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A Framework to Enhance Women Empowerment in the Engineering Sector of Sri Lanka

J.M.J.W. Jayasinghe and M. Kesavan

Abstract: Women's representation in engineering remains notably lower than in other fields across many developing nations, including Sri Lanka. This study explores gender-based barriers and proposes strategies to enhance women's empowerment in the Sri Lankan engineering sector. The potential factors affecting women engineers were identified through literature review and expert interviews. The severity of each of these factors was evaluated in a survey with the participation of over 300 engineering professionals, revealing crucial challenges that women engineers face. Following further expert consultations, an action plan was developed and validated using an eight-step concept analysis approach. Key findings highlight that cognitive, transferable, self-management, and self-motivation skills significantly influence women's empowerment. These foundational traits also impact job competence, workplace support, and gender balance. Based on these insights, a framework was developed to guide organizations in implementing gender-sensitive policies that support women's growth in engineering. While the framework is tailored to Sri Lanka, its strategies offer insights for similar efforts in other developing countries. This study provides a roadmap for modernizing workplace practices, potentially advancing social, cultural, and economic empowerment for women engineers and setting a path toward sustainable industry transformation.

Keywords: Women empowerment, Gender equality, Developing country, Modern framework, Concept analysis

1. Introduction

The landscape of gender in education and the workforce has shifted over the past decades: women have made gains in representation, equitable pay, and recognition through awards, grants, and publications. Despite overall change, differences persist in the fields of science, technology, engineering, and mathematics (STEM). Gender gaps in STEM are evident in representation, particularly in engineering [1]. As per the Science and Engineering indicators, women make up about one-third of the STEM workforce, less than their representation in the employed US population (48%) [2]. The distribution of US women with a bachelor's degree or higher was uneven among the different types of STEM occupations, with 16% of engineers.

The cultural landscape of engineering is masculine in various ways, which can be challenging, especially for female engineers who need to match cultural expectations with their identities. Yet, among engineering educators, engineering knowledge and processes are widely thought to be gender-neutral [3]. Even though they are attracted to the field, and complete a rigorous program of studies to be prepared as engineers, something occurs to either prevent them from entering an engineering career or leave the field after they enter [0]. Cultural climate has been noted to drive female graduate engineers away from the workforce in many countries [3].

So far, several studies conducted in various countries or regions have compared the professional identities of early-career men and women engineers. Among them, Naukkarinen & Bairoh [5] aimed to understand the professional identities of newly graduated Finnish male and female engineers by analysing their perceptions of the importance and development of professional engineering skills. They analyzed the reasons for departure given by a national sample of over a thousand women engineers who left the profession after

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having worked in the engineering field. A study conducted in the United States in 2016 [4] revealed that the major factors closer to the decision to leave the organization are that women are not confident enough to be engineers, vulnerable to stereotype threats, and engage in more social coping. Women engineers may contemplate departure when they perceive their work and occupational environment as not meeting their needs, as pointed out in [5].

In a sample of European electrical cooperatives [6], women make up no more than 25% of the Boards of Directors due to the conventional responsibilities that women are expected to play in society. The assumption of women's representation in energy cooperatives that are technologically complicated is just 4% [6]. Accordingly, a stereotyped perception of gender and internalized gender prejudices are suggested in [6]. Importantly, women's empowerment includes participation in decision-making and deliberative processes as well as access to resources like clean energy [7]. It is significant to look at the study presented in [8], who investigated the energy routes as a correction by including gender studies and innovation principles based on gender perspectives and specialized energy advances that might overthrow the system. A framework was proposed in a study [8] to examine different gender perspectives on energy transition pathways, including onstream pathways that exist within the mainstream pathway, to promote equal opportunities for women and men in the energy sector. The framework of [8] was used to evaluate indigenous perspectives on the oil sands industry in Canada, the effects of large-scale renewable energy on indigenous communities in Kenya, and the transition away from fossil fuels and toward renewable technology in Spain. Importantly, the framework made it clear that the dominant male perspective was represented by mainstream paths, while the perspectives of women were mostly ignored. Lieu et al. [8] further state that such omission results in energy paths that are distant from local reality, lack public support and impede a transition to sustainable energy.

The findings of [9] support the notion that organizational efforts to create inclusive work environments that allow female engineers to balance their work-family roles and value their contributions do indeed enhance women's sense of overall attachment to the engineering field and their decision to persist in it. In short, any efforts to address women's departure from technical careers need to first take a deep look at organizational factors that play a role in occupational attachment and withdrawal decisions.

As per Sri Lanka University Statistics [10], about 65% of the undergraduates enrolled at universities and higher education institutes established under the Universities Act are females. However, in the fields of engineering, technology, architecture and computer science, male enrolment is higher, while the most significant gender imbalance exists among engineering undergraduates. The variation of undergraduate admissions to the faculties of engineering over the past 12 years is illustrated in Figure 1.

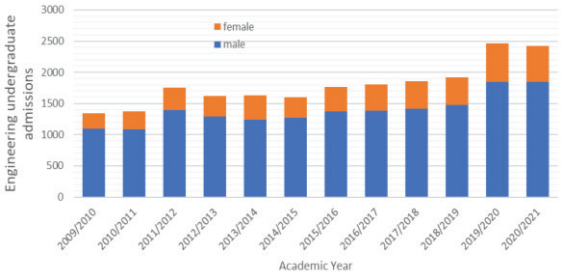


Figure 1 - Variation of annual undergraduate admissions to the faculties of engineering [10]

In Sri Lanka, females are underrepresented not only in engineering education but also in careers. However, only a limited number of research studies have been conducted to identify the gender gaps or gender issues related to the engineering profession in Sri Lanka. The first-ever island-wide survey conducted to collect information on the female engineers living and working in Sri Lanka was carried out in [11]. The sample comprised women engineers working in the industry and academia, postgraduate students, and entrepreneurs. In that survey, views of male engineers were not obtained, and gender-related issues were addressed only using a limited number of questions. On the other hand, [12] concluded that the majority of young Sri Lankan women engineers have the capacity, knowledge, skills, and capabilities to work competently in the industry with men, based on 82 responses. For that survey as well, responses were collected only from women engineers, whereas the majority of them were satisfied with their current achievements and had recommended engineering as a promising career choice for young female students in Sri Lanka. More importantly, it was recommended

that studies should be conducted with senior women engineers, engineering employers. and male engineering colleagues in Sri Lanka to expand the research literature. Further, that study highlights the unavailability of any generalized action mechanisms and logical frameworks currently practised to enhance the empowerment of women engineers in Sri Lanka and numerous other developing countries.

Given the aforementioned considerations, it is imperative that the causes for the less presence of women in the engineering sector compared to other economic sectors are to be investigated. This research has discovered an industrial knowledge gap on gender discrimination and gender-blind practices that have the potential to exacerbate gender inequality. The initial part of this research was intended to identify these crucial elements, which in turn led to the formulation of suitable suggestions for the most pressing problems and how to resolve them. Additionally, this research aims to uncover gender-responsive ways that facilitate positive outcomes and gender-sensitive provisions related to present organizational practices, leading to find better ways for the enhancement of women's empowerment in the engineering sector of Sri Lanka.

2. Methodology

The overall design of the research process flow is shown in Figure 2, that indicates the different phases of the study, showing what approaches were applied in each phase and how those phases are connected sequentially towards the development of a framework to enhance women's empowerment in engineering.

2.1 Questionnaire survey

A set of crucial elements connected to this study was determined using literature analysis, expert discussions, and cognitive interviews. In order to achieve the aims and objectives of this research, a questionnaire survey was conducted among the engineering professionals employed in various organizations located in Sri Lanka. The prepared questionnaire contained the elements connected with those research objectives, as described in Table 1, and thus included questions related to personal information and employment history as well as a five-point Likert scale and open-ended questions. Noticeably, such 35 elements were identified as crucial to the current study through discussions with seven engineering experts, including four female engineers and three male engineers. The questionnaire was arranged in the form of a Google sheet and circulated via the Institution of Engineers Sri Lanka (IESL), and the responses were collected online. The snowball sampling method, which is a non-probability method of survey sample selection that is suitable when the samples with target characteristics are not easily accessible, was used for the questionnaire survey [13]. Cognitive interviews were also conducted among some selected members in order to validate the designed questionnaire.

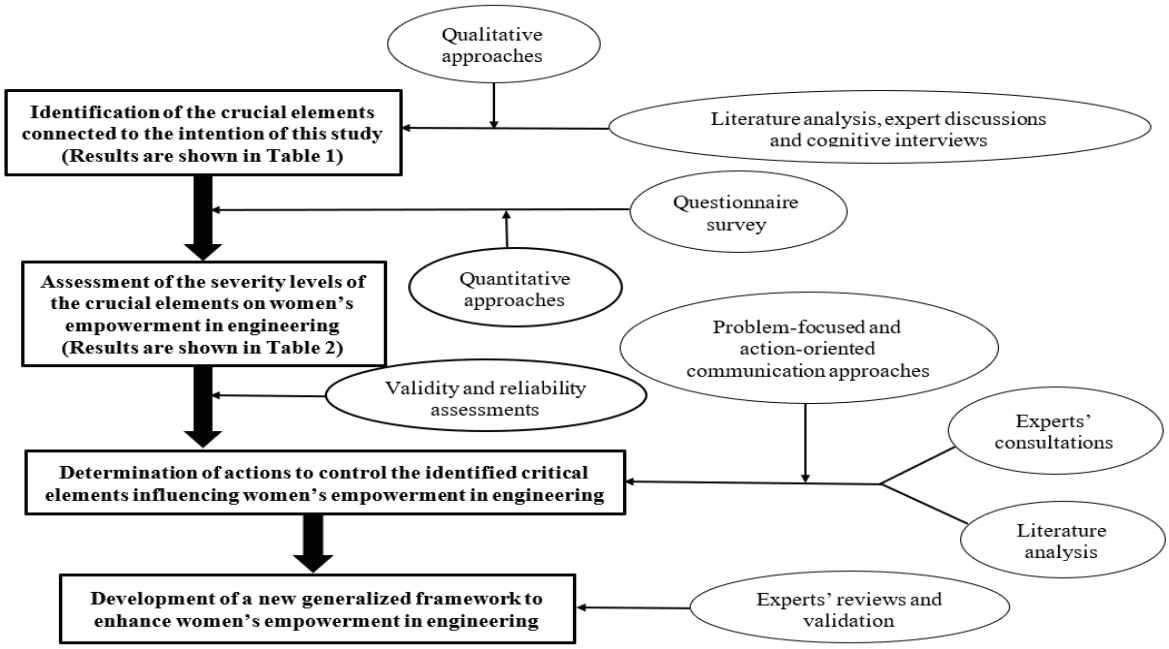


Figure 2 - Overall design of the research process flow

Table 1 - Crucial elements connected to the intention of this study

Item	Element
1	I balance my family and work.
2	Orientation session helped me start this employment well.
3	Job description/ ToR and my role/responsibility is well defined.
4	I am competent to perform my job.
5	My self-motivation and job interest are enhanced during my employment.
6	My cognitive abilities are improved during my employment.
7	My transferable skills are improved during my employment.
8	My self-management skills are improved during my employment.
9	My physical abilities are strengthened during my employment.
10	Working with engineers of the same gender as mine is more convenient.
11	I receive good guidance/support from my supervisor.
12	I receive good support from my peers.
13	I receive good support from my subordinates.
14	Networking opportunities are created by the employer.
15	I have time to speak with my co-workers (including the supervisor) closely about me, especially understanding my situation, my needs and wants, personal challenges and opportunities, my strengths and weaknesses, my achievements, etc.
16	The criterion for performance evaluation or work measurement in this organization is good.
17	My performance evaluation was adhered to the criterion and not biased/ influenced.
18	My promotions were adhered to the criterion and were unbiased/ not delayed.
19	I am satisfied about the facilities given at the work place.
20	Flexible working hours are allowed.
21	Work from home is allowed when a necessity arises from my side.
22	I am allowed to keep children at my workplace at special occasions (e.g. child is sick)
23	I received adequate training on the organization's anti-sexual harassment policy. I understand when, how and to whom I should report instances of harassment and abuse.
24	There were instances in which I faced or about to face sexual harassment.
25	I am well-aware of employment/labor law aspects that can be applied in my job.
26	I am satisfied about the vision of my career.
27	I get treated as an equal in my work place among my fellow engineering staff.
28	I get treated equally respectfully by non-engineering staff in my work place.
29	I face political interference/influence.
30	Having females in leadership positions in my work place was more successful.
31	I see role models of my gender, specialized in the same field.
32	Work long/ extended hours and site work are eliminated during pregnancy of female engineers working at our organization.
33	Transfer schemes are available for mothers.
34	Majority of the engineers at my workplace are males.
35	I am satisfied about my career progression/ achievements.

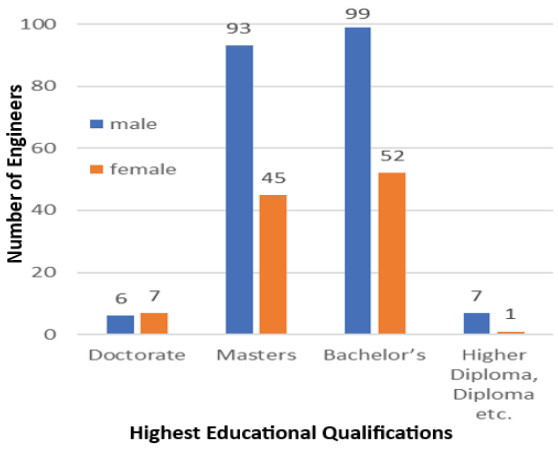
2.2 Respondent profile

After removing responses received from engineers currently working overseas, there were 310 responses, with 205 (66.1%) of the respondents male and 105 (33.9%) female. Importantly, the female respondents were asked to respond to the survey based on the practices currently experienced in their present employment. The survey respondents represented various organizations related to civil, building services, electrical, electronic, telecommunication, software, mechanical, and chemical engineering located all over the country.

Among the respondents, male engineers with a Doctorate or a Master's as the highest qualification were 3% and 45%, respectively, while the female engineers in the same sequence were 7% and 43% (Figure 3a). Among the responded male engineers, 48% and 3% had completed only the BSc Engineering degree and other relevant qualifications (Higher Diploma or Diploma), respectively. Considering the female respondents, percentages were 50% and 1%, respectively. Accordingly, the responses of male and female engineers can be considered unbiased by the level of education.

Views of the recently graduated engineers as well as well-experienced engineering professionals were collected, with about 15% of them new to the engineering sector, and about 20% having 5-10 years of experience in engineering (Figure 3b). About 38% of the respondents had 10-20 years of experience, while the rest (26%) comprised well-experienced engineers engaged in professional practice for more than 20 years.

Among the male engineering respondents, a significant number of about 78% is performing technical/engineering duties, while Academic/Teaching/Research/Analytical work is the major focus of 6% of male engineering respondents. A majority (70 %) of the female engineering respondents performed technical/engineering duties, while a considerable amount (20%) are engaged in Academia/Teaching/Research/Analytical work. The male and female engineers among the respondents whose major duty is in administration (HR Financial/ Accounting/ Policy/Law/Customer relationship) are 16% and 10%, respectively.



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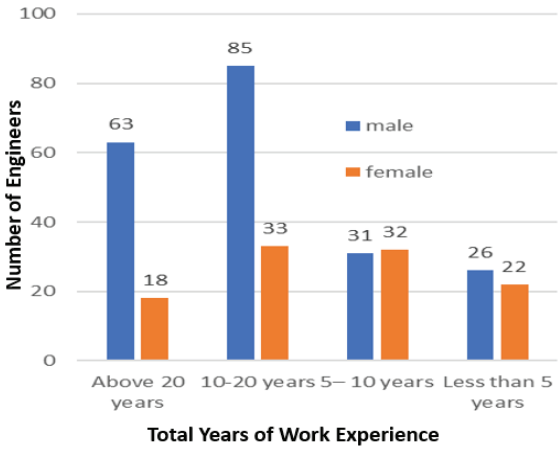


(b)

Figure 3 - Respondent profile (a) Highest educational qualification (b) Total years of work experience

2.3 Evaluation criteria

2.3.1 Relative importance index (RII)

The severity of the selected items was calculated using the relative importance index (RII) approach [14].

$$RII = \frac{\sum W}{A * N} \quad \ldots(1)$$

where

W: represents weight assigned to each factor by response ranges (1= Very low level effect [Strongly disagree], 2 = Low level effect [Disagree], 3 = Moderate level effect [Neither agree nor disagree], 4 = High level effect [Agree], 5 = Very high level effect [Strongly agree])

A: represents the maximum weight given (A = 5)

N: represents the total number of responses for each factor

According to the guidelines provided in [14] for the use of the RII method, the levels of effect (LEs) with the RII value range are presented in Table 2.

Table 2 - Level of effect with the RII value

RII value	Level of effect
RII >= 0.9	Very high (VH)
0.9 > RII >= 0.8	High (H)
0.8 > RII >= 0.7	High – Moderate (HM)
0.7 > RII >= 0.6	Moderate (M)
0.6 > RII >= 0.5	Moderate – Low (ML)
0.5 > RII >= 0.3	Low (L)
0.3 > RII	Very low (VL)

The increased RII value shows that the component has a significant and high influence. Noticeably, the critical items have RII ratings of 0.7 or above. Standard Deviation (SD) and Coefficient of Variation (CV) values were also determined for each element to ensure the validity and reliability of the results associated with the severity of the elements. The lower SD shows that the respondents' values are in the general area of the mean values. According to [14], CV is referred to as the relative standard deviation, and it is the ratio of SD to the mean.

2.3.2 Spearman's rank correlation coefficient

The degree of agreement between male and female respondents on the indicated factor or items was determined using Spearman's rank correlation coefficient. The degree of agreement levels can also be used to evaluate the inter-rater reliability of the results associated with the severity of the elements. According to the instructions given in [15], this was estimated using the formula shown below.

$$\rho = 1 - \frac{6\sum D^2}{n(n^2-1)} \quad \ldots(2)$$

where ρ is Spearman's rank correlation coefficient, D is difference between the ranks of two variables, and n is number of observations.

According to guidelines offered in [16] on the application of the aforementioned formula, the effects of Spearman's rank correlation coefficient value range can be determined, as Positive degree of agreement (positive relationship) when ρ > 0, Neutral (No correlation) when ρ = 0, and Negative degree of agreement (Negative relationship), when 0 > ρ.

2.4 Experts' consultations

Meetings and discussions were carried out among ten experts in order to determine suitable actions to control the identified critical elements influencing women's empowerment in engineering based on the assessment results. Importantly, problem-focused and action-

oriented communication approaches were used throughout these consultation meetings and discussions. All the experts recruited for these consultation meetings/discussions had more than 5 years of work experience in the engineering field, whereas the majority of them had nearly 10 years of experience. Noticeably, all the experts had a minimum of Bachelor's degree qualification in engineering, whereas more than half of them had a Master's degree or above level qualifications. It should also be noted that 40% of the experts were from the civil engineering discipline, 30% from the electrical and electronic engineering discipline, and the remaining 30% represented computer, mechanical and chemical engineering disciplines. Further, male and female representation was equal among the recruited experts for the consultation meetings/discussions. These experts' consultations continued up to the development of a new generalized framework to enhance women's empowerment in engineering, according to the determined actions of controlling the impacts of the identified critical elements.

2.5 Experts' reviews

The validity and reliability of the application of the developed framework were evaluated by a panel of six experts consisting of three academic members and three industry professionals. It should also be noted that all the experts had minimum Masters level degree qualifications and more than ten years of work experience, whereas the male:female representation was 1:2 in the panel. Further, it was notable that the panel included three experts from the engineering discipline, and the remaining three were from non-engineering disciplines, such as medical, social science and management sectors. This review process was performed based on the eight-step approach of concept analysis method introduced in [17]. Although there are numerous concept analysis approaches, this concept analysis method was chosen for the purpose of this study since it is perceived to be the most widely applied for assessing contemporary and fundamental concepts in multi-disciplinary areas. As recommended in [19], the eight steps that make up the Walker and Avant framework are covered, as shown in Figure 4.

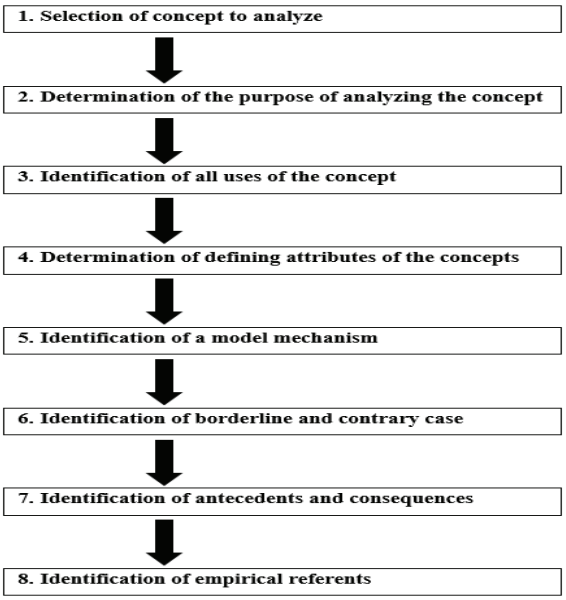


Figure 4 - Eight-steps of the concept analysis method of Walker and Avant framework [17]

In applying the eight-steps of the concept analysis method, the functional mechanism of the proposed framework (See Figure 7) was examined. In this process, the well-enhanced empowerment of women engineers was the major purpose of the proposed mechanism expected to be achieved. The literature highlights how the concept is used and understood defining the attributes that are essential to the concept mechanism. Accordingly, model cases were constructed, borderlines were determined, and antecedents and consequences were identified, leading to the classification of the results, direct outcomes and indirect outcomes, as shown in Figure 7. The descriptions are discussed in Section 4. Discussion and recommendations for actions specify how the proposed concept can be observed and assessed in real-world situations.

3. Results

As per the survey results, the most important factor for choosing engineering employment is professional development opportunities irrespective of gender, according to 66% of male engineers and 77% of female engineers (Figure 5). The second most motivational factor is salary, as stated by 56% of male engineers and 36% of female engineers. Around 36% of male respondents considered the distance to the workplace when selecting the current engineering employment, while only 26% of females considered that factor. About one-fifth (22%) of the female engineers had considered the women-friendly facilities when choosing the employment.

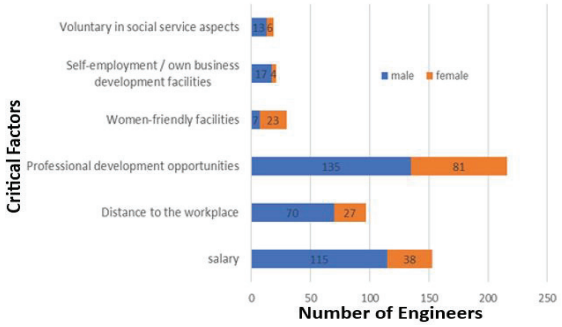
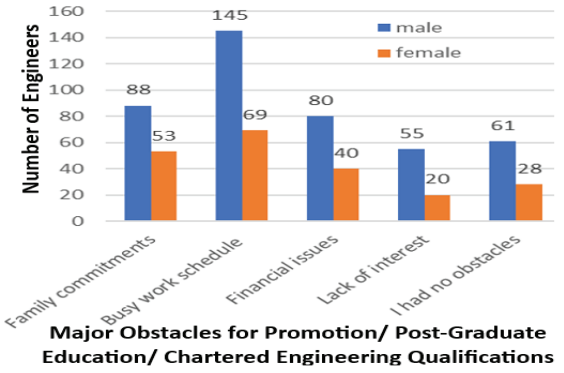


Figure 5 - Major factors considered in choosing the current employment

Most of the engineers faced obstacles in obtaining promotions, post-graduate education, or chartered engineering qualifications (Figure 6a). The most significant obstacle is busy work schedules, as mentioned by about 70% of the respondents. Half of the women engineers and 43% of male engineers stated that family commitments were obstacles. About 38% of the respondents faced financial issues in continuing their higher education and professional development.

After getting employed, 93% of the women engineers and 81% of the male engineers were supported by their parents, enabling them to focus on their careers (Figure 6b). Though 88% of the male engineers were supported by their spouses, only 73% of the women engineers were supported by their husbands. Half of the respondents got the support of domestic helpers and relatives as well.

About 56% of the women engineers were unemployed, on no-pay leave or on half-pay leave for family-related reasons, while 41% of their male counterparts experienced the same (Figure 6c). The rate of unemployment was equally distributed with no gender bias. A higher percentage (17%) of women engineers were on no-pay leave in contrast to only 13% of male engineers. The number of female engineers on half-pay leave was double that of their male counterparts, indicating maternity leave.



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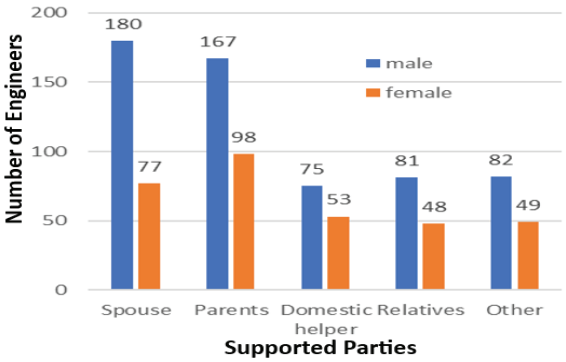

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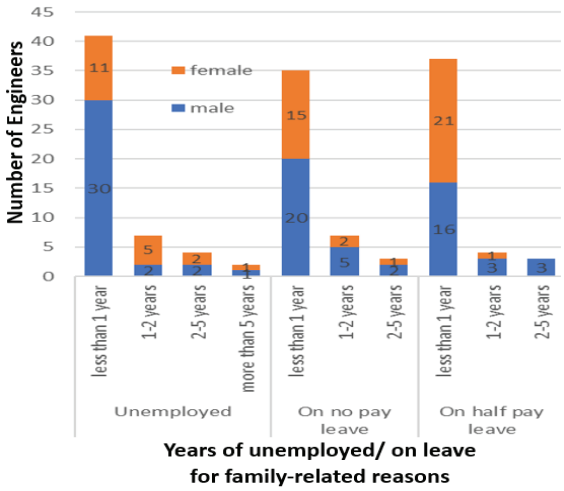

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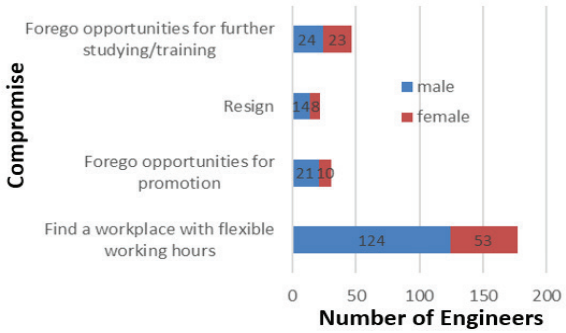

(d)

Figure 6 - Information related to work-life balance (a) major obstacles for promotion/ post-graduate education/ chartered engineering qualifications (b) supported parties (c) History of being unemployed/ on leave for family-related reasons (d) compromise

In the questionnaire survey, it was asked what kind of compromise they would adopt if they had to spend more time on family unexpectedly (Figure 6d). Finding a workplace with flexible working hours was the most popular solution, voted by 60% of males and 50% of females. Forgoing opportunities for further studying or training is the compromise selected by 22% of the women engineers, while 12 % of male engineers agree with that. Resigning and forgoing opportunities for promotion are selected respectively by 7.5% and 10% by the rest of the sample, irrespective of gender. Besides, the severity level of each item was determined for males and females separately (Table 3) as well as for the entire respondent population (Table 4).

Table 2 - Severity levels of elements based on different perspectives

Item	Female						Male						d^2
	Mean	SD	RII	CV	LE	Rank	Mean	SD	RII	CV	LE	Rank	
1	3.97	0.19	0.79	0.05	HM	8	3.89	0.21	0.78	0.05	HM	11	9
2	3.21	0.10	0.64	0.03	M	28	3.33	0.14	0.67	0.04	M	26	4
3	3.46	0.12	0.69	0.04	M	20	3.55	0.15	0.71	0.04	HM	22	4
4	4.41	0.25	0.88	0.06	H	1	4.38	0.25	0.88	0.06	H	1	0
5	4.07	0.18	0.81	0.04	H	5	4.16	0.21	0.83	0.05	H	4	1
6	4.10	0.20	0.82	0.05	H	4	4.03	0.24	0.81	0.06	H	6	4
7	4.34	0.27	0.87	0.06	H	2	4.21	0.23	0.84	0.06	H	2	0
8	4.28	0.25	0.86	0.06	H	3	4.20	0.23	0.84	0.05	H	3	0
9	3.65	0.14	0.73	0.04	HM	14	3.59	0.13	0.72	0.04	HM	20	36
10	3.33	0.12	0.67	0.03	M	26	3.26	0.10	0.65	0.03	M	27	1
11	3.90	0.15	0.78	0.04	HM	10	3.85	0.19	0.77	0.05	HM	13	9
12	3.96	0.22	0.79	0.05	HM	9	3.91	0.23	0.78	0.06	HM	8	1
13	4.07	0.27	0.81	0.07	H	5	3.97	0.25	0.79	0.06	HM	7	4
14	3.65	0.17	0.73	0.05	HM	14	3.63	0.17	0.73	0.05	HM	17	9
15	3.90	0.23	0.78	0.06	HM	11	3.83	0.20	0.77	0.05	HM	14	9
16	3.42	0.11	0.68	0.03	M	23	3.37	0.16	0.67	0.05	M	25	4
17	3.64	0.15	0.73	0.04	HM	16	3.60	0.16	0.72	0.04	HM	18	4
18	3.39	0.10	0.68	0.03	M	24	3.42	0.13	0.68	0.04	M	24	0
19	3.36	0.10	0.67	0.03	M	25	3.58	0.16	0.72	0.05	HM	21	16
20	2.93	0.02	0.59	0.01	ML	29	3.20	0.09	0.64	0.03	M	29	0
21	2.85	0.03	0.57	0.01	ML	30	3.10	0.09	0.62	0.03	M	30	0
22	2.72	0.12	0.54	0.04	ML	32	2.75	0.11	0.55	0.04	ML	33	1
23	2.68	0.09	0.54	0.03	ML	33	2.87	0.05	0.57	0.02	ML	32	1
24	2.03	0.17	0.41	0.08	L	35	1.79	0.21	0.36	0.12	L	35	0
25	3.26	0.12	0.65	0.04	M	27	3.52	0.16	0.70	0.04	HM	23	16
26	3.64	0.15	0.73	0.04	HM	16	3.73	0.18	0.75	0.05	HM	16	0
27	3.67	0.15	0.73	0.04	HM	13	3.91	0.22	0.78	0.06	HM	8	25
28	3.80	0.17	0.76	0.04	HM	12	3.90	0.22	0.78	0.06	HM	10	4
29	2.42	0.11	0.48	0.05	L	34	2.60	0.09	0.52	0.03	ML	34	0
30	3.44	0.19	0.69	0.05	M	22	3.01	0.20	0.60	0.07	M	31	81
31	3.63	0.13	0.73	0.04	HM	18	3.60	0.19	0.72	0.05	HM	19	1
32	3.45	0.14	0.69	0.04	M	21	3.75	0.16	0.75	0.04	HM	15	36
33	2.74	0.09	0.55	0.03	ML	31	3.22	0.14	0.64	0.04	M	28	9
34	4.05	0.20	0.81	0.05	H	7	4.09	0.22	0.82	0.05	H	5	4
35	3.58	0.14	0.72	0.04	HM	19	3.85	0.20	0.77	0.05	HM	12	49
$\sum d^2 = 342$ Spearman's rank correlation = 0.952 Degree of agreement / relationship = Positive, Very High													

Table 3 - Severity levels of elements in overall category

Item	Mean	SD	RII	CV	LE	Rank
1	3.92	0.20	0.78	0.05	HM	9
2	3.29	0.13	0.66	0.04	M	26
3	3.53	0.14	0.71	0.04	HM	21
4	4.39	0.25	0.88	0.06	H	1
5	4.13	0.20	0.83	0.05	H	4
6	4.05	0.22	0.81	0.06	H	6
7	4.26	0.24	0.85	0.06	H	2
8	4.23	0.24	0.85	0.06	H	3
9	3.61	0.13	0.72	0.04	HM	19
10	3.28	0.10	0.66	0.03	M	27
11	3.87	0.17	0.77	0.04	HM	10
12	3.93	0.23	0.79	0.06	HM	8
13	4.00	0.25	0.80	0.06	H	7
14	3.64	0.17	0.73	0.05	HM	17
15	3.85	0.21	0.77	0.05	HM	12
16	3.38	0.14	0.68	0.04	M	25
17	3.62	0.15	0.72	0.04	HM	18
18	3.41	0.12	0.68	0.03	M	24
19	3.50	0.14	0.70	0.04	HM	22
20	3.11	0.06	0.62	0.02	M	29
21	3.02	0.06	0.60	0.02	M	31
22	2.74	0.11	0.55	0.04	ML	33
23	2.81	0.05	0.56	0.02	ML	32
24	1.87	0.19	0.37	0.10	L	35
25	3.43	0.14	0.69	0.04	M	23
26	3.70	0.17	0.74	0.05	HM	15
27	3.83	0.19	0.77	0.05	HM	13
28	3.87	0.20	0.77	0.05	HM	10
29	2.54	0.09	0.51	0.04	ML	34
30	3.15	0.19	0.63	0.06	M	28
31	3.61	0.17	0.72	0.05	HM	19
32	3.65	0.15	0.73	0.04	HM	16
33	3.06	0.11	0.61	0.04	M	30
34	4.08	0.21	0.82	0.05	H	5
35	3.76	0.18	0.75	0.05	HM	14

Accordingly, facts like competencies to perform jobs, cognitive abilities, transferrable skills, self-management skills, self-motivation and job interest, the type of support received from subordinates and the majority of male compositions in the workplace were determined to highly influence the empowerment of engineering women in Sri Lanka. Other critical elements that have significant influences (moderate to high level) were found to be balancing family and work, job description, working hours, physical abilities, site works during pregnancy, terms of reference, the guidance received from the supervisory staff, the support received from the peers, networking opportunities, the way of communication linkages and relationships with co-workers, the communication patterns of fellow engineering staff, work practices of non-engineering staff, performance evaluation practices, job roles and responsibilities, career vision, progression and achievements, and the work environment/facilities.

As per the results shown in Table 3 and Table 4, the viewpoint of males or females did not significantly deviate from the overall category. Only noticeable difference can be noted between those two perspectives on the item in relation to having females in leadership positions. Spearman's correlation values assure a positive relationship on the degree of agreement between the male and female respondents at a very high level. This confirms that there are not many differences in the viewpoints between the male and female respondents on the factors/elements related to women's empowerment in the Sri Lankan engineering sector. This ensures the inter-rater reliability of the results mentioned above. In addition, CV values fall under 0.1 under all categories and items, assuring the reliability and precision of the findings discussed above. Based on the range of CV values mentioned in [18], the results of this category were determined as potentially useful for the purpose of this study.

4. Discussion and Recommendations

Based on the above-highlighted results, the experts' consultation outcomes emphasize the critical need to upgrade current awareness practices focusing on women's competence associated with cognitive, transferrable, self-management and self-motivation characteristics. Cognitive abilities are known as the fundamental mental skills that the brain requires for thought, learning, memory, reasoning and focus [19]. The work qualities that can be transferrable from one employment to another are known as transferable characteristics [20]. The capacity to regulate one's thoughts, feelings and behaviors is known as self-management characteristics [21]. In order to attain better outcomes for such women engineers' competency characteristics, the work processes must provide a wide range of procedures that need to be prioritized with self-directed activities and high-level autonomies. Additionally, it is critical to ensure that female engineers perform effectively in both familiar and new environments with a broad knowledge incorporating theoretical concepts and analytical interpretation of information.

Taking on the cognitive abilities of Sri Lankan women engineers, the experts' consultations and the literature analysis [22] spotlight that paying more attention to enhancing the attributes of women engineers associated with innovative thinking and analytical aspects will lead to making them more precise in their job process, whereas their technical-based and scholastic attribute characters can fall under less importance category. They must be inquisitive about both the present and the future phases of their work processes in order to be creative, and it is important that they ask open-ended questions to elicit knowledge rather than making snap decisions about what will or will not work. It is crucial that the practice of asking insightful questions spark creative thought. Enhancing their ability to actively listen will also enable them to discover fresh concepts and answers. As stated by [23], it is important for women engineers to make time in their daily lives to venture outside their comfort zones and typical routines. They will be better able to view a clear picture and come up with original solutions when they take chances and take a step back from what has already been done. Further, the experts' consultations highlight that the women engineers' attributes in the application of conceptualized theories are very poor in many developing countries similar to the Sri Lankan context due to the influences of other numerous elements shown in Table 1. It is vital to make women engineers feel that a concept that is developed and put into action in real-world situations is of greater significance than one that remains purely theoretical.

When it comes to transferrable characteristics of women engineers in Sri Lanka, experts' consultations and literature analysis [24] point out leadership, planning, multiple work coordination, management/administrative characters, teamwork, and communication abilities as the critical elements where special attention needs to be paid. Experts' consultations further state that most Sri Lankan women engineers do not come out from their own circle to take leadership roles in industry-based or community-based activities. More leadership training sessions should be organized for women engineers to tackle their lack of attitude in taking leadership and voluntary roles. Such apprenticeships should focus on enhancing the abilities of women engineers in recognizing the critical aspects, pointing out critical issues, directing and motivating co-workers in the proper direction, accepting self-responsibility for promptly and authentically sharing information, communicating the information to others effectively, being aware of others' needs and expectations, managing tasks to improve performance outcomes, being aware of one's obligations regarding social and environmental aspects and their attractiveness in routine activities. As emphasized by recent studies [24], the leadership qualities of women in work processes can be further strengthened by their observance of temperance and patience, their ability to discern the motives and conjectures in difficult situations, their self-dedication and bold actions, their capacity to work without stress or frustration and their time management and planning skills. In addition, considering the importance of each person understanding that a good team consists of several hands with one mind, the teamwork abilities of women engineers are other key transferrable characteristics influencing their empowerment. Being aware of the distinction between working as a team and an individual, respecting human needs, feelings, and expressions, talking with teammates to get their input on decisions, sharing knowledge and experiences from the past with teammates, developing a self-attitude of giving up for teammates, being someone who takes pride in the accomplishments of others, developing self-coordinating skills to complete tasks as a team, developing self-abilities to compromise with others and express the team spirit and creating opportunities for teammates, are the ways for enhancing teamwork characteristics [25]. Apart from these, the communication attributes of women engineers are the other transferrable competency elements where proper attention should be paid by the organizations in order to lay a bridge between confusion and clarity in their workflows. As emphasized in [25], the regular communication styles of women in engineering can be enhanced by maintaining good eye contact and facial expressions, thinking before speaking, speaking confidently, considering other people's perspectives, not interrupting others while they are speaking, maintaining a smile throughout, speaking in a loud but not too soft tone, and not changing the subject frequently when someone is showing interest.

When considering the self-management characteristics of Sri Lankan women engineers, experts' consultations highlight that decision-making, critical reasoning, problem-solving, punctuality, participation, work commitment,

and their ability to adapt to changes in environments are the key elements that need to be enhanced during their employment. Making wise decisions requires striking a balance between analytical and intuitive thinking. As stated in [26], better self-management policies that enable women engineers to make precise decisions in their process can be achieved by having them consider whether they are the right person to make a particular decision, gathering and properly analyzing the necessary information before making a decision, being aware of the expected outcomes in their decision-making process, asking themselves multiple times (if they have identified the right things to act upon) and re-evaluating the crucial issues in their decision-making process after consulting with experts. On the other hand, the critical thinking abilities of women engineers will be strengthened by their increased attention to detail, constant awareness of their surroundings, ability to discuss important issues with others and comprehend the viewpoints of various parties, capacity to choose the best course of action and constant consideration of their methods in light of their applicability and practicality in real-world scenarios [27]. Besides, the experts' consultations highlight that most of the Sri Lankan women engineers fail to behave in attempting to tackle an issue at its source to prevent it from arising again. Achieving the necessary level of knowledge with enhanced critical thinking, adhering to the correct protocols and guidelines in their work tasks, being eager to apply their knowledge and skills in their work tasks, being constantly mindful of the potential for human error in work tasks, comprehending the nature and scope of the problems, asking repeated questions to determine the precise causes of the problems, discussing the issues with their supervisors to identify potential solutions, taking into account the applicability of the solutions to actual situations and evaluating their procedures in light of the wealth of their organizations and other sectors are the key self-management approaches that need to be added into problem-solving characters of Sri Lankan women engineers. Moreover, working hard and maintaining a positive attitude is much required from the women engineers in Sri Lanka to adapt their self-characteristics to the changes in new work environments. As per the experts' consultations, recognizing the new challenges that need to be overcome, exuding confidence and adopting mental fitness, comprehending their roles and responsibilities in the workplace, abstaining from pointless activities and negative events, maintaining good relationships with their coworkers, encouraging them to do good deeds and reevaluating their procedures in light of their own prosperity and satisfaction are the self-practices that need to be carried out by the women engineers in Sri Lanka to reinforce their self-characteristics in light of changes in new work environments.

Experts' consultations spotlight that poor punctuality aspects of women in engineering have resulted in many negative impacts on their career advancement in many developing countries, indicating a signal to employers that women engineers have self-control problems. Self-planning and self-preparation are the keys to punctuality [28]. First and foremost, female engineers need to understand exactly what benefits they will have when they overcome their tardiness. Making being on time a habit can allow them to lessen tension at work and conflict with their coworkers. They need to ensure that their daily schedule is reasonable and that they only agree to complete the tasks that they can reasonably complete in a timely manner.

Experts' consultations reveal that some of the Sri Lankan women engineers' self-motivation and work commitment levels are inadequate to turn a promise into reality. The experts' consultations add that the majority of women engineers in Sri Lanka do not have time management characteristics at the right level, especially when it comes to prioritizing critical and significant tasks. They must put aside distractions and pessimistic ideas and give their full effort. It is crucial for them that they follow the work norms to overcome their shortcomings in their job tasks. Setting and achieving goals in relation to professional duties will improve both their performance and individuality.

Experts' consultation outcomes reveal that employers need to take necessary awareness activities on the application of necessary conceptualized models to enhance the self-motivation and performance of women engineers. Initially, consultative experts emphasize the application of Adam's Equity theoretical model, which is a process model of motivation, meaning that higher levels of motivation and performance are only reasonable when women engineers believe they are being treated fairly. The ratio of a woman

engineer's input to output determines the equity theory scenarios, especially the balance between what she puts into her job (time, energy, aptitude, loyalty, tolerance, adaptability, integrity, commitment, dependability, heart and soul, and individual sacrifice, etc.) and what she gets from her job (salary, bonus, benefits, security, acknowledgement, curiosity, growth, reputation, appreciation, accountability, enjoyment, etc.). Women engineers become demotivated, contribute less input and demand changes whenever they believe their contributions are not being fairly acknowledged. However, it is crucial to realize that fairness is determined by what is considered to be the norm in the market. According to Herzberg's two-factor hypothesis, certain workplace variables influence job satisfaction while other variables operate independently of one another. Accordingly, organizations should take necessary actions to increase job satisfaction of women engineers by increasing/improving motivating factors associated with achievement, recognition, responsibility, advancement and personal growth, and reducing/controlling poor hygiene factors related to work conditions, coworker relations, organizational policies, quality regulations and wage policies. Taking on the hypothesis of goal-setting theory in relation to clarity, challenges, commitment, feedback and complexity, better performance outcomes can be claimed by women engineers by creating an action plan with the intention of inspiring and directing an individual or group. On the other hand, according to McClelland's Need Theory, each individual woman engineer can primarily be driven by one of three needs: the need for power, affiliation or achievement. These must not be innate motivators, rather, they must be acquired from our upbringing and experiences in life. This will assist organizations in figuring out what drives their women engineers to be the best versions of themselves. This will support women engineers in maintaining their motivation to contribute to organizational improvement. When the specified needs of the women engineers are met, motivation may result, and motivation may boost a woman engineer's output. Productivity gains might raise the likelihood that the organization will expand. By appealing to women engineers by meeting their wants depending on their behavior, this concept can help recruit the top individuals. Accordingly, it is important for organizations to comprehend, evaluate and pinpoint the primary necessity influencing the behavior of each woman engineer. This will help in the efficient development of new tactics to maintain the satisfaction and motivation of women engineers.

On the other hand, as emphasized in Code of Ethics Institution of Engineers Sri Lanka [29], women engineers must develop their ethical character to maintain sustainable and healthy self-policies in their work approaches. It should be noted that the characteristics associated with trustworthiness, self-respect, self-responsibility, fairness, caring and citizenship are the deciding factors of the ethical behavior of each person [30]. It is notable that ethical aspects of transitions and politics and power in transitions are a couple of potential research themes in sustainability transitions [31]. In particular, truthfulness, sincerity, candour, integrity, loyalty and honesty make the trustworthiness of each person, whereas autonomy, courtesy and self-determination are the required elements to gain self-respect for each person [32]. Diligence and self-restraint are the key elements of self-responsibility, whereas justice, impartibility and equity are the key aspects of fairness [33]. Kindness and compassion are important aspects of caring attributes, and philanthropy is an essential element in citizenship characteristics [34].

Apart from the above, physical fitness is very important and the first requisite for the successful career of women engineers in industrialized or institutional-based practices. The experts' consultations highlight that the continuous involvement of women engineers in physical exercises and meditation is essential. Accordingly, women engineers may follow simple physical exercises related to side bend, neck stretch, hamstring stretch, quadriceps stretch, shoulder circle, chest and shoulder stretch, wrist stretch and calf stretch in their daily activities, as recommended by [35]. Further, practising healthy habits, such as sleeping well, taking healthy meals, avoiding the habits which are harmful to health, reading good articles, listening to music and gaining goodwill among others, will provide better ways to strengthen their physical character. Additionally, it is beneficial for them to follow the public health tips in daily meals revealed by the US government's nutrition information portal. Moreover, the experts stated that the key psychological aspects also influence the physical characteristics of women engineers. Accordingly, the experts' consultations highlight that every woman engineer can

strengthen her psychological characteristics by expressing herself with features that are known to her and unknown to others rather than hiding them. This may lead them to perform their job tasks with a positive mindset. Based on [36] and experts' consultations, performing with an awareness of social obligations and needs, keeping up positive relationships with knowledgeable and trustworthy people to solicit their insightful opinions and thoughts, adapting the abilities to the demands of a changing environment, maintaining the same frame of mind through successes and setbacks and performing with an awareness of the needs and feelings of others are also notable ways to reinforce the psychological characteristics of women engineers' work attributes.

As per the above-highlighted discussions, this study has produced a detailed reinforcement design for strengthening the structure of women's empowerment in the engineering sector of Sri Lanka. Additionally, this study recommends performing a survey to measure the fulfilment levels of achievement needs among women engineers in Sri Lanka, especially under the main five categories of Masslow's hierarchy, namely, physiological needs, safety needs, belongingness and love needs, esteem needs and self-actualization.

The proposed framework contains a new functional mechanism, generating a novel hypothesis that the actions to develop cognitive, transferrable, self-management, and self-motivational characteristics will have direct influence on other crucial elements, such as the competency to perform jobs, type of support received from subordinates, and the male/female compositions at workplaces. The hypothesis generated in this framework further leads to indirect influences on other significant elements highlighted in the results, especially balancing work and family life, job description, working hours, physical capabilities, working on construction sites while pregnant, terms of reference, peer and supervisor support, networking opportunities, coworker relationships and communication styles, non-engineering staff work practices, performance evaluation procedures, job roles and responsibilities, career vision, advancement and accomplishments, and the work environment and facilities. As a result of such direct and indirect outcomes and influences, the impacts of all the relevant factors will be controlled within a generalized, systematic and sustainable mechanism, and significant improvement will result in women's empowerment in the engineering sector, as shown in Figure 7. Such expected changes and improvements in the work practices of women engineers highlight the theoretical contribution and values of the outcomes of this study connected with practical and social implications.

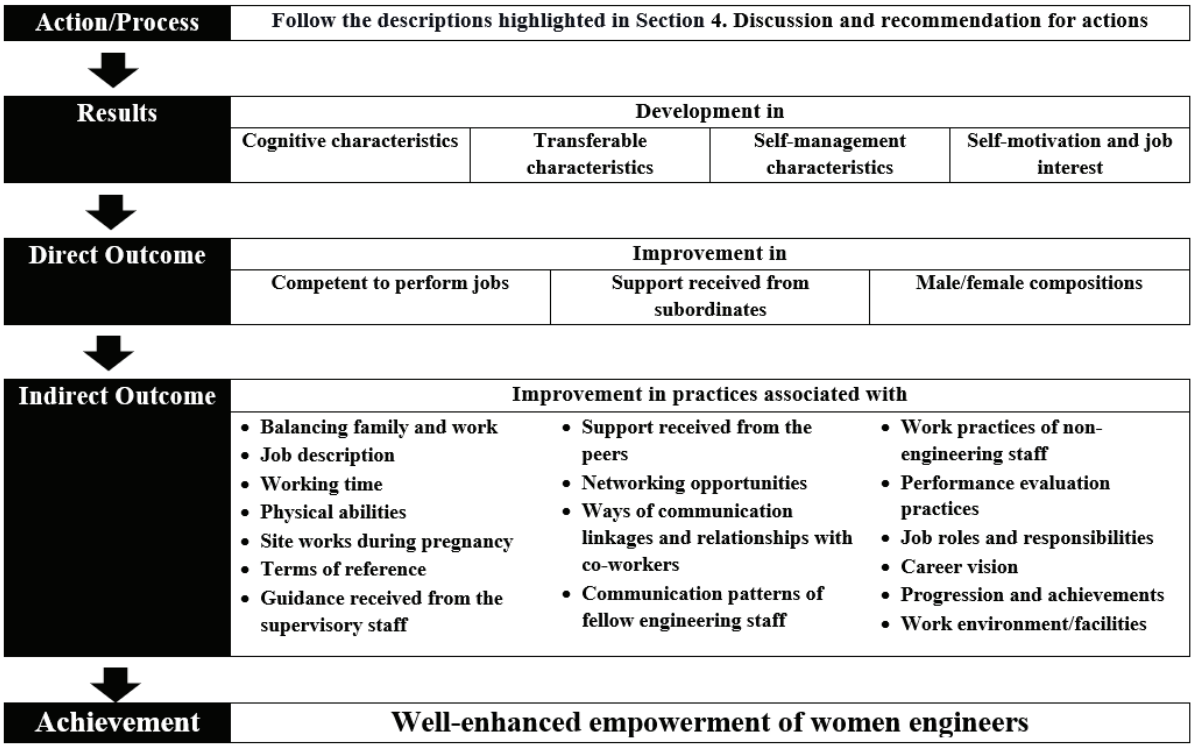

Figure 7 - Functional mechanism of the proposed framework to enhance the empowerment of women engineers

5. Conclusion

The current study has presented a new lesson plan to women engineers as well as a new roadmap for organizations to find out the conceptual solutions for the following questions.

- Why is the empowerment of women engineers significant?
- What outcomes will result from enhancing their empowerment of them?
- How should the approaches, policies and practices need to be directed and upgraded to achieve significant enhancement in women engineers' empowerment?

Accordingly, the study has developed a framework to enhance the empowerment of women engineers. The validity and reliability of the proposed framework were assured through experts' reviews, revealing the satisfactory level of feedback under all eight steps of the concept analysis method of Walker and Avant highlighted in [19], as per the intention of its mechanism. The implementation of this mechanism will result in making significant changes in the current work norm policies, by-laws, terms of references, key performance indicators and standard operating procedures associated with organizational practices.

In addition to the above-discussed contributions and implications, the expected study outcomes may also contribute to the industrial and institutional sectors in upgrading the current practices into a sustainable scope with the concept of performance improvement towards social, cultural and economic advancement in Sri Lanka. While the study's applicability was restricted to the Sri Lankan setting, similar methods and approaches can be applied in other developing nations to produce results that are equivalent to their industrial and community-based processes. The study's conclusions may also have an impact on advancing the current policies, processes and practices to re-structure women's empowerment internationally. In light of the features of various job categories in various trades or industry sectors in various situations, this study recommends future studies concentrating on developing new apprenticeship and awareness programmes that strengthen the action of the proposed framework. Future studies can then expand the scope and have a greater impact and emphasis on reskilling and upskilling practices on women's empowerment to find more beneficial ways to effectively address the opportunities and challenges associated with technological advancement and other next-normal conditions.

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