Professional Skills Requirement of Mechanical Engineers

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Abstract. Professional Skills is the basic requirement that all engineers need to master in the current job market. This study was conducted throughout peninsular Malaysia using the Soft Skills Model introduced by the Ministry of Education (MoE). Among the objectives of this study is the level of requirement of the Soft Skills (SS) element to produce a competitive Mechanical Engineer and identify the most dominant Soft Skills needed in the current job market against Mechanical Engineers. The questionnaire distributed to respondents and data was analysed using XL-STAT 2014 software to obtain Discriminant Analysis (DA) to achieve the objective of the study. The overall percentage for (SS) elements is 91% respectively. This study will be a complementary set for the students of Mechanical Engineering in Malaysia. Mastering the features required by the industry makes it easy for students to put themselves in the real job world.

1. Introduction

Soft Skills

The Ministry of Education (MoE) has emphasised on standard methods and objectives to measure the students’ soft skills. Among the elements emphasised are psychomotor, communication, English proficiency, leadership, ethics, spirituality and emotional intelligence. All universities need to incorporate these elements into the program’s learning outcomes to evaluate student achievement [1]. Soft skills, generic skills and employability skills refer to modern engineering graduates [2] who need to be skillful in every aspect of this skill if they want to succeed at work then carry out successful work at the workplace [3] in helping to improve the capabilities of a company [4]. It is the primary asset for any workforce at the professional level, manager or business owner [5].

![Soft Skills Model](image_url)

**Figure 1.** Soft Skills Model
Based on Figure 1, there are seven elements of Soft Skills outlined by (MoE) for reference of all universities. i. **Communication Skills:** through effective communication skills, one will try to absorb and adapt [6] with news or situation that has the potential to reduce concerns and improve performance [7] as claimed by employers to meet high market demands in the industry employment [8] especially engineering graduates [9]. ii. **Critical Thinking and Problem Solving Skills:** reform in education is now increasingly focusing on essential processes of thinking, including problem-solving items [10,11]. Critical thinking and judgment are needed for engineering at a professional level to solve workplace problems [12,13]. Critical thinking is a step to make assumptions, testing of legitimacy, seeing things from different points of view, and taking into account every action [14,15,16]. As future graduates, university students need to equip themselves with critical thinking and problem-solving skills [17,18] as this is the focus of employers in hiring a new workforce [19]. iii. **Teamwork Skills:** teamwork is a high-level need that needs to be addressed [20]. Students believe that they are studying teamwork skills through the curriculum approach [21], joining sports teams or volunteers to work in an organisation that does not involve profit [22]. iv. **Continuous Learning and Information Management:** through the development of the methods used by incorporating the adapted learning, it can address the various learning styles of students and improve the effectiveness of the use of technology and information management [23]. v. **Entrepreneurial Skills:** nowadays, entrepreneurial skills are considered the ideal strategy for expanding productivity and overall development of any organisation [24] and being recognised as one of the critical skills [25], among engineering graduates [26]. Graduates not only have business opportunities and manage their businesses but also to create jobs for others [27,28,29]. vi. **Professional Ethics and Moral:** professional ethics is the best practice for all engineering students and engineering practitioners and advisable to stick to this principle [30] for the well-being of society which is the essence of engineering profession [31]. vii. **Leadership Skills:** essential skills are personality skills that are related to interpersonal skills such as leadership skills [32,33] that can develop the quality of competent leadership skills [34].

Based on the Program Outcomes (PO), engineering students are expected to master the skills, knowledge and attitudes through programs offered. That includes the following items: i. Engineering Knowledge; ii. Problem Analysis; iii. Design/Development of Solutions; iv. Investigation; v. Modern Tool Usage; vi. The Engineer and Society; vii. Environment and Sustainability; viii. Ethics; ix. Communication; x. Individual and Team Work; xi. Life-Long Learning; and xii. Project Management and Finance [35]. The items contained in (PO) are closely related to the employability of mechanical engineering graduates also involve the professional skills required by the industry.

2. **Materials and methods**
The research was conducted throughout the Peninsular of Malaysia. It is also involved in Mechanical Engineering industrial activities. A set of questionnaires is distributed by researchers to obtain feedback from industry, employers and organisations involved in the process of finding and securing the workforce in this field. All surveys have distributed, updated into XL-Stat software. All of the data generated, and the results of the study included Descriptive Statistics (DS) and Discriminant Analysis (DA).

3. **Results and discussions**
A total of 300 respondents have responded to the question item with a different current position. Eight items for Soft Skills (Communication) - (SSA), seven items Soft Skills questions (Critical Thinking
and Problem Solving Skills) - (SSB), five Soft Skills questions (Teamwork) - (SSC), three-question item of soft skills (Continuous Learning and Information Management) - (SSD), four Soft Skills questions (Entrepreneurship Element) - (SSE), three Soft Skills questions (Professional Ethics and Moral) - (SSF) and four Soft Skills questions (Leadership ) - (SSG).

Table 1. Descriptive Statistics Demographics

| No. | Gender  | Frequency | Percentage |
|-----|---------|-----------|------------|
| 1   | Man     | 240       | 80.00      |
| 2   | Woman   | 60        | 20.00      |

Table 1 shows the Histogram and Descriptive Statistics Gender Demographics with the number of respondents noted, 240 were men and 60 women. It involves staff in heavy, medium and small industries throughout Peninsular Malaysia.

Table 2. Descriptive Statistics Demographics

| No. | Current Position           | Frequency | Percentage |
|-----|----------------------------|-----------|------------|
| 1   | Management & Administration| 100       | 33.33      |
| 2   | Senior Engineers           | 72        | 24.00      |
| 3   | Senior Technologist        | 38        | 12.67      |
| 4   | Engineers                  | 90        | 30.00      |

Table 2 shows the Histogram and Descriptive Statistics Current Position Demographics of respondents have work experience of more than five years in the industry, especially in the mechanical engineering field and engineering department.

Table 3. Percentage of Classification of Level Needed

| Formula | Percentage | Level  | Justification |
|---------|------------|--------|---------------|
| 80.6 - 100 | Five       | Very High |               |
| 60.7 - 80.5 | Four     | High    |               |
| 40.8 - 60.6 | Three    | Moderate |               |
| 20.9 - 40.7 | Two      | Low     |               |
| 1.00 - 20.8 | One      | Very Low |               |

Percentages used in this study were divided into five categories, as shown in Table 3 based on the Likert Scale (1932).

i. Soft Skills (Communication) - (SSA)

Mean of the question item i. SSA1 (4.37); ii. SSA2 (4.43); iii. SSA3 (4.47); iv. SSA4 (4.34); v. SSA5 (4.42); vi. SSA6 (4.30); vii. SSA7 (4.31); and viii. SSA8 (4.32).
Table 4. Descriptive Statistic Question Item Soft Skills (Communication)

| Question Item                                                                 | Frequency | Percentage | Level of Need |
|--------------------------------------------------------------------------------|-----------|------------|---------------|
| SSA1: Ability to communicate ideas, effectively, and with confidence, verbally and in writing | 273       | 91.00      | Very High     |
| SSA2: Ability to practice active listening skills and provide feedback      | 292       | 97.34      | Very High     |
| SSA3: Ability to make a presentation expressly with confidence and appropriate to the audience level | 276       | 92.00      | Very High     |
| SSA4: Ability to use technology in a presentation                          | 260       | 86.67      | Very High     |
| SSA5: Ability to negotiate and reach agreement                              | 278       | 92.67      | Very High     |
| SSA6: Ability to communicate with participants of communication with different cultures | 260       | 86.67      | Very High     |
| SSA7: Ability to develop personal communication skills                      | 275       | 91.66      | Very High     |
| SSA8: Ability to use non-verbal skills                                      | 258       | 86.00      | Very High     |

Table 4 shows the question items SSA2 are ranked first with a percentage (97%) followed by SSA5 (93%), SSA3 (92%), SSA7 (92%), SSA1 (91%), SSA4 (87%), SSA6 (87%) finally is SSA8 (86%). The researcher collected the result shows significant as a ref [6,7,8,9].

ii. Soft Skills (Critical Thinking and Problem Solving Skills) - (SSB)

Mean of the question item i. SSB1 (4.52); ii. SSB2 (4.47); iii. SSB3 (4.57); iv. SSB4 (4.28); v. SSB5 (4.43); vi. SSB6 (4.56); and vii. SSB7 (4.48) as shown.

Table 5. Descriptive Statistics Question Item Soft Skills (CTPSS)

| Question Item                                                                 | Frequency | Percentage | Level of Need |
|--------------------------------------------------------------------------------|-----------|------------|---------------|
| SSB1: Ability to identify and analyse problems in complex and blurring situations, and make a justified evaluation | 282       | 94.00      | Very High     |
| SSB2: Ability to expand and improve thinking skills such as describing, interpreting and evaluating discussions | 282       | 94.00      | Very High     |
| SSB3: Ability to find ideas and find alternative solutions                     | 281       | 93.66      | Very High     |
| SSB4: Ability to think beyond the reach                                         | 259       | 86.33      | Very High     |
| SSB5: Ability to make decisions based on substantial evidence                  | 287       | 95.66      | Very High     |
SSB6: Ability to survive and to give full responsibility 300 100.00 Very High
SSB7: Ability to understand and adapt to a new community and working culture 274 91.33 Very High

Table 5 shows the question item SSB6 lead the highest value with percentage value (100%), followed by item SSB5 with percentage (96%), SSB1 (94%), SSB2 (94%), SSB3 (94%), SSB7 (91%) and SSB4 (86%). Percentage gives the impression that the element of the Critical Thinking and Problem-Solving Skills needed by engineering students as a ref [10,11,12,13,14,15,16,17,18,19] mentioned in the research before.

iii. Soft Skills (Teamwork)

The Mean values recorded are as follows: i. SSC1 (4.46); ii. SSC2 (4.38); iii. SSC3 (4.41); iv. SSC4 (4.43); and SSC5 (4.46).

Table 6. Descriptive Statistic Question Item Soft Skills (Teamwork)

| Question Item | Frequency | Percentage | Level of Need |
|---------------|-----------|------------|---------------|
| SSC1: Ability to build relationships, interact with others and work effectively with them to achieve the same objectives | 279 | 93.00 | Very High |
| SSC2: Ability to understand and take alternate roles between the group leader and group members | 267 | 89.00 | Very High |
| SSC3: Ability to recognise and respect, behaviours and beliefs of others. | 263 | 87.66 | Very High |
| SSC4: Ability to contribute to planning and aligning the outcome of the group's efforts | 280 | 93.33 | Very High |
| SSC5: Responsible for group decisions | 287 | 95.66 | Very High |

Table 6 shows the SSC5 question items got the highest percentage requirement reading (96%), followed by SSC4 (93%), SSC1 (93.00%), SSC2 (89%) and SSC3 (88%). As mention before in ref [20,21,22], all the item gives their contribution to producing the competitive of Mechanical Engineers in the future.

iv. Soft Skills (Continuous Learning and Information Management)

The Mean values recorded by the researcher are as follows: i. SSD1 (4.39); ii. SSD2 (4.44); and iii. SSD3, (4.56).

Table 7. Descriptive Statistic Question Item Soft Skills (CLIM)

| Question Item | Frequency | Percentage | Level of Need |
|---------------|-----------|------------|---------------|
| SSD1: Ability to locate and manage relevant Information from multiple sources | 279 | 93.00 | Very High |
| SSD2: Ability to accept new ideas and capable of autonomous learning | 267 | 89.00 | Very High |
SD3: Ability to develop curiosity and a thirst for knowledge 287 95.66 Very High

Table 7 shows the question item SSD3 gets the highest percentage requirement reading (96%), followed by SSD1 (93%) and SSD2 (89%) as a ref [23] mention before, the effectiveness of the use of technology and information management should be improved and up to date.

v. Soft Skills (Entrepreneurship)
Mean values recorded are as follows: i. SSE1 (4.29); ii. SSE2 (4.17); iii. SSE3 (4.21) and iv. SSE4 (4.12).

Table 8. Descriptive Statistic Question Item Soft Skills (Entrepreneurship)

| Question Item | Frequency | Percentage | Level of Need |
|---------------|-----------|------------|--------------|
| SSE1: Ability to identify business opportunities | 258 | 86.00 | Very High |
| SSE2: Ability to design business planning | 239 | 79.67 | High |
| SSE3: Ability to build, explore and seize business and employment opportunities | 251 | 83.67 | Very High |
| SSE4: Ability to work alone | 252 | 84.00 | Very High |

Table 8 shows the SSE1 question items get the highest percentage requirement reading (86%), followed by SSE4 (84%), and SSE3 (84%). The only question in a high group is SSE2 (80%). According to the ref [24,27,28,29], entrepreneurship is one of the strategies to manage properly by the graduate to fulfil the needed of the job and task on the engineering fields.

vi. Soft Skills (Professional Moral and Ethics)
The Mean values recorded are as follows: i. SSF1 (4.41); ii. SSF2 (4.38); and iii. SSF3 (4.47).

Table 9. Descriptive Statistic Question Item Soft Skills (Professional Ethics and Moral)

| Question Item | Frequency | Percentage | Level of Need |
|---------------|-----------|------------|--------------|
| SSF1: Ability to understand economic, environmental and socioeconomic effects in professional practice | 283 | 94.83 | Very High |
| SSF2: Ability to analyse and decide on ethical-related issues | 270 | 90.00 | Very High |
| SSF3: Ability to practise ethical behaviour, also to have a sense of responsibility towards society | 281 | 93.66 | Very High |

Table 9 shows the question item SSF1 got the highest percentage (95%), followed by SSF3 (94%), and SSF2 (90%). To produce the competitive of the mechanical engineer, an institution of higher education must show good manners and principle, as mention before in ref [30,31].

vii. Soft Skills (Leadership)
The Mean values recorded are as follows: i. SSG1 (4.22); ii. SSG2 (4.35); iii. SSG3 (4.30); and iv. SSG4 (4.36).

Table 10. Descriptive Statistic Question Item Soft Skills (Leadership)

| Question Item                                         | Frequency | Percentage | Level of Need |
|-------------------------------------------------------|-----------|------------|---------------|
| SSG1: Knowledge of basic theories of leadership        | 247       | 82.34      | Very High     |
| SSG2: Ability to lead the project                     | 275       | 91.66      | Very High     |
| SSG3: Ability to understand and take alternate roles  | 271       | 90.34      | Very High     |
| between team captains and team members                |           |            |               |
| SSG4: Ability to oversee team members                 | 269       | 89.67      | Very High     |

Table 10 shows the SSG2 question items got the highest percentage requirement reading (92%), followed by SSG3 (90%), SSG4 (90%), finally is SSG1 (82%). According to ref [32,33,34], the quality of competent leadership skills can be developed and learn time to time with the best attitude of the leader.

Fig. 2 shows a histogram ratio of the percentage of the requirement that involves seven Soft Skills: i. SSA - Communication (91%); ii. SSB - Critical Thinking and Problem Solving Skills (94%); iii. SSC - Teamwork (92%); iv. SSD - Continuous Learning and Information Management (95%); v. SSE - Entrepreneurship Elements (84%); vi. SSF - Professional Ethics and Morals (93%); and vii. SSG - Leadership (89%). The results of the study have shown that all the elements strongly required by the employers and the industry to the graduates of Mechanical Engineering. It is complementary to each other to produce the best result on an engineering organisation. It must be mastered completely before facing the real world, as mentioned in a ref [35].

Discriminant Analysis

Discriminant Analysis (DA) is used in systematic scientific research [36,37,38] to identify clusters [39], discriminating against two or more groups [40,41,42]. Four types of clusters are involved in Management and Administration, Senior Engineers, Senior Technicians and Engineers. DA is also used to validate the classification of careful observations [43] classification of identified groups [44],
and it is a classification technique [45] on observations performed [46] by researchers at the early stage of study [47].

Table 11. Wilks’ Lambda Test (Rao Estimate - Position)

| Criteria | i: Management & Administration | Value | Criteria | ii: Senior Engineers | Value |
|----------|---------------------------------|-------|----------|-----------------------|-------|
| Lambda   | 0.069                           | 11.145| Lambda   | 0.069                 | 11.095|
| F (Observed value) | 1.261                            | 102   | F (Observed value) | 1.262             | 102   |
| DF1      | 788                             | <0.0001| DF1      | 785                   | <0.0001|
| DF2      | <0.0001                         | 0.05  | p-value  | <0.0001               | 0.05  |
| p-value  | alpha                           |       | alpha    |                       |       |

| iii: Senior Technologist | iv: Engineers |
|--------------------------|---------------|
| Criteria Lambda          |   Value       | Criteria Lambda |   Value       |
| F (Observed value)       | 10.988        | F (Observed value) | 10.804        |
| DF1                      | 1.262         | DF1              | 1.262         |
| DF2                      | 782           | DF2              | 779           |
| p-value                  | <0.0001       | p-value          | <0.0001       |
| alpha                    | 0.05          | alpha            | 0.05          |

Table 11 (i, ii, iii, and iv) shows the Discriminant Analysis of the results of the Wilks' Lambda Test (Rao Estimate) obtained for the Soft Skills - (position) clusters for i. Management and Administration; ii. Senior Engineers; iii. Senior Technologist and; iv. Engineers. The test shows that H0: The vector mean of the four clusters is the same and Ha: At least one mean vector is different from the others. Based on the analysis, the resulting p-value is lower than the significant level of alpha = 0.05. Hence, the three hypotheses H0 Zero rejection, and alternative Ha hypotheses are accepted. The risk of rejecting the H0 zero hypothesis is when the accuracy is lower than 0.01%. The four clusters are different from each other [48].

Table 12. Error Matrix for Budget Samples

| From / To | 1  | 2  | 3  | 4  | Total | % Correct |
|-----------|----|----|----|----|-------|-----------|
| 1         | 75 | 21 | 0  | 4  | 100   | 75.00     |
| 2         | 8  | 61 | 0  | 3  | 72    | 84.72     |
| 3         | 0  | 10 | 28 | 0  | 38    | 73.68     |
| 4         | 7  | 20 | 0  | 63 | 90    | 70.00     |

Table 12 shows the formulation of the matrix of errors in the sample estimates involving four Cluster Type Positions. Based on the table: i. One hundred respondents from Management and Administration with 75% correct percentage; ii. Seventy-two respondents from Senior Engineer with 85% correct; iii. Thirty-eight respondents from Senior Technician with percentage right 74%; and iv.
Ninety respondents among engineers with a percentage of 70%. That means Senior Engineer answered questions item of the study with the highest level of accuracy.

4. Conclusions
Overall, it can be stated by the researcher that industry in Malaysia needs the seven elements of Soft Skills in obtaining competitive Mechanical Engineers. It can be proved by the evidenced available in the results of the study. The most dominant Soft Skills is Continuous Learning and Information Management. Employers and engineering organisations today expect every engineer always strive to find and get the latest inputs as well as efficient in technologically advanced. These soft skills are combined with the knowledge and attitudes to produce future high-quality Mechanical Engineering workforce following the expectations expected by the (MoE) and the Malaysian industry.

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