Aspects that develop soft skills - a way for inclusion in engineering programmes

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ABSTRACT: Engineers and other professionals with developed soft skills are in high demand in industry due to its need to sustain success and expand. For this reason, university programmes should include training on these skills in their study plans to reduce the gap between the industry requirements and the skills of the professionals. In this research, the aims were to determine the aspects that influence soft skills development and propose a curricular change in a mechanical engineering programme. A survey was designed and administered to 81 mechanical engineering graduates. It contained 14 demographic and 54 soft skills development indicators. According to the bilateral Kolmogorov-Smirnov test, this survey showed good validity and non-parametric and non-normal data. *Training* was statistically the most relevant demographic aspect, using the Kruskal-Wallis/ANOVA test, compared with others, such as the job range, time of experience, job position. It is proposed to include new subjects using experiential learning methodology into the curricular programme to develop soft skills to reduce the gap between the industry requirements and university education, and make the programme more competitive.

INTRODUCTION

Professionals with excellent soft skills are in high demand, and regional, national and multinational companies require that potential employees demonstrate those skills [1][2] which are also needed for education quality assessments and standards agencies. Furthermore, based on company data and research, it appears that more development is needed, especially in some regions [2-4], and that there exist a colossal gap between soft skills required by enterprises and those demonstrated by professionals educated in the traditional university education system [5].

Due to this pressing need, currently, the personnel selection processes evaluate the development of soft skills to satisfy the requirements of the hiring company. Moreover, in view of the transformation towards Industry 4.0 professionals with these skills are more competitive and readily employed [6]. This situations on the labour market, opens the possibility of improving the competitiveness of university graduates by focusing on the appropriate training already during their undergraduate study.

In this context, it is worthy to analyse which aspects influence soft skill development and how to include practical soft skills training into academic programmes. Skills are generally classified into two basic groups, hard and soft ones. Soft skills are commonly referred to as socio-emotional, generic, transferable across disciplines or employment-related skills. They are associated with attitudes, attributes, habits and practices that enable positive relationships, influence learning, and allow to successfully interact with work colleagues, the close environment and the world. These skills are in high demand by enterprises as they need to assure employees' efficiency and productivity in a well-organised work environment, and maintain their image as well-managed and productive organisations [2][4][7][8]. More specifically, soft skills usually include: self-management, critical thinking, communication skills, responsibility, teamwork skills, interpersonal skills, ability to work under pressure, imagination, planning and organising, creativity, willingness to learn, attention to detail, vision, maturity, professionalism, emotional intelligence and others [7][9-11].

RESEARCH QUESTION

The following questions were formulated for this study:

- Q1. Which aspects are relevant in increasing softs skills development (age, experience, type of enterprise, university degree, non-academic training, range, position, function)?
- Q2. How to incorporate soft skills development into an engineering curriculum?

RESEARCH METHODOLOGY

Based on a literature review, a survey was designed to trace soft skills development back. The survey structure comprises two dimensions, each divided into categories and subdivided into indicators or questions.

The first dimension, named demographic, was subdivided into three categories containing 14 indicators. The first category was job characteristics disaggregated into five indicators: function (technical, administrative, managerial), range (CEO, operative manager, project engineer, operational engineer, consultant, docent, other), experience time (in range of three years), engineering level (junior or senior) and the number of people in charge (8, 9 to 25, 26 to 40, more than 41). The second category, related to the characteristics of the company where the survey respondent works, involved five indicators: organisation type (private or public), coverage (regional, national or international), size (micro, small or large enterprise), economic activity (five different activities related with engineering areas) and organisational culture. The third category was personal information containing four indicators: age (in range of five years), university degree (graduated, Master, PhD), non-university training (none, technical, administrative, personal development areas) and gender (male, female).

The second dimension, called soft skills development, consisted of ten categories associated with one particular soft skill selected due to its high worth. Each category was divided between two to eight indicators for a 54 total. The number of indicators depended on the complexity of the soft skills (Table 1). Each indicator involved one self-assessment question about the soft skills development level and was related with the acting manner in everyday professional life situations. Questions used a 5-point Linkert scale (1- hardly ever, 2 - sometimes, 3 - usually, 4 - almost always, 5 - always). Table 1 shows the proposed indicators of soft skills, and some bibliographic references taken into account to clarify the concepts.

Table 1: Soft skills development indicators in the second dimension and relevant references to clarify the concepts.

Indicators	Reference
Responsibility: R1. Take responsibility for the problem that affects others; R2. Take action despite the circumstances; R3. Reflect on causes for which results are not obtained; R4. Actively participate in solving situations that involve others; R5. Change points of view to get results; R6. Awareness of their actions and their impact on others.	[12]
Integrity: I1. Consider the effects of professional practice; I2. Act according to self-values; I3. Continue or withdraw from projects according to self-values; I4. Prioritise win-win actions.	[2][3]
Humility: H1. Express views calmly; H2. Learn from each other; H3. Provide help without hesitation; H4. Admit mistakes publicly.	[12]
Critical thinking: T1. Make effective decisions; T2. Ability to prospect.	[2-4] [13][14]
Communication: C1. Lead others to understand the impact in a conflict situation; C2. Express opinions and intentions clearly, honestly and respectfully; C3. Use and interpret non-verbal language; C4. Listen without interrupting and check understanding; C5. Identify emotions of others in difficult conversations; C6. Speak from the facts and logical arguments; C7. Effective public presentation/discussion; C8. Effective writing.	[3][8], [12][15], [16]
Negotiation: N1. Preparation of the physical site for negotiations; N2. Realise the emotional and temporal disposition of the counterpart; N3. Be clear about the possible worst result to obtain; N4. Give space for discussion to understand the situation; N5. Result of the negotiation where everyone is satisfied; N6. Escalation to higher authorities when the negotiation is not effective.	[12][17]
Action co-ordination: A1. Effective requests; A2. Attempt negotiations before default; A3. Effective claim; A4. Indicators agreed before follow-up; A5. Effective recall of engagement during a follow-up; A6. Regular team recognition; A7. Public recognition highlighting impacts at different levels.	[12]
Emotional competence: E1. Resolve situations calmly and keep the emotional balance; E1. Ease of working under pressure; E2. Understanding and emotional management; E3. Express emotions without toxicity; E4. Accept and find out the emotional causes of each other; E5. Ability to calm intense team situations.	[6][7] [9-12] [15]
Leadership: L1. Easy to influence a team; L2. Manage the acceptance of the team faced with new proposals; L3. Easy role change (leader-follower); L4. Ease of influencing leaders; L5. Co-ordination of actions based on mutual support; L6. Promote values within the team.	[2][3][8] [15][18]
Entrepreneurship: B1. Risk level analysis in a project; B2. Ease of seeking and relying on others or in support networks; B3. Systemic analysis of a project; B4. Ability to generate new opportunities, products or processes; B5. Creative problem solving; B6. Resilience.	[1-3][8] [17][18]

To assure the validity of the survey, three experts, a PhD in statistics, a Master's degree holder in education plus a life coach, and a Master's degree holder in administration, evaluated the validity of the survey with a positive result. Cronbach's alpha coefficient was used to calculate the reliability in groups of a maximum of 20 indicators. The average value was $\alpha = 0.88$, indicating its good internal consistency. The bilateral Kolmogorov-Smirnov test for the 54 indicators was used to evaluate the statistical parametricity of data, resulting in a significance less than 0.05 (p-value < 0.05) in all cases, which means that the data are both non-normal and non-parametric. For data analysis, non-parametric statistical tools such as the Kruskall-Wallis test/one-way ANOVA and Spearman's correlation coefficient were applied using SPSS 23.

Based on the results found in this research and explained below, an interview was conducted with five specialists including a life coach, ontological coach, neuro-linguistic programmer, leadership trainer, one of PSYCH-K® facilitators who work with companies and offer soft skills training. They had more than 2,000 hours in the interview room. The interviewer asked about the pedagogical model applied in this type of training.

RESULTS

Voluntarily 81 mechanical engineering graduates from Pamplona University, Colombia, took part in this research through an on-line Google questionnaire in 2019. As the total number of graduates was 210, the calculated error and reliability were 8% and 95%, respectively. Women accounted for 6.3% and men for 93.8% of the participants. In regard to a university degree, the majority of participants (63%) had graduated, a quarter of them (25%) were specialised, and only a minor share (11.3%) had a Master degree. None of the participants had a PhD degree. All 14 demographic dimensions were contrasted against 54 soft skills development indicators (Table 1) by the Kruskal-Wallis/ANOVA test to determine which of them exhibit a difference in its median; in other words, which demographic shows a statistically significant influence on the soft skills development indicators.

Table 2 shows only the soft skills development indicators with a significance value less than 0.05 ($p < 0.5$) by Kruskal-Wallis/ANOVA. *Training* (21) and *Experience time* (14) are the two demographic indicators that exhibit the most significant number of soft skills development indicators; between them, *Training* is the most important. Furthermore, the Spearman correlation coefficient was calculated to identify the correlation of indicators exhibiting influence. Table 2 shows the soft skills development indicators with a weak Spearman correlation coefficient ($Rs < 0.29$) in black colour and moderate ones ($0.3 < Rs < 0.49$) in red colour. The last table row summarises the quantity of soft skills indicators influenced by each demographic aspect.

Table 2: Kruskal-Wallis/ANOVA for soft skills development indicators versus demographic aspects.

Demographic indicators	Job characteristics					Enterprise characteristics					Personal information		
Soft skill development indicators	Function	Range	Experience time	Level	People in charge	Type	Coverage	Size	Activity	Culture	Academic degree	Training	Age
Responsibility	R1 R4	R3		R2		R4	R4		R2			R4	R5
Integrity	I4		I2 I3 I4							I1			
Humility		H1	H1 H2									H1	H1
Critical thinking	T2					T2							
Communication	C4	C4	C7 C8	C4 C8	C4	C2 C8	C6			C4		C3 C7 C8	C8
Negotiation	N1 N3 N5			N1				N1	N3			N1 N2 N3 N5	
Action co-ordination	A7		A1 A3 A7	A2		A7	A1						A8
Emotional competence			E2 E5			E1 E2 E3					E1 E2 E4 E5	E2	
Leadership		L2	L2 L4	L2		L1	L2 L3 L4			L2		L1 L2 L4 L5 L6	L1
Entrepreneurship		B1 B3 B5		B3		B1 B3 B4 B5			B1			B1 B2 B3 B4 B5 B6	B2 B4 B5 B6
Total	9	7	14	7	1	9	9	2	3	3	4	21	9

Q1. Which aspects are relevant in increasing softs skills development?

Training is the most significant indicator for developing the soft skills level. It correlates with 21 indicators, 16 with a moderate Spearman correlation and five with weak ones. Indicators that exhibit a moderate Spearman coefficient are correlated with entrepreneurship, leadership, negotiation and communication skills. It is essential to highlight that although other indicators help develop soft skills, such as experience time, age, type of company and coverage, their influence is relatively low, and these indicators are not controllable by the person. Therefore, they cannot be trained through educational activities.

According to several authors cited above, university education develops a limited number of soft skills, and also some findings indicate that only emotional competence is developed in this case. This research shows that soft skills can be trained if the pedagogical models that use *training* are reviewed, replicated and/or adjusted and included in the curriculum.

Also, in the survey, *Training* included four types of possibilities: personal development (including leadership, team working or assertive communication), administrative (involving sales, management or project), technical or none (Table 1). A Games-Howell post-hoc test was carried out on the 16 indicators, which exhibit a moderate Spearman correlation

coefficient to define how the *Training* indicator influenced the development of soft skills. The results are presented graphically in Figure 1. The analysis of each soft skill is explained as follows.
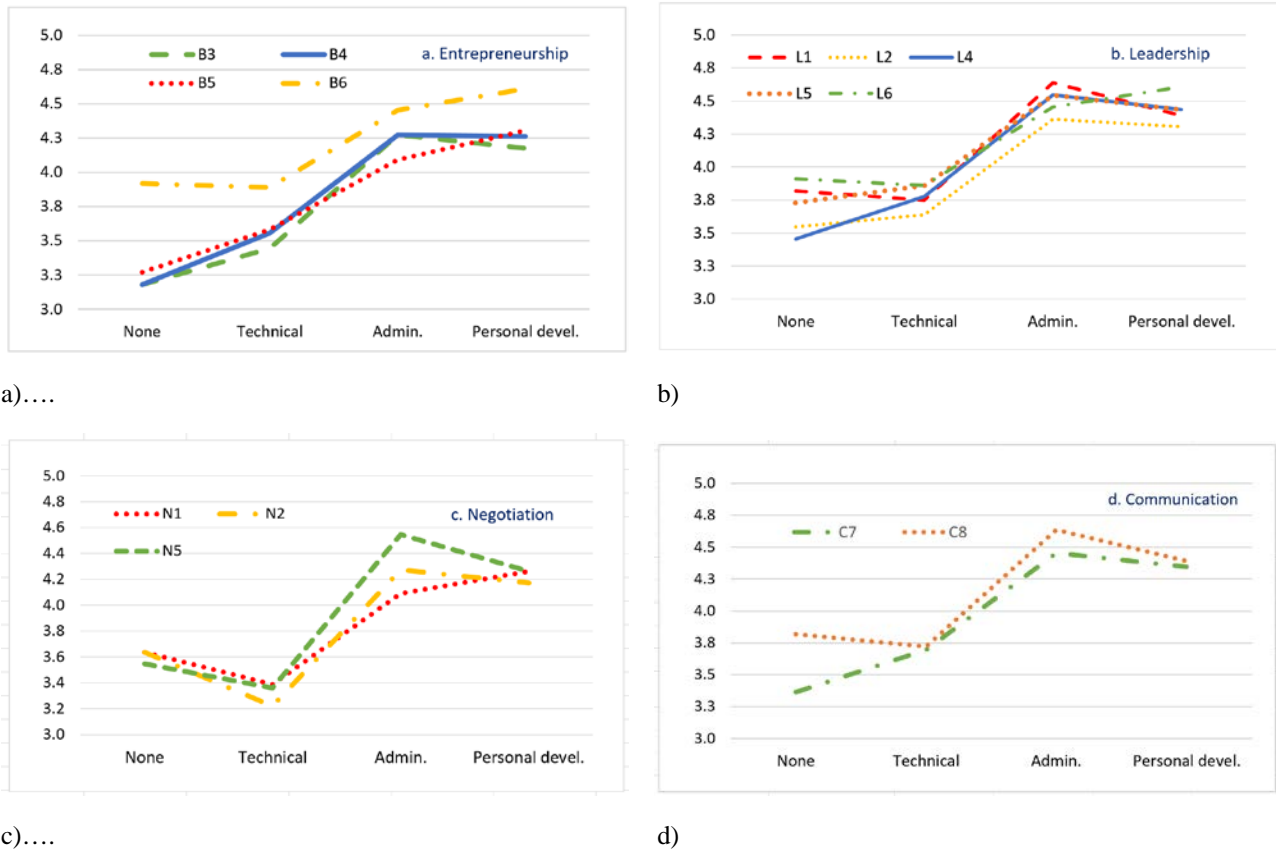

a)….

b)

c)….

d)

Figure 1: Comparison between selected soft skills development indicators and the *Training* indicator.

Entrepreneurship: All six entrepreneurship indicators (Table 2) show a Spearman correlation with *Training*, but only four show a value between 0.3-0.49, indicating a moderate and positive correlation. Using the Games-Howell post-hoc statistical measure (Figure 1a), it was possible to observe the following remarkable points. The more significant development was on (B6) *Resilience* than the other indicators. Training in personal development and/or administrative areas develop entrepreneurship indicators: (B3) *Systemic analysis of a project*, (B4) *Facility to generate new opportunities, products, or processes*, (B5) *Creative problem solving*, (B6) *Resilience*, much more than those in technical areas or no training (none). There is the same low entrepreneurship soft skills level if both, technical or no training (none) is carried out. If both, personal development or administrative training are carried out, entrepreneurship increases the same level.

Leadership: The results for the Spearman correlation coefficient between training and leadership indicators showed five indicators out of six with moderate and positive values (Table 2). Using the Games-Howell post-hoc statistic (Figure 1b), it was possible to conclude that training in personal development and/or administration demonstrated more remarkable development in all leadership indicators than the technical ones or not doing any. Training in personal development slightly develops (L6) *Promote values within the team* compared to administrative ones. The indicators related to (L1) *Easy to influence a team*, (L2) *Manage the acceptance of the team faced with new proposals*, (L4) *Ease of influencing leaders*, (L5) *Co-ordination of actions based on mutual support* are developed at the same level with administrative or personal development training. There is no difference between not doing any training and technical training related to soft skills development.

Negotiation: Four indicators for negotiation out of six exhibit a Spearman correlation related with *Training* (Table 2). One of them showed a weak Spearman correlation coefficient, but the other three are moderate. To further analyse the correlations of these indicators, the Game-Howell post-hoc test was performed (Figure 1c). It is evident that *Training* in both areas, personal development or administrative, promote greater growth in the following aspects: (N1) *Preparation of the physical site for negotiations*, (N2) *Realise the emotional and temporal disposition of the counterpart* and (N5) *Result of the negotiation where everyone is satisfied*. Training in technical areas or none developed the same, low-level soft skills. Training in administrative areas has a slightly higher development than those in the personal development ones for N5.

Communication: Although this skill has only two indicators with a moderate and positive Spearman correlation - of the eight indicators that make it up (Table 2), it is essential to analyse them since communication is one of the skills widely mentioned in the literature as a key requirement in professional life and one of the most demanded from graduates in

an organisation. From the Games-Howell post-hoc test (Figure 1d) performed on these two indicators, it can be seen that *Training* in the area of personal or administrative development brings a more significant development in the communication skill related to (C7) *Effective public presentation/discussion* and (C8) *Effective writing* than *Training* in technical areas or no training (none). Training in the technical area has more significant impact on C7 than not doing any certification. C8 is not developed with technical certifications and is at the same level as those without any certification. C7 and C8 are indeed slightly more empowered, with management certifications, compared to personal development.

Q2. How to incorporate soft skills development into an engineering curriculum?

Low development of soft skills was determined in the mechanical engineering programme at Pamplona University, Colombia. In view of that, it is essential to reorient the policies and content of the programme, to make it more competitive, taking into account that companies recognise the importance of developing soft skills. In this way, it can include mandatory units (subjects, courses, seminars) to develop this type of skill. They can be carried out through different pedagogical strategies applied in *Training* and measured by non-traditional methods. Generally, *Training* in the administrative and personal development area is carried out by experiential learning, transformative learning and real-life learning [19][20], with a direct application to real-life problems. The interviewed coaches unanimously defined experiential learning as applied methodology. This methodology viewed as a cycle of experiential learning is demonstrated below.
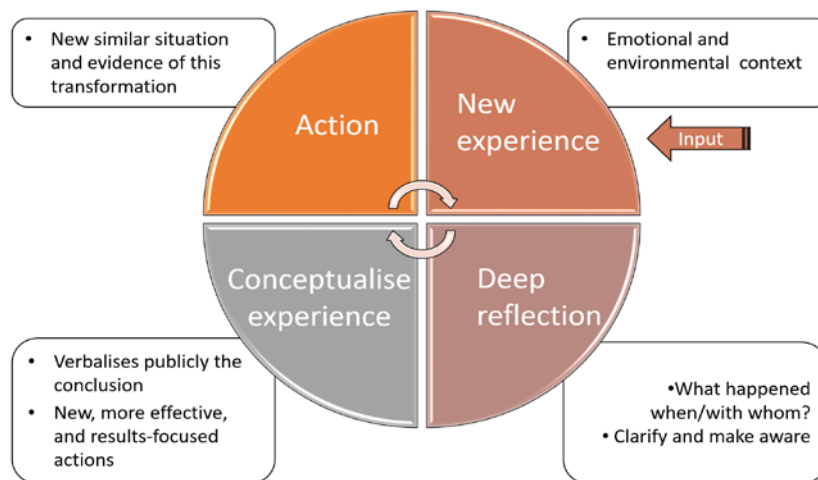

Figure 2: Cycle of experiential learning.

The principle of experiential learning is immersion in specific situations that promote internal transformations and paradigm change, which is reflected in a shift of attitudes and actions. The learning process occurs through experience/transformation following a four-stage cycle as described by Kolb [19].

In the first stage (Figure 2), the student goes through a specific new experience, activity or exercise that has been carefully designed, taking care of the emotional and environmental context in which it develops with the specific objective of overcoming any particular fear or problematic situation.

The second stage consists of a deep reflection about emotions, fears and limitations that appeared during the experience to clarify and make the student aware of how to act in this specific situation; the general question can be summarised as what happened when/with whom?

In the third stage, the student conceptualises the experience (from concrete experience to abstract conceptualisation) as an individual or as a part of the team; in doing so, the student realises new, more effective and results-focused actions can be formed and verbalises publicly this conclusion as an opinion, declaration or a point of view in the group.

The last stage involves action; the student goes through a new similar situation and demonstrate this transformation in their emotion and a new form of action. This methodology changes the role of teachers too. They must be able to act in four roles: facilitator, expert, evaluator and coach.

The role of the coach helps students to discover how to achieve their goals with the available resources and to define performance standards; it guides them during their development too.

The role of the facilitator identifies the interests, motivations, desires that students have and their prior knowledge, which helps to connect and reflect on the lived experience.

The expert's role helps students connect their reflections with concepts and knowledge, promoting critical analysis of the situations experienced.

The evaluator guides the review of the results based on the previously defined standards. The ability of the teacher to perform these different roles is essential for the success of this methodology. Since teachers are designers and facilitators of didactic situations and experts in the discipline, they guide students to apply the acquired knowledge, providing adequate and timely feedback to develop their skills.

CONCLUSIONS

Statistically, it was found that *Training* in administrative or personal development areas was the most influencing aspect in soft skills development compared to the other 13 aspects. It influences 21 indicators of the 54 researched. Likewise, *Training* significantly develops communication, negotiation, entrepreneurship and leadership.

A university degree can only develop emotional competence, and the other nine soft skills researched do not show statistical evidence of development with increasingly higher university studies. However, one way to increase soft skills development is to include training in the policies and content of mechanical engineering programmes. The development of soft skills through non-traditional pedagogical methodologies, such as experiential learning, experiential e-learning or real-life learning can reduce the significant gap between the industry's requirements and the professional skills of a graduate.

Also, university pedagogues who are engaged in soft skills training must have the relevant experience and expertise as they are expected to act in the four crucial roles: coach, facilitator, expert and evaluator. For some, it could be one of the most significant challenges because it may require additional training for them, and then the accurate application of the learned knowledge.

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