.7\%$) labeled *Social Growth*, factor 3 ($\sigma^2 = 7.8\%$) labeled *Personal Growth*, and factor 4 ($\sigma^2 = 7.3\%$) labeled *Professional Growth*.

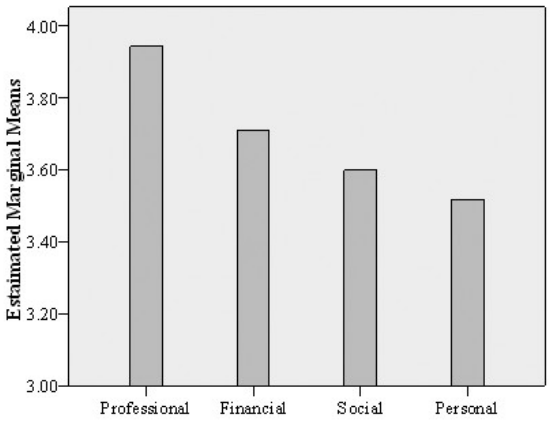

Fig. 1. Estimated mean of motives on a scale of '5'.

Four new variables were computed based on the mean of the items falling under each factor. A one-way repeated measures ANOVA was conducted to detect the main effects between the located variables. The results revealed significant differences among the four factor scores, ($F(3, 1158) = 30.16$, $p < 0.0001$).

Figure 1 shows the *Professional Growth* factor as the most powerful motivator for enrolling in engineering major and influencing students' decisions to pursue this discipline ($\mu = 3.94$ on a scale of 5) followed by the *Financial Growth* factor ($\mu = 3.71$),

Table 5. Rotated factor matrix with extraction method. principal component. Rotation method. Varimax with Kaiser Normalization

	Component			
Items	**Financial growth**	**Social growth**	**Personal growth**	**Professional growth**
Earnings potential	0.758			
Availability of employment	0.755			
Promotion prospects/opportunities	0.713			
Prestige of the Profession	0.565			
Employment security	0.547			
Potential to travel		0.823		
Opportunity to work overseas		0.710		
Opportunity to work for a large corporation		0.618		
Possibility to be director of a company			0.823	
Self-employment opportunity			0.667	
Becoming a partner in a partnership			0.616	
Potential for professional growth				0.441
Opportunity to be creative				0.656
Challenging and exciting profession				0.599
Career flexibility and options				0.549
Job satisfaction				0.501

the *Social Growth* factor (μ = 3.61), and the *Personal Growth* factor (μ = 3.51).

The items falling under the *Professional Growth* factor are job satisfaction with the highest mean (μ = 4.1), potential for professional growth (μ = 4.0), opportunity to be creative (μ = 4.0), a challenging and exciting profession (μ = 3.8), and Career flexibility (μ=4.0). Such results are consistent with previous studies [25, 38], showing that job satisfaction along with creativity are among the main factors impacting students in choosing their major.

The following important factors fall under the *Financial Growth* desires include earning potential, availability of employment, and promotion prospects, which were rated equally (μ = 4.0) with employment security (μ = 3.4) and prestige of the profession (μ = 3.3). The need for such financial prospects and opportunities was shown as an important contributor to students' decisions for major enrollment and agrees with previous studies ([39, 40].

Although the *Professional Growth and Financial Growth* factors were statistically significant using Bonferroni's method, this significance cannot be seen as meaningful, since the difference is not remarkable on a scale of '5'. Such result suggests that both types of growth-prospects contribute almost equally to the students' choice of a major.

7. LIMITATIONS

This research is a case study that included students from one country in the Middle East region. The scarcity of available information about education in general and engineering education in particular in the Arab World was one of main constraints of this study. Therefore, there is a strong need for more studies in the region to provide data and analysis to assess the status of education enrollment in the Middle East. In addition, surveys are a convenient way of gathering information from a large number of participants, but are not enough to gain a complete understanding of students' motivations and perceptions. Interviews may confirm the findings and may be appropriate to gain a more complete picture of influences and motives for choosing engineering major. Further investigations of other Arab students are needed to see the degree to which the findings presented here are consistent and to assess the cultural and social factors that tend to impact students' attitudes toward major enrollment and job preferences. Also, female enrollment in engineering needs to be investigated for a better understanding of the gender-related issues in major selection. The milieu of the Middle East region undoubtedly has different aspects of perspectives and therefore students who have graduated from high school in this region may have new perceptions that are yet to be discovered.

8. CONCLUSIONS

The increase in enrollment in engineering courses enhances the quality of life in the long term and affects economic growth. It is observed that engineering is becoming an attractive major in the Arab world. In this study, several sources of influence and motives were analyzed in order to understand the factors that might contribute to students' decisions in choosing engineering major. A personal interest in the subject matter appeared to be the leading influence on students' decisions to enroll in engineering. Four motivational dimensions were found: professional, financial, social, and personal growth. The results showed that students were driven largely by their desires to obtain a satisfying job that would provide opportunities for professional growth and creativity. Participants also indicated a strong need for a profession with earning potentials and promotion opportunities. The analysis showed identical importance—for intrinsic and extrinsic factors—which suggests that the students' need for a balance between intrinsic and extrinsic driven prospects for a life time profession.

Moreover, it is shown that the high school plays no role in guiding students to choose the major that meet their talents and interests. Due to its vital role, the high school orientation is very essential for providing adequate information for students' future success. Therefore, there is a pressing need for high school administrators to address this issue of giving effective guidance.

Nonetheless, it is important to point out the importance of the cultural role that might have an impact on the students' choice and therefore it is likely that some students decide to enroll in a major because it conforms to the norms of their society. Also, the oil producing countries in the Middle East have recently invested billions of dollars at home, in the building industries, repairing roads, and expanding social services. This economic boom has created job opportunities for graduate engineers and might have motivated students to enroll in engineering programs due to the high demand for engineers. Finally, the observed increase in enrollment requires additional attention to the quality of education provided. Consequently, it is essential to ensure that such an increase will not be at the expense of education quality.

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