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Empowerment, Mobile Technology, and Managerial Support: A Multidimensional Analysis of Work-Life Balance Among Women Engineers

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ABSTRACT

Women's empowerment is a crucial objective in advocating for women's rights. Giving women in the energy industry more authority could help them manage work and family obligations. According to studies, mobile technology may have conflicting effects on users' work-life balance. Organizational intervention, such as managerial support, is crucial to ensuring that employee empowerment and mobile technology usage may improve work-life balance. Thus, it is believed that managerial support could fortify the empowerment initiative and guarantee that mobile technology would improve workers' work-life balance. Therefore, the purpose of this paper is to investigate how work-life balance is affected by managerial support, mobile technology usage, and women's empowerment. The originality stems from a thorough examination of how various variables, such as work-life balance, managerial support, mobile technology usage, and women's empowerment, intersect and influence the lives of female engineers. This study provides significant insights into possibilities for closing the gender gap in engineering while empowering and supporting women in the workplace. This paper discusses the grounded theories, methodology, data analysis results, discussion of findings, and theoretical and practical contributions.

Keywords: Women Empowerment, Mobile Technology Usage, Managerial Support, Work-Life Balance, Women Engineers
JEL Classifications: J – Labor and Demographic Economics

1. INTRODUCTION

Women's empowerment has become a global focus aimed at advancing women's rights in education, employment, and social welfare. It also plays a vital role in promoting gender equality by ensuring women's active participation in economic growth and national development. In Malaysia, female participation in the workforce has consistently increased in recent years (Department of Statistics Malaysia, 2020). However, the situation in the engineering field remains less encouraging. Despite technological advances and broader access to science, technology, engineering, and mathematics (STEM) education, women remain significantly underrepresented in engineering and related fields (UNESCO, 2025).

Although the Malaysian Gender Gap Index (MGGI) edged up from 0.692 (69.2 %) in 2021 to 0.694 (69.4 %) in 2022, the workforce participation underrepresentation of women in technical and professional roles (Department of Statistics Malaysia, 2023). Recent figures from the Board of Engineers Malaysia (2023) reveal that although 27% of engineering graduates are women, only around 8% of them attain professional engineer status. A key reason for women leaving the engineering profession is the struggle to maintain work-life balance. Extended working

hours, for example, often reduce the time available for personal responsibilities (Fouad et al., 2020).

Many women engineers report a lack of job autonomy and limited opportunities to engage in physically demanding or high-responsibility tasks, owing to prevailing stereotypes about their skills and capabilities. This perception is often reinforced by colleagues and supervisors questioning their judgment and competence. Such a workplace culture contributes to unequal treatment compared to their male counterparts. In this context, managerial support and supervisor engagement are crucial in empowering women through inclusive policies and practices. Furthermore, a bibliometric review of studies on Malaysian female engineers underscores that flexible work arrangements such as flexible hours, remote working, and job sharing are among the most effective strategies to alleviate work–life pressure and retain women in engineering roles (Chen et al., 2024).

Similarly, a national survey found that work–life balance is one of the most sought-after benefits among Malaysian female professionals, indicating a strong preference for employers who offer such support (Randstad and Kantar TNS, 2021). In engineering, managerial support, particularly through managers' attitudes and responsiveness, is instrumental in shaping employees' well-being and maintaining work-life balance. However, there remains a lack of in-depth research into how managerial support directly impacts employee well-being, especially in high-demand sectors such as engineering (Martinez Montes et al., 2025; Huo and Boxall, 2017).

Moreover, mobile technology usage (MTU), referring to internet-enabled portable devices such as smartphones, tablets, and laptops, has a dual effect on work-life balance. Malaysia is highly digitally connected, with internet penetration reaching 98.0% of the population and mobile connections exceeding 121% of the total population, indicating widespread reliance on mobile internet access for daily activities and communication (DataReportal, 2025; Digital 2026 Report). Wang et al. (2019) argue that mobile technology usage can aid work-life balance by increasing flexibility but may also blur the boundaries between work and home life, extending work into personal time. In fact, some studies in Western contexts have found that excessive mobile technology usage can lead to stress and burnout (Wang et al., 2019). Therefore, while MTU can enhance productivity and flexibility, it also poses risks to users' work-life balance. A review of existing literature shows a lack of studies specifically addressing the impact of mobile technology usage on the work-life balance of women engineers in Malaysia's energy sector (Chen et al., 2024). In light of these gaps, the present study aims to examine the influence of women's empowerment and mobile technology usage on the work-life balance of women engineers in the energy industry. Furthermore, the study introduces managerial support as a moderating variable, evaluating how it affects the relationship between women empowerment, mobile technology usage, and work-life balance in this context.

This paper presents the findings of a study that analysed survey data using statistical methods to examine the impact of women's empowerment and mobile technology usage on work-life balance, with managerial support as a moderating factor. Grounded in relevant theories and a structured conceptual framework, the study employed Partial Least Squares Structural Equation Modelling (PLS-SEM) to analyse data collected from women engineers in Malaysia's energy sector. Preliminary sections include demographic findings and descriptive statistics of the study variables. The analysis encompasses measurement and structural models, with assessments of construct reliability, validity, path relationships, and predictive relevance. The moderating role of managerial support is explored through interaction analysis. Key findings are then aligned with the research objectives, followed by discussions of theoretical and practical implications. The study concludes with a summary of contributions and recommendations for future research.

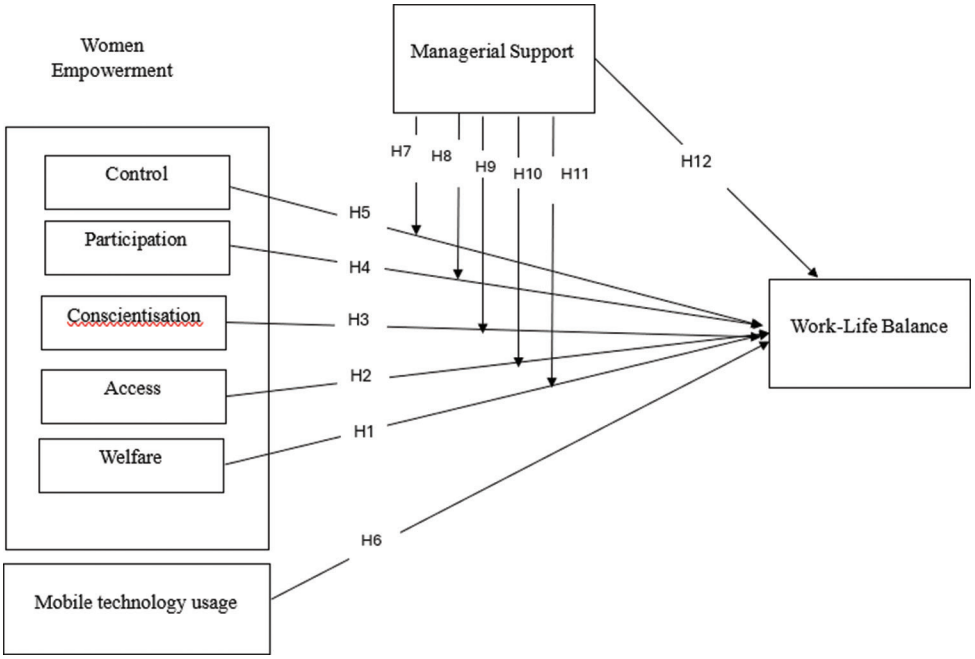
This study is grounded in three interrelated theoretical frameworks: Empowerment Theory, Border Theory, and Enrichment Theory. Empowerment Theory, as proposed by Zimmerman (1995), offers a multidimensional psychological, behavioural, and organizational lens to understand women's empowerment. It aligns closely with the Longwe Framework (Longwe, 1995), highlighting elements such as welfare, access, participation, conscientisation, and Control in promoting empowerment. Psychological empowerment enables women to believe in their ability to manage personal and professional roles (Kabeer, 1999), while behavioural empowerment is reflected in their capacity to make decisions such as negotiating flexible work arrangements (Mahmud et al., 2012). Organizational empowerment focuses on structural support and inclusive decision-making, including gender-sensitive policies. In this study, empowerment is examined in relation to women engineers, considering how managerial support moderates its impact on work-life balance outcomes.

To explore the role of mobile technology in this dynamic, Border Theory by Clark (2000) is employed to explain how individuals negotiate boundaries between work and personal life. For women engineers, constant connectivity can blur these boundaries, making it harder to maintain separation between domains (Wajcman, 2015; Wang et al., 2019). Simultaneously, Enrichment Theory (Greenhaus and Powell, 2006) supports the idea that positive experiences in one life domain can improve satisfaction in another. Managerial support plays a critical role here, acting as a catalyst for enrichment by offering flexibility, recognition, and emotional backing (Lapierre et al., 2018; Allen et al., 2020). Together, these theories provide a comprehensive framework to understand how empowerment, technology, and managerial support interact to influence the work-life balance of women engineers in Malaysia's energy sector. The overall research framework is given in Figure 1.

2. METHODOLOGY

This study employed a cross-sectional quantitative research design to examine the relationship between women's empowerment and work-life balance among women engineers in Malaysia's energy sector, with managerial support as a moderating variable. The cross-sectional design captures data at a single point, efficiently identifying relationships and patterns. A survey-based strategy

Figure 1: The conceptual framework



was used to collect data appropriate for quantitative studies aiming to analyze behavioral or perceptual trends. A structured self-administered online questionnaire was developed, allowing participants to complete it independently. This method was selected due to its practicality, especially during post-COVID-19, when virtual data collection was essential.

The instrument underwent content and construct validity checks to ensure measurement quality, including expert reviews and a pilot test involving 30 women engineers. The Content Validity Index (CVI) for all items ranged from 0.86 to 1.00, confirming their relevance and clarity. Internal consistency was evaluated using Cronbach's alpha, with values ranging from 0.78 to 0.97 across all constructs, indicating high reliability.

The target population consisted of women engineers working in Malaysia's energy sector. Given the lack of sector-specific databases, a non-probability purposive sampling technique focused on individuals with relevant knowledge and experience. The minimum sample size was determined using G*Power analysis based on six predictors, requiring at least 98 respondents for statistical validity. A total of 72 items were included in the questionnaire, distributed across five sections measuring women's empowerment (based on Longwe's Framework), managerial support, mobile technology usage, and work-life balance, using a 5-point Likert scale. Data were collected over 1 year (January 2022–January 2023) using Google Forms, promoted through professional networks such as IEEE Women in Engineering Malaysia, IEM, WiN Malaysia, and LinkedIn. The responses were analyzed using SPSS for preliminary data screening, followed by PLS-SEM using SmartPLS 4 to test the research model.

2.1. Demographic Findings

demographic and background characteristics of the 361 women engineers who participated in the study. The profile includes six demographic variables (age, ethnicity, marital status, education level, work mode, and years of service) and two screening questions. The majority of respondents were aged between 26 and 30 years (34.1%), followed by those aged 31–35 years (21.1%) and 36–40 years (20.8%). Most respondents identified as Malay (60.1%), with the remaining comprising Chinese (20.2%), Indian (8.0%), and other ethnicities (11.6%). Nearly half of the respondents were single (49.6%), 46.0% were married, and 4.4% divorced.

Regarding education, the vast majority held a bachelor's degree (81.2%), followed by those with master's or PhD qualifications (18.6%). Only one respondent reported a diploma qualification (0.3%). Regarding the nature of their work, 62.3% of participants were involved in field and office-based tasks, while 24.9% were exclusively field-based, and 12.7% were office-based. Concerning years of service, the highest proportion of respondents (43.2%) had 5-10 years of working experience, 32.4% had more than 10 years, and 24.4% had 1-5 years of experience. Overall, the sample reflects diverse experience levels and job scopes among women engineers in Malaysia's energy sector.

2.2. Descriptive Statistic

All variables in this study were measured using a 5-point Likert scale, ranging from 1 = Strongly Disagree to 5 = Strongly Agree. Table 1 presents the mean and standard deviation for each construct examined. The results indicate that all variables recorded high mean scores, suggesting generally positive responses from participants. The highest mean score was for work-life balance (M = 4.11, SD = 0.9213), indicating that respondents perceived a relatively strong balance between work and personal life. This was followed closely by conscientisation (M = 3.94) and control (M = 3.89), which reflect key dimensions of women's empowerment. Other empowerment dimensions, such as welfare, access, and participation, also showed high means ranging

from 3.82 to 3.87. Additionally, respondents perceived mobile technology usage (M = 3.85) and managerial support (M = 3.81) positively, further supporting the study's framework. Overall, the results suggest that women engineers in the Malaysian energy sector generally experience a high level of empowerment, managerial support, technology usage, and work-life balance.

2.3. Measurement Model

For the measurement model, the researcher followed the suggestions of Anderson and Gerbing (1988) to test the model developed using a 2-step approach. First, in the measurement model, the instrument's validity and reliability were tested by following the guidelines of Hair et al. (2022) and Ramayah et al. (2018). Then, the structural model was run to test the hypothesis that had been developed. Firstly, the researcher evaluated the composite reliability (CR), average variance extracted (AVE), and loadings. Loading values should be ≥0.5, AVE values should be ≥0.5, and CR values should be ≥0.7. All constructs' composite reliability (CR) ranged from 0.86 to 0.93 and exceeded the recommended value of 0.70. Meanwhile, the AVE values of all constructs ranged from 0.54 to 0.60 and exceeded the recommended value of 0.50. All loadings exceeded the minimum threshold of ≥0.5.

The discriminant validity was then evaluated in step 2 using the HTMT criterion. The moderately lenient criterion is that the HTMT values should be ≤0.90, and the more rigid criterion is 0.85. The values of HTMT were all lower than the tougher threshold of ≤0.85, leading us to believe that the respondents were aware that the eight constructs are separate. Together, these two validity checks have demonstrated the reliability and validity of the measuring items.

2.4. Structural Model

Hair et al. (2022) suggested that the researcher assess the multivariate skewness and kurtosis. As a result, the researcher reported the path coefficients, the standard errors, t-values, and p-values for the structural model using a 10,000-sample re-sample bootstrapping procedure, as the results indicated that the data collected was not multivariate normal, see Table 2. It is also based on the claim made by Hahn and Ang (2017) that p-values are a subpar standard for judging the importance of a hypothesis and that p-values, confidence intervals, and effect sizes should be combined instead.

First, the effect of 7 predictors was tested on work-life balance; the R2 for the direct effect was 0.365, which shows that all seven predictors explained 36.5% of the variance in work-life balance. Next, the bootstrapping of 10,000 re-samples was analysed to determine the path coefficient values, P-values, and t-values for each path or relationship. Therefore, looking at each structural path, welfare ($\beta = 0.276$, $P < 0.0$), conscientisation ($\beta = 0.168$, $P < 0.05$), participation ($\beta = 0.167$, $P < 0.05$), Control ($\beta = 0.162$, $P < 0.05$), mobile technology usage ($\beta = 0.141$, $P < 0.05$), and managerial support ($\beta = 0.187$, $P < 0.05$), were found to have a significant relationships with work-life balance, thereby, H_1, H_3, H_4, H_5 and H_6 were supported. In contrast to the research expectations, the relationship between access and work-life balance was non-significant ($\beta = 0.086$, $P > 0.05$), hence rejecting hypothesis 2 (H_2).

Hypotheses H_7, H_8, H_9, H_{10}, H_{11}, and H_{12} were focused on testing the model's moderating effects. The bootstrapping results indicated that there was an insignificant moderating effect of managerial support on the relationship between women's empowerment (access) and their work-life balance ($\beta = 0.073$, $P > 0.05$), hence rejecting the H_8. Whereas, the moderating impact of managerial support between welfare and work-life balance ($\beta = 0.132$, $P < 0.05$), conscientisation and work-life balance ($\beta = 0.190$, $P < 0.05$), participation and work-life balance ($\beta = 0.153$, $P < 0.05$), and Control and work-life balance were significant ($\beta = 0.143$, $P < 0.05$), meeting the research expectations. Tables 1 and 2 exhibit the path coefficients and the results of the hypothesis testing on the relationship between women's empowerment (welfare, access, conscientisation, participation, and control).

2.5. Interaction Plots

Figures 2-5 below show the interaction plots of women's empowerment (welfare, conscientisation, participation, and control). The plot graph shows that the line of high managerial support was much steeper than that of low managerial support. Thus, it's elucidated that with high managerial support, welfare, conscientisation, control, participation, and work-life balance will be high. In other words, the positive relationship between welfare, conscientisation, control, participation, and work-life balance will be higher at a high level of managerial support.

2.6. Coefficient of Determination

The coefficient of determination (R^2) was assessed to determine the model's predictive accuracy. The R^2 value is a standard

Table 1: Hypothesis testing on the moderation effect

Path model	Beta	Sample mean (M)	P-value	Decision
Welfare X Managerial Support -> Work-life Balance	0.132	0.028	0.014	Accept
Access X Managerial Support -> Work-life Balance	0.073	0.025	0.167	Reject
Conscientisation X Managerial Support -> Work-life Balance	0.19	0.03	0.000	Accept
Participation X Managerial Support -> Work-life Balance	0.153	0.032	0.007	Accept
Control X Managerial Support -> Work-life Balance	0.143	0.03	0.009	Accept

Table 2: Hypothesis testing direct effect

Path model	Beta	T statistics	P-values	Decision
Welfare -> Work-life Balance	0.276	4.739	0.000	Accept
Access -> Work-life Balance	0.086	1.450	0.148	Reject
Conscientisation -> Work-life Balance	0.168	2.863	0.004	Accept
Participation -> Work-life Balance	0.167	2.539	0.012	Accept
Control -> Work-life Balance	0.162	2.803	0.005	Accept
Mobile Technology Usage -> Work-life Balance	0.141	2.510	0.012	Accept
Managerial Support -> Work-life Balance	0.187	3.174	0.002	Accept

measurement to evaluate the structural model representing the combined effects of exogenous variables on endogenous variables. In other words, R^2 represents the amount of variance in the endogenous constructs explained by the combination of all exogenous constructs linked to it. The effect ranges of the R^2 value from 0 to 1, with higher values indicating higher levels of predictive accuracy. Hence, the rules of thumb regarding acceptable R^2 values are that a value higher than 0.02 is considered small, a value higher than 0.13 is considered medium, and a value higher than 0.26 is considered significant.

The R^2 value of Work-life balance was 0.342, suggesting that 34.2% of the variance in work-life balance was explained by women's empowerment (welfare, access, conscientisation, participation, and control), mobile technology usage, and managerial support. Hence, based on Cohen's, the R^2 value in this study is more than 0.26, which was explained as substantial for the work-life balance construct. Hence, the moderating effect of managerial support on the relationship of women's empowerment (welfare, access, conscientisation, participation, and Control) and work-life balance was 0.342, considered a large effect size.

2.7. Importance and Performance Matrix Analysis (IPMA)

The importance-performance matrix analysis (IPMA), which extends the findings of the fundamental PLS-SEM results, is helpful. IPMA was used in this work to quantify the importance of the performance of the structural model linkages using the latent variable scores to generate the index values for each latent variable. The findings revealed that the most critical construct (with highest total effect values) in predicting women engineer's work-life balance was welfare (total effect = 0.227, index value = 71.633), followed by Participation (total effect = 0.196, index value = 72.41), Conscientization (total effect = 0.162, index value = 72.08), managerial support (total effect = 0.152, index value = 71.63), Control (total effect = 0.147, index value = 71.21), and mobile technology (total effect = 0.126, index value = 70.178). Moreover, since the direct impact of access on the dependent variable was insignificant, this variable is not considered significant for reporting such findings.

2.8. Summary of Findings

The summary of findings are presented in Table 3.

3. DISCUSSION ON FINDINGS

The study found that women engineers in Malaysia's energy sector experience high levels of empowerment across all five dimensions: welfare, access, conscientisation, participation, and Control, reflecting ongoing efforts to foster gender diversity in a traditionally male-dominated industry. Among these, conscientisation and Control recorded the most decisive influence on work-life balance, while access showed no significant direct impact. Notably, work-life balance received the highest overall mean score, suggesting it is a central concern for female engineers. This indicates progress driven by national policies and industry initiatives, yet highlights persistent challenges in balancing demanding professional roles with societal expectations.

In addition, the study found that mobile technology usage and managerial support each had a significant positive effect on work-life balance. Mobile technology offers flexibility and intrusion; while it blurs boundaries between work and personal life, it also enables greater control and task management when used effectively. Managerial support emerged as a critical factor, directly enhancing work-life balance and significantly moderating the relationship between most empowerment dimensions and work-life outcomes, particularly for welfare, conscientisation, participation, and Control. However, managerial support did not moderate the access dimension, implying that structural or policy-level changes may be required. These findings suggest that fostering supportive leadership and responsible technology use are essential for improving the work-life integration of women engineers in the energy sector.

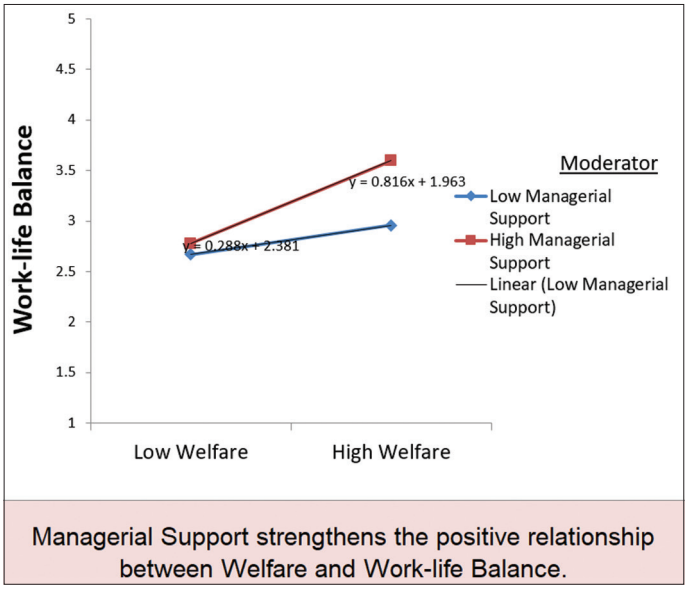
4. THEORETICAL AND PRACTICAL CONTRIBUTIONS AND IMPLICATIONS

This study offers substantial theoretical contributions by integrating Empowerment Theory, Border Theory, and Enrichment Theory into a comprehensive model examining the influence of women's empowerment, mobile technology usage, and managerial support on work-life balance. It addresses critical gaps by operationalizing Longwe's Women Empowerment Framework (WEF), which includes welfare, access, participation, conscientisation, and Control, specifically for women engineers in Malaysia's energy sector. The study extends Border Theory by introducing mobile technology usage as a digital dimension in boundary management,

Table 3: Summary of findings

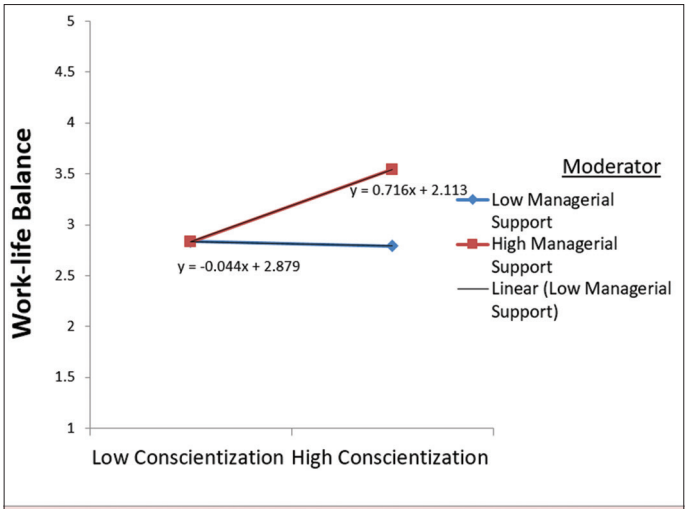
Hypothesis	Result
H_1 - There is a significant positive relationship between welfare and work-life balance.	Supported
H_2 - There is a significant positive relationship between access and work-life balance.	Not supported
H_3 - There is a significant positive relationship between conscientisation and work-life balance.	Supported
H_4 - There is a significant positive relationship between participation and work-life balance.	Supported
H_5 - There is a significant positive relationship between control and work-life balance.	Supported
H_6 - There is a significant positive relationship between mobile technology usage and work-life balance.	Supported
H_7 - Managerial support positively moderates the relationship between welfare and work-life balance of women engineers in the energy sector.	Supported
H_8 - Managerial support positively moderates the relationship between access and work-life balance of women engineers in the energy sector.	Not supported
H_9 - Managerial support positively moderates the relationship between conscientisation and work-life balance of women engineers in the energy sector.	Supported
H_{10} - Managerial support positively moderates the relationship between participation and work-life balance of women engineers in the energy sector.	Supported
H_{11} - Managerial support positively moderates the relationship between control and work-life balance of women engineers in the energy sector.	Supported
H_{12} - There is a significant positive relationship between managerial support and work-life balance.	Supported

Figure 2: Interaction plot (welfare and managerial support)



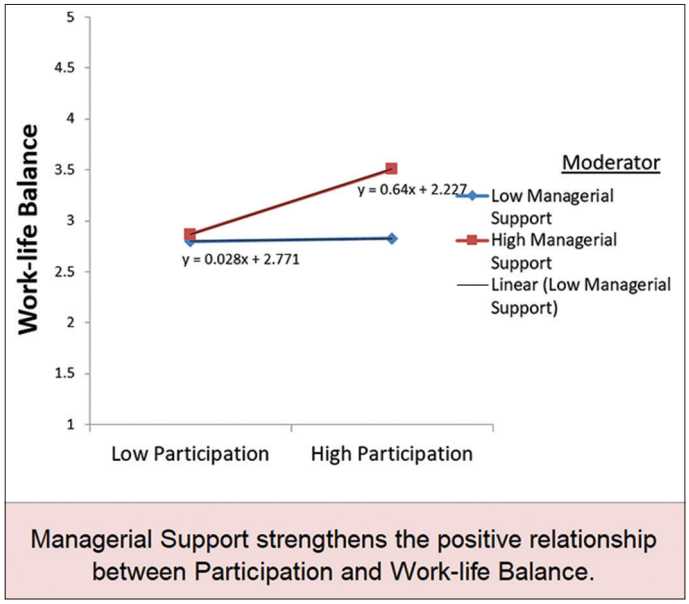
Managerial Support strengthens the positive relationship between Welfare and Work-life Balance.

Figure 3: Interaction plot (conscientisation and managerial support)



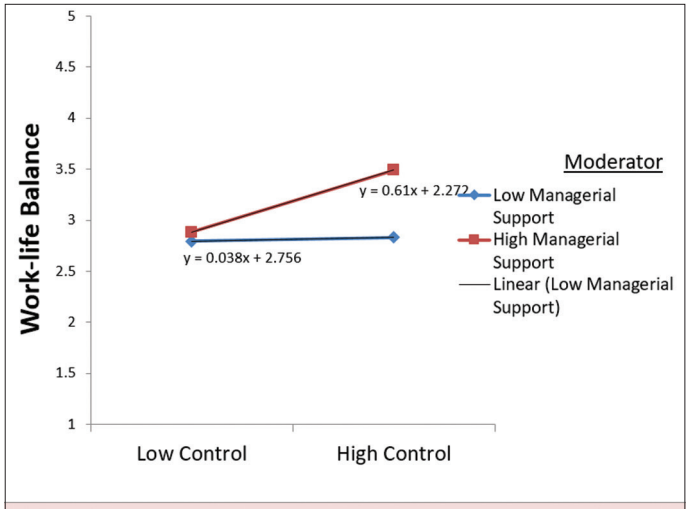
Managerial Support strengthens the positive relationship between Conscientization and Work-life Balance.

Figure 4: Interaction plot (participation and managerial support)



Managerial Support strengthens the positive relationship between Participation and Work-life Balance.

Figure 5: Interaction plot (control and managerial support)



Managerial Support strengthens the positive relationship between Control and Work-life Balance.

providing new insights into how digital tools either support or hinder the separation of work and personal life.

Additionally, it enhances Enrichment Theory by demonstrating how managerial support facilitates positive spillovers between work and non-work domains. The integration of these theories offers a deeper understanding of how empowerment, mobile technology usage, and managerial support interact to shape work-life outcomes for women engineers.

This study offers practical insights for organizations, particularly in Malaysia's energy sector, on how women's empowerment, mobile technology usage, and managerial support influence women engineers' work-life balance. First, the non-significant relationship between access and work-life balance (both direct and moderated) highlights a need to improve not just the availability, but also the quality and suitability of resources. Access must be tailored to individual needs, as generic solutions may be ineffective (Van der Heijden and De Lange, 2005; Medina Garrido et al., 2023).

Second, this study introduces the practical application of the Women's Empowerment Framework (WEF), offering structured guidance for organizations to address welfare, access, participation, conscientisation, and Control. Integrating these elements into support systems ensures holistic interventions that strengthen work-life balance (Longwe, 1991; Kabeer, 2005; Cornwall and Edwards, 2014). The findings also underscore the positive impact of mobile technology usage. It enhances women engineers' flexibility, autonomy, and real-time problem-solving, supporting better work-life integration in a high-demand sector (Gajendran and Harrison, 2007; RodríguezModroño and LópezIgual, 2021).

Managerial support emerged as a key factor in enhancing well-being and retention. It moderates the empowerment work-life balance relationship, amplifying empowerment efforts when mentorship and open communication are present (Sonnentag and Frese, 2022; Acker, 2022). Managers must be trained to offer flexibility, support systems, and inclusive decision-making (Kossek and Thompson, 2023).

In sum, organizations should invest in empowering frameworks, digital flexibility, and strong managerial support to foster a more inclusive and productive work environment for women engineers.

5. CONCLUSION

This study explores the relationship between women's empowerment, mobile technology use, and managerial support on the work-life balance of women engineers in Malaysia's energy sector. It emphasizes the importance of empowerment, particularly in terms of participation and Control, for improving work-life balance. However, industry-specific challenges can limit their effectiveness without additional support.

The study also highlights that mobile technology usage significantly enhances work-life balance by providing flexibility through remote work and access to job-related tools, increasing job satisfaction. Organizations in the energy sector are encouraged to invest in mobile technologies to facilitate flexible work arrangements. Managerial support is identified as a critical moderator that amplifies the positive effects of empowerment and mobile technology on work-life balance, except in the case of access. Managers who promote flexible work schedules and professional growth foster a more positive work environment, boosting the impact of these factors.

Although the study finds no direct moderating effect of managerial support on access, it underscores the need for a comprehensive approach that addresses empowerment's various dimensions, especially considering sector-specific challenges. The findings suggest further research on these areas to understand how to fully enhance work-life balance for women engineers.

In conclusion, the study advocates for a multifaceted strategy that combines women's empowerment, mobile technology, and managerial support to improve work-life balance. This approach benefits women engineers and promotes organizational success by increasing job satisfaction and retention. Encouraging inclusive workplace cultures supports SDG 8 (Decent Work and Economic Growth), benefiting employees and the organization.

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