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RESEARCH ARTICLE

Environmental and social psychological perspectives on training system optimization: A case study of knowledge workers in engineering consulting

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ABSTRACT

This study examines how environmental and social psychological factors influence training effectiveness for knowledge workers in engineering consulting firms. Using mixed-methods research with surveys (n=200) and interviews (n=12) at a leading Chinese engineering consulting firm, the research investigates six key factors: physical environment, organizational environment, social environment, self-efficacy, social identity, and psychological safety. Structural equation modeling reveals organizational environment as the strongest predictor ($\beta = 0.43$, $p < 0.001$), followed by psychological safety ($\beta = 0.33$, $p < 0.001$) and self-efficacy ($\beta = 0.29$, $p < 0.001$). The model explains 59% of variance in training effectiveness. The study identifies significant interaction effects, particularly between social environment and psychological safety ($\beta = 0.23$, $p < 0.01$), and a compensatory mechanism where professional identity moderates organizational support ($\beta = -0.16$, $p < 0.05$). These interactions explain an additional 6% of variance beyond main effects. Findings demonstrate that training effectiveness depends on complex interdependencies between environmental conditions and psychological processes rather than isolated influences. The research provides evidence-based strategies for engineering consulting firms to optimize training systems by prioritizing organizational support while creating synergistic interventions addressing both social learning environments and psychological safety, contributing to training effectiveness theory and professional development practices in knowledge-intensive industries.

Keywords: training systems; engineering consulting; knowledge workers; environmental factors; social psychological factors; self-efficacy; professional identity; training transfer

1. Introduction

In the era of digital transformation and increasing global competition, the engineering consulting industry—encompassing technical advisory services across civil engineering, environmental engineering, and project management—has evolved from traditional project-based consulting to comprehensive whole-process consulting services[1,2]. As knowledge-intensive organizations, engineering consulting firms depend critically on knowledge workers who transform specialized knowledge into valuable client solutions, making effective training systems essential for competitive advantage[3].

Engineering consulting firms face significant challenges in optimizing their training systems for

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knowledge workers. Project-driven organizations often lack standardized workforce planning processes, leading to misalignment in talent development approaches[4]. Modern economic pressures demand new competencies including critical thinking, interpersonal skills, and digital capabilities, while traditional training approaches struggle to address these evolving requirements[5]. The project-based nature of engineering consulting creates dynamic environments where knowledge workers must rapidly adapt to diverse client requirements and multidisciplinary team structures, presenting unique challenges that distinguish this sector from other professional services[6].

Research demonstrates that training effectiveness depends on complex interactions between environmental and psychological factors. Environmental factors include physical training facilities, organizational support mechanisms, and social learning contexts, each contributing distinctively to training outcomes[7]. Psychological factors such as self-efficacy, social identity, and psychological safety play increasingly important roles in determining training effectiveness in knowledge-intensive settings[8,9]. Recent studies provide compelling evidence that both peer and supervisor support function as critical antecedents for training transfer and knowledge sharing, while motivation and volition serve as key mediators in the training-performance relationship[10].

Despite growing recognition of both environmental and psychological influences on training effectiveness, existing research in engineering consulting contexts remains fragmented. While individual studies have examined specific aspects of training transfer or knowledge management, comprehensive frameworks that integrate environmental and psychological perspectives are notably absent. This theoretical gap is particularly problematic given the unique characteristics of engineering consulting work, including technical complexity, client-driven project structures, and multidisciplinary collaboration requirements that differ substantially from other professional service contexts[11].

The existing literature lacks multi-dimensional analysis of training systems for knowledge workers in the engineering consulting industry, specifically regarding how environmental factors (physical, organizational, and social) interact with psychological factors (self-efficacy, social identity, and psychological safety) to influence training effectiveness. This research gap limits both theoretical understanding and practical guidance for optimizing training systems in knowledge-intensive professional service environments.

To address these theoretical and practical gaps, this study adopts an integrated environmental and social psychological perspective to examine training system optimization for knowledge workers in engineering consulting firms. Specifically, this research investigates: (1) How do environmental factors affect training effectiveness of knowledge workers in engineering consulting firms? (2) What roles do social psychological factors play in the training process? (3) How do environmental factors and social psychological factors interact to jointly influence training system effectiveness? (4) How can optimized training systems suitable for engineering consulting knowledge workers be constructed based on environmental and social psychological perspectives?

The theoretical significance of this study lies in developing a comprehensive framework that bridges environmental and psychological perspectives on training effectiveness, contributing to both human resource development and organizational psychology literature. From a practical perspective, this research addresses urgent industry needs for evidence-based training optimization strategies that maximize return on investment while supporting sustainable competitive advantage.

This study employs a mixed-methods approach, combining quantitative analysis with qualitative exploration, using Company J, a leading engineering consulting firm in Shandong Province, China, as a case study. While this single-organization focus provides opportunities to examine training dynamics in depth, it also presents limitations for generalizability that must be acknowledged. The mixed-methods design enables both breadth of coverage across organizational contexts and depth of insight into specific mechanisms underlying training effectiveness[12]. The findings provide engineering consulting firms with specific strategies for optimizing training systems through coordinated attention to both environmental conditions and psychological enablers, while contributing to broader understanding of knowledge worker development in professional service contexts.

2. Literature review

2.1. Environmental factors in knowledge worker training

The effectiveness of training systems for knowledge workers is significantly influenced by environmental factors, which encompass physical, organizational, and social dimensions. Recent research has emphasized the critical role of environmental conditions in determining training outcomes, particularly in knowledge-intensive industries such as engineering consulting.

Physical environmental factors constitute the foundational infrastructure for effective training delivery. Industry 4.0 transformation requires comprehensive reskilling initiatives, with an estimated 50% of employees needing new competencies by 2025[13]. This technological evolution necessitates advanced physical training environments equipped with digital tools and platforms. A systematic literature review identified four broad themes affecting online training transfer, including computer literacy and digital infrastructure as fundamental requirements. Organizations increasingly adopt online training for cost efficiency and flexibility, making technological infrastructure a critical environmental consideration. Training management systems can significantly enhance accessibility and convenience for professionals, particularly in technical fields where specialized equipment and software are essential[14].

Organizational environmental factors represent perhaps the most influential dimension affecting training effectiveness. Project-driven companies face significant challenges in workforce planning, with lack of standardized processes leading to misalignment in talent development approaches. Research across ten project-based enterprises revealed that organizational support mechanisms, resource allocation, and management commitment are fundamental determinants of training success. A comprehensive systematic review revealed that inclusive talent development, when coupled with organizational support, significantly affects individual growth and organizational performance[11]. Organizations often focus on exclusive talent development rather than nurturing talent inclusively, highlighting the importance of organizational culture and support systems in training effectiveness.

The temporal dimension of organizational support proves particularly critical in project-driven environments. Comprehensive engineering consulting companies implementing whole-process consulting require continuous professional development support throughout project lifecycles. The Technology Acceptance Model demonstrates that organizational digital management significantly influences knowledge transfer willingness in engineering consulting projects. Structural equation modeling results show that perceived usefulness and perceived ease of use mediate the relationship between digital management and knowledge transfer willingness, emphasizing the importance of organizational technological support.

Social environmental factors extend beyond immediate organizational boundaries to encompass professional networks and industry communities. Consulting firms with different project experience configure dynamic capabilities differently, with firms having richer experience relying less on external opportunity sensing but maintaining commitment to external integration and collaborative learning[15]. This research highlights the importance of external professional networks in supporting internal training initiatives. Daily social support exchange patterns in hierarchical organizations show four distinct support exchange profiles that differently affect employee need satisfaction and emotional exhaustion[16]. Multilevel latent profile analysis revealed that over-reciprocating support patterns yield the highest levels of autonomy and relatedness satisfaction.

The integration of environmental factors creates complex systems that influence training effectiveness. Different forms of work-related learning show that informal learning positively relates to internal employability, while self-regulated learning links to external employability[17]. Formal training surprisingly showed no significant contribution to employability, suggesting that environmental factors supporting informal and self-regulated learning may be more critical than traditional formal training environments. This finding has particular relevance for engineering consulting, where project-based learning and client interaction provide rich informal learning opportunities.

2.2. Social psychological perspectives on training systems

Social psychological factors play increasingly important roles in determining training effectiveness, particularly in knowledge-intensive professional environments. Contemporary research has identified self-efficacy, social identity, and psychological safety as critical psychological determinants of training participation, engagement, and transfer.

Self-efficacy serves as a fundamental predictor of training outcomes, functioning as a key mediator between organizational support and performance outcomes[3]. Knowledge workers who communicate and mutually support each other are more inclined to share knowledge and best practices, suggesting that self-efficacy operates within social contexts rather than as an isolated individual characteristic. Manager support plays a crucial role in linking learning to performance through self-efficacy enhancement[18]. A coaching analogy framework identifies three critical dimensions of support—direct assistance, guidance, and emotional support—that collectively build employee confidence in applying new competencies.

The development of self-efficacy in knowledge work contexts requires particular attention to the complexity and ambiguity inherent in professional tasks. Expert panel research identified critical thinking, interpersonal skills, and digital capabilities as key competencies required in the modern economy. Knowledge workers must continuously adapt to evolving requirements, making self-efficacy development an ongoing process rather than a one-time training outcome. Project managers conceptualized as knowledge workers require specific competency combinations for effective project management in developing countries. This research highlights how self-efficacy beliefs influence the acquisition and application of both technical and soft skills in complex professional environments.

Psychological safety has gained prominence as a critical factor in knowledge worker training and development. Contemporary workplaces require psychological safety more than ever, yet psychologically safe environments remain rare in practice[19]. The concept describes a shared belief that teams are safe for interpersonal risk-taking, including asking questions, seeking feedback, and experimenting with new approaches. Large-scale research involving over 2,000 employed adults confirms that workers in psychologically safe environments report notably different experiences in terms of job satisfaction, performance, and productivity.

However, psychological safety research has revealed important boundary conditions and complexities. A longitudinal study using over 170,000 survey responses found that psychological safety is not universally beneficial for organizational performance[20]. The best conditions for organizational performance occur when psychological safety is relatively low and felt accountability is relatively high, suggesting that these two workplace climate dimensions interact in complex ways over time. This finding has important implications for training system design, indicating that creating psychologically safe learning environments must be balanced with appropriate performance expectations and accountability mechanisms.

Social identity factors significantly influence training engagement and knowledge transfer in professional contexts. The dynamic relationship between knowledge management processes and project success shows that knowledge worker satisfaction mediates this relationship[21]. Professional identity strength affects how workers respond to training initiatives and organizational support. A holistic framework for knowledge worker productivity identifies organizational commitment and engagement as key components influenced by professional identity development[22].

The intersection of individual psychological factors with organizational and social environments creates complex dynamics that affect training outcomes. Knowledge-based dynamic capabilities and knowledge worker productivity in professional service firms show that organizational culture moderates the relationship between knowledge capabilities and productivity[23]. Adaptability, consistency, involvement, and mission-oriented cultures differently influence how psychological factors translate into performance outcomes. Knowledge-based human resource management practices reveal that only knowledge-based recruiting practices have direct effects on organizational performance, while other practices require mediating psychological mechanisms to achieve effectiveness[24].

2.3. Training evaluation and transfer mechanisms

Effective training systems require comprehensive evaluation approaches that capture both immediate learning outcomes and long-term transfer to workplace performance. Contemporary research has advanced beyond traditional evaluation models to examine the complex mechanisms through which training translates into organizational capability and competitive advantage.

As illustrated in **Figure 1**, Kirkpatrick has four subsequent evaluation levels: reaction (satisfaction among participants), learning (knowledge and skills gained), behavior (application in work life), and results (effect on organization)[25]. A bibliometric analysis covering 60 years of research applications confirms the model's enduring influence while identifying areas for enhancement[26]. While the Kirkpatrick model provides essential evaluation structure, contemporary training challenges require additional considerations of informal learning, social embedding, and organizational transformation processes.

Figure 1. Kirkpatrick's four-level training evaluation model

Modern evaluation approaches increasingly emphasize the role of social support and organizational context in training transfer. A mixed-method analysis examining social support, training transfer, and knowledge sharing relationships among 541 employees revealed that both peer and supervisor support function as critical antecedents for training transfer and knowledge sharing, with motivation and volition serving as key mediators[10]. Training impact extends beyond individual skill acquisition to encompass organizational knowledge creation and sharing processes. Qualitative investigation of knowledge networks before and after training shows that participants primarily gain new contacts within their own organizations, and that training transfer predicts changes in professional network structure.

The complexity of training transfer mechanisms has led researchers to examine organizational and technological factors that facilitate or inhibit knowledge application. Research investigating the impact of automation and knowledge workers on employee outcomes found that knowledge transfer mediates the relationship between technological automation and both employee creativity and innovative performance[27]. Partial least squares structural equation modeling demonstrates that automation, when properly integrated with knowledge worker capabilities, enhances organizational innovation through effective knowledge transfer processes.

Training effectiveness measurement has evolved to incorporate broader organizational and industry-level factors. Research examining factors influencing training evaluation effectiveness across 207 Czech organizations found that systematic evaluation processes depend on business sector, organizational structure, human resource department existence, and organizational size[28]. Organizations prefer subjective evaluation methods based on supervisor and self-assessment, but objective measurement approaches may provide more reliable indicators of training impact.

The integration of formal and informal learning processes has become increasingly important in training evaluation frameworks. Future research should examine different learning forms together rather than in isolation, emphasizing that socially embedded individual learning must extend beyond personal transfer to drive organizational transformation. This framework highlights opportunities for integrating artificial intelligence in work-related learning to foster sustainable learning practices, linking individual learning pathways to organizational capability development.

Industry-specific evaluation considerations have gained attention as researchers recognize that generic training models may not adequately address sector-specific requirements. A digital triplet approach for empowering production systems consultants through on-the-job training support demonstrates that formalized training approaches describing skilled consultant improvement processes can effectively transfer traditionally difficult-to-transfer knowledge[29]. This finding has particular relevance for engineering consulting, where tacit knowledge and experience-based expertise constitute critical professional capabilities.

The measurement of training effectiveness increasingly incorporates longer-term organizational outcomes and competitive advantage indicators. A comprehensive review of 100 years of training and development research identifies critical trends including greater consideration of trainee characteristics, training context, and learning that occurs outside formal classroom settings[9]. This analysis emphasizes the need for evaluation approaches that capture training's impact across different organizational levels and extended time periods.

Contemporary training evaluation must also address the challenges posed by rapid technological change and evolving work structures. The research collectively suggests that effective training systems require integrated evaluation approaches that combine immediate learning assessment with longer-term transfer measurement, organizational capability development, and strategic competitive advantage achievement. This comprehensive evaluation perspective provides the foundation for understanding how environmental and social psychological factors interact to influence training effectiveness in knowledge-intensive professional environments.

3. Research methodology

3.1. Research design

This study adopted a mixed-methods approach, combining quantitative and qualitative research strategies to provide a comprehensive understanding of the complex factors influencing training effectiveness. The sequential explanatory design began with a quantitative survey followed by in-depth interviews to elaborate on survey findings. This approach enabled both breadth of coverage across the organization and depth of insight into specific contextual factors affecting training systems.

The research framework integrated environmental and social psychological perspectives, establishing relationships between core variables. The model posits that physical, organizational, and social environmental factors interact with psychological factors (self-efficacy, social identity, and psychological safety) to influence training outcomes across multiple evaluation levels. This integrative framework extends previous models by examining the moderating effects of psychological variables on environmental influences.

The study employed Partial Least Squares Structural Equation Modeling (PLS-SEM) for several methodological reasons. The research has a predictive orientation, focusing on explaining variance in training outcomes rather than confirming a specific theoretical model. The sample size of 200 is adequate for PLS-SEM analysis with multiple constructs and interaction effects. The conceptual model includes interaction terms between environmental and psychological factors, which are effectively handled through PLS-SEM's product indicator approach. Additionally, the analytical framework treats each environmental and psychological factor as an independent first-order construct, providing specific insights for practitioners regarding individual intervention targets.

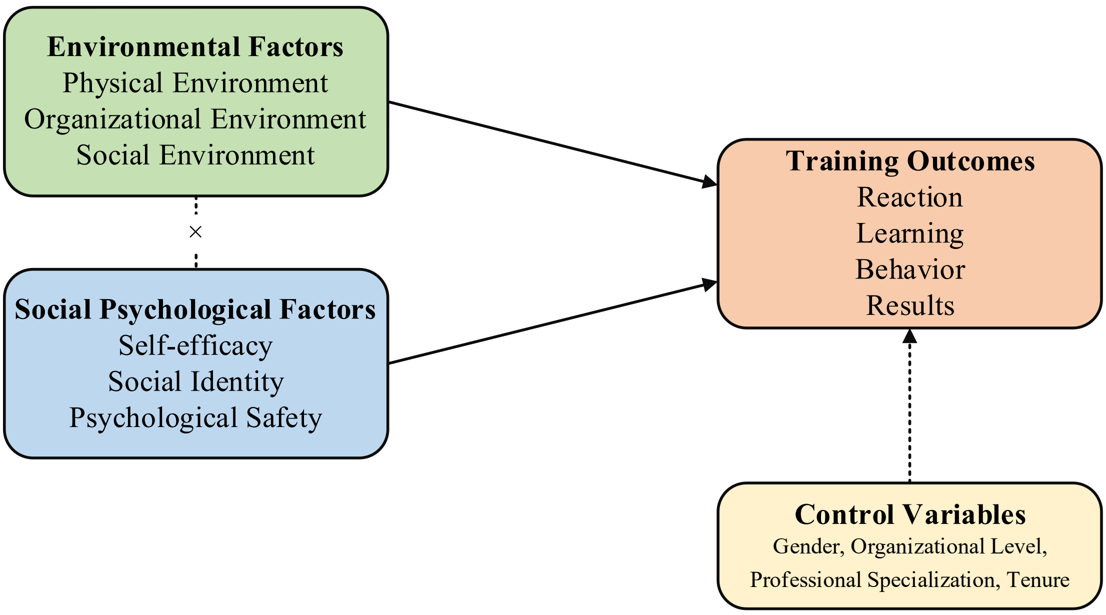

Figure 2. Integrated research framework for environmental and social psychological factors in training effectiveness

As shown in **Figure 2**, the research framework conceptualizes environmental and psychological factors as both independent and interrelated influences on training outcomes. While the conceptual framework organizes variables into environmental and psychological domains for theoretical clarity, the empirical analysis treats each construct as an independent first-order factor. This methodological choice enables precise identification of specific influences on training effectiveness and provides more actionable insights for practitioners regarding individual intervention targets.

3.2. Sample and data collection

This case study focused on Company J, a leading engineering consulting firm in Shandong Province, China with approximately 1,200 knowledge workers across multiple divisions. While focusing on a single organization limits generalizability, this approach enabled control of organizational culture, management style, and industry context variables that might otherwise confound results. The sampling strategy employed stratified random sampling to ensure proportional representation across organizational levels, professional specializations, and tenure categories.

The stratified sampling approach was based on the actual employee structure of Company J. According to data provided by the company's human resources department, senior management comprises 6.2% of total employees, middle management 16.8%, and professional staff 77%. The study's sample distribution closely aligns with this actual employee structure, ensuring sample representativeness. As detailed in **Table 1**, the sample comprised 200 participants with diverse professional backgrounds and organizational experiences, providing a representative cross-section of the company's knowledge worker population.

Table 1. Sample characteristics.

Characteristic	Category	Number	Percentage
Gender	Male	120	60%
	Female	80	40%
Organizational Level	Senior Management	12	6%
	Middle Management	34	17%
	Professional Staff	154	77%
Professional Specialization	Civil Engineering	68	34%
	Environmental Engineering	42	21%
	Project Management	48	24%
	Other Specializations	42	21%
Tenure in Organization	< 2 years	56	28%
	2-5 years	72	36%
	6-10 years	46	23%
	> 10 years	26	13%
Total		**200**	**100%**

The sample size was determined based on requirements for structural equation modeling analysis, considering the complexity of the proposed model with multiple constructs and interaction terms. Data collection employed multiple instruments to capture the multidimensional nature of training environments and outcomes. The primary quantitative instrument was a comprehensive questionnaire with established measurement scales for key constructs, as outlined in **Table 2**.

Prior to full-scale data collection, a pre-test was conducted with 10 participants representing different departments and organizational levels. The pre-testing process involved expert evaluation and target population feedback to ensure instrument clarity and appropriateness. The pre-test administration revealed an average completion time of 15-20 minutes, which was deemed acceptable. Based on pre-test feedback, three items were modified to improve clarity and cultural appropriateness for the Chinese engineering consulting context. The pre-test data reliability analysis showed all construct Cronbach's alpha values exceeded 0.70, indicating acceptable internal consistency.

Table 2. Measurement instruments for key constructs.

Construct	Measurement Approach	Items	Reliability (α)	AVE	CR
Physical Environment	Modified Training Environment Scale	8	0.78	0.52	0.84
Organizational Environment	Organizational Support for Training	10	0.92	0.61	0.93
Social Environment	Team Learning Climate Scale	7	0.81	0.55	0.86
Self-efficacy	Training Self-efficacy Scale	6	0.85	0.58	0.87
Social Identity	Professional Identity Scale	5	0.72*	0.48	0.79
Psychological Safety	Psychological Safety Scale	7	0.79	0.53	0.84
Training Outcomes	Modified Kirkpatrick Evaluation	16	0.84	0.57	0.89

***Note:** While the Social Identity scale's Cronbach's α = 0.72 is slightly below the 0.8 threshold, the composite reliability (CR = 0.79) and average variance extracted (AVE = 0.48) approach acceptable levels. Confirmatory factor analysis showed all factor loadings exceeded 0.6, and convergent validity was further supported through expert evaluation and correlation analysis with related constructs, confirming the scale's validity for this research context.*

As indicated in **Table 2**, the measurement scales demonstrated acceptable to excellent reliability with Cronbach's alpha values ranging from 0.72 to 0.92. The Average Variance Extracted (AVE) and Composite Reliability (CR) values provide additional evidence of construct validity and internal consistency. All items were measured using 5-point Likert scales ranging from 1 (strongly disagree) to 5 (strongly agree), except for demographic variables which used categorical measures.

Qualitative data collection involved 12 semi-structured interviews selected through purposive sampling to represent diverse perspectives across organizational levels and departments. The interview protocol explored participants' experiences with training environments, psychological responses, and perceived training effectiveness, with questions derived from the research framework. All interviews were audio-recorded with permission and transcribed for analysis.

3.3. Data analysis methods

Analysis employed both quantitative and qualitative techniques appropriate to the mixed-methods design. Quantitative analysis utilized SmartPLS 3.0 and included descriptive statistics, correlation analysis, and structural equation modeling to test relationships between environmental factors, psychological variables, and training outcomes.

Prior to conducting structural equation modeling, several prerequisite analyses were performed to ensure data quality and analytical assumptions. Data normality was assessed using the Shapiro-Wilk test and visual inspection of distribution plots. Linearity assumptions were evaluated through scatterplot analysis and correlation matrices. Multicollinearity was tested using Variance Inflation Factors (VIF), with all values below 5.0 indicating acceptable levels. Sample adequacy was confirmed through the Kaiser-Meyer-Olkin (KMO) test, which yielded a value of 0.856, exceeding the recommended threshold of 0.8. Bartlett's test of sphericity was significant ($p < 0.001$), indicating that the correlation matrix was suitable for factor analysis. Common method bias was assessed using Harman's single-factor test, which showed that no single factor accounted for more than 40% of total variance, indicating that common method bias was not a significant concern.

The PLS-SEM analysis followed a two-stage approach. First, the measurement model was evaluated to ensure reliability and validity of constructs through assessment of internal consistency reliability, convergent validity, and discriminant validity. Internal consistency was confirmed through Cronbach's alpha values exceeding 0.7 and composite reliability values above 0.7. Convergent validity was established through Average Variance Extracted (AVE) values above 0.5 and factor loadings exceeding 0.6. Discriminant validity was assessed using the Fornell-Larcker criterion and Heterotrait-Monotrait ratio (HTMT) values below 0.9.

Second, the structural model was assessed to test hypothesized relationships and examine explanatory power. The evaluation included R^2 values to assess the explanatory power of endogenous constructs, Q^2 values to evaluate predictive relevance through blindfolding procedures, and f^2 values to determine effect sizes of predictor constructs. Path coefficient significance was tested using bootstrap procedures with 5,000 subsamples. Model fit was evaluated using Standardized Root Mean Square Residual (SRMR) and Normed Fit Index (NFI). Interaction effects were modeled using the product indicator approach, creating interaction terms between relevant environmental and psychological constructs. The significance of interaction effects was assessed through bootstrap confidence intervals and simple slopes analysis.

Qualitative analysis employed thematic content analysis to identify key patterns related to the research questions. Interview transcripts were systematically coded using both deductive codes derived from the theoretical framework and inductive codes emerging from data analysis. The coding process involved three researchers independently coding a subset of transcripts to establish inter-rater reliability (Cohen's $\kappa = 0.83$), followed by collaborative coding of all transcripts. These qualitative findings were then integrated with quantitative results to provide a more comprehensive understanding of the phenomena under study.

The mixed-methods integration followed a convergent approach, where quantitative and qualitative results were analyzed separately and then merged during interpretation. Qualitative findings were used to explain and elaborate quantitative results, particularly regarding interaction effects and underlying mechanisms, providing a comprehensive understanding of how environmental and psychological factors influence training effectiveness in knowledge-intensive professional environments.

4. Research results and analysis

4.1. Descriptive statistics and correlation analysis

The descriptive statistics and correlation analysis provide preliminary insights into the relationships between environmental factors, social psychological factors, and training outcomes. **Table 3** presents the means, standard deviations, and correlations among all study variables.

Table 3. Evaluation of Physical and Organizational Environmental Factors (N=200).

Variable	Mean	SD	1	2	3	4	5	6	7
1. Physical Environment	3.68	0.87	0.78						
2. Organizational Environment	3.01	1.12	0.45**	0.92					
3. Social Environment	3.76	0.73	0.38**	0.52**	0.81				
4. Self-efficacy	3.84	0.89	0.31**	0.58**	0.42**	0.85			
5. Social Identity	3.92	0.76	0.28**	0.36**	0.51**	0.47**	0.72		

Variable	Mean	SD	1	2	3	4	5	6	7
6. Psychological Safety	3.45	0.94	0.41**	0.61**	0.68**	0.52**	0.39**	0.79	
7. Training Outcomes	3.58	0.82	0.35**	0.67**	0.54**	0.71**	0.43**	0.58**	0.84

Table 3. (*Continued*)

Note: *Diagonal values are Cronbach's α coefficients; **p < 0.01*

As shown in **Table 3**, all constructs demonstrated acceptable reliability with Cronbach's alpha values ranging from 0.72 to 0.92. The correlation analysis revealed significant positive relationships between all variables and training outcomes, with organizational environment showing the strongest correlation ($r = 0.67$, $p < 0.01$), followed by self-efficacy ($r = 0.71$, $p < 0.01$) and psychological safety ($r = 0.58$, $p < 0.01$). Physical environment showed the weakest but still significant correlation with training outcomes ($r = 0.35$, $p < 0.01$).

The correlation matrix also revealed moderate to strong intercorrelations among predictor variables, ranging from 0.28 to 0.68, indicating potential multicollinearity concerns. However, variance inflation factor (VIF) analysis confirmed that all VIF values were below 3.5, well within acceptable limits for regression analysis.

4.2. Measurement model evaluation

Before examining structural relationships, the measurement model was rigorously evaluated to ensure construct reliability and validity. **Table 4** presents the comprehensive assessment results for all constructs.

Table 4. Measurement model assessment

Construct	Items	Factor Loadings Range	Cronbach's α	CR	AVE	HTMT (Max)
Physical Environment	8	0.62-0.84	0.78	0.84	0.52	0.73
Organizational Environment	10	0.71-0.91	0.92	0.93	0.61	0.84
Social Environment	7	0.68-0.86	0.81	0.86	0.55	0.79
Self-efficacy	6	0.69-0.88	0.85	0.87	0.58	0.76
Social Identity	5	0.61-0.79	0.72	0.79	0.48	0.68
Psychological Safety	7	0.67-0.83	0.79	0.84	0.53	0.81
Training Outcomes	16	0.64-0.87	0.84	0.89	0.57	0.85

Note: *CR = Composite Reliability; AVE = Average Variance Extracted; HTMT = Heterotrait-Monotrait ratio*

The measurement model evaluation demonstrated satisfactory psychometric properties. All factor loadings exceeded the minimum threshold of 0.6, with most loadings above 0.7, indicating adequate item reliability. Composite reliability values ranged from 0.79 to 0.93, all exceeding the recommended 0.7 threshold. While the Social Identity construct showed a slightly lower AVE (0.48), it approached the 0.5 threshold and was retained given its theoretical importance and acceptable composite reliability.

Discriminant validity was confirmed through the heterotrait-monotrait (HTMT) criterion, with all HTMT values below 0.9, indicating that constructs are sufficiently distinct from one another. The Fornell-Larcker criterion was also satisfied, with the square root of each construct's AVE exceeding its correlations with other constructs.

4.3. Structural model results

The structural model analysis examined the direct effects of environmental and social psychological factors on training outcomes. **Figure 3** illustrates the standardized path coefficients and their significance levels in the structural model.

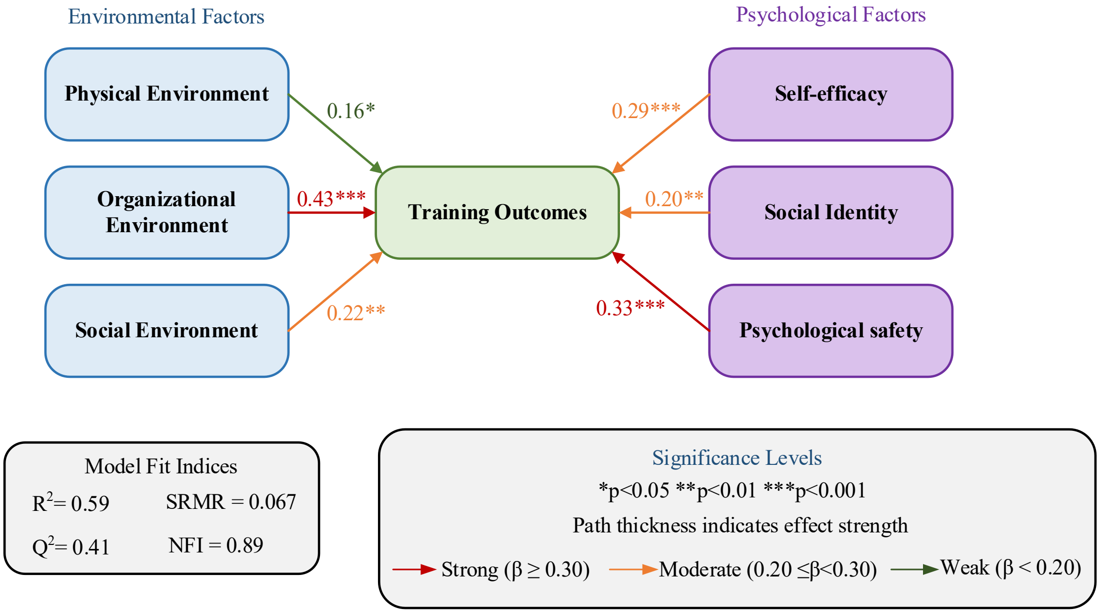

Figure 3. Structural model results with path coefficients

Table 5 presents the detailed results of the structural model analysis, including path coefficients, t-values, significance levels, and confidence intervals for all hypothesized relationships.

Table 5. Structural model results - direct effects.

Hypothesis	Path	β	t-value	p-value	95% CI	f²	Decision
H1a	Physical Environment → Training Outcomes	0.16*	2.34	0.019	[0.03, 0.29]	0.04	Supported
H1b	Organizational Environment → Training Outcomes	0.43***	6.78	0.000	[0.31, 0.55]	0.21	Supported
H1c	Social Environment → Training Outcomes	0.22**	3.45	0.001	[0.09, 0.35]	0.06	Supported
H2a	Self-efficacy → Training Outcomes	0.29***	4.56	0.000	[0.17, 0.41]	0.11	Supported
H2b	Social Identity → Training Outcomes	0.20**	3.12	0.002	[0.07, 0.33]	0.05	Supported
H2c	Psychological Safety → Training Outcomes	0.33***	5.23	0.000	[0.21, 0.45]	0.14	Supported

Note: *Model $R^2 = 0.59$, $Q^2 = 0.41$; *p < 0.05, **p < 0.01, ***p < 0.001; f^2 = effect size*

The structural model explained 59% of the variance in training outcomes ($R^2 = 0.59$), indicating substantial explanatory power. The Stone-Geisser Q^2 value of 0.41 confirmed adequate predictive relevance. All hypothesized direct relationships were supported, with organizational environment demonstrating the strongest effect ($\beta = 0.43$, $p < 0.001$), followed by psychological safety ($\beta = 0.33$, $p < 0.001$) and self-efficacy ($\beta = 0.29$, $p < 0.001$).

Among environmental factors, organizational environment showed the largest effect size ($f^2 = 0.21$), indicating a large practical effect, while physical environment demonstrated a small but significant effect (f^2

= 0.04). Among psychological factors, psychological safety exhibited the largest effect size (f^2 = 0.14), followed by self-efficacy (f^2 = 0.11) and social identity (f^2 = 0.05).

4.4. Interaction effects analysis

To examine the complex relationships between environmental and social psychological factors, interaction effects were tested through moderation analysis. Table 6 presents the results of the interaction effects analysis.

Table 6. Interaction effects results.

Interaction	β	t-value	p-value	95% CI	f²	Decision
Organizational Environment × Self-efficacy	0.18*	2.45	0.014	[0.04, 0.32]	0.09	Supported
Organizational Environment × Social Identity	-0.16*	-2.23	0.026	[-0.30, -0.02]	0.07	Supported
Social Environment × Psychological Safety	0.23**	3.67	0.000	[0.11, 0.35]	0.15	Supported
Physical Environment × Self-efficacy	0.11	1.67	0.095	[-0.02, 0.24]	0.03	Not Supported

Note: **p < 0.05, **p < 0.01; f^2 = effect size; Interaction model R^2 = 0.65*

The interaction analysis revealed three significant moderating effects. The interaction between organizational environment and self-efficacy was positive and significant (β = 0.18, $p < 0.05$), indicating that the effect of organizational environment on training outcomes is stronger when self-efficacy is high. Simple slopes analysis revealed that for employees with high self-efficacy (Mean + 1SD), organizational environment had a stronger effect on training outcomes (β = 0.52, $p < 0.001$) compared to those with low self-efficacy (β = 0.34, $p < 0.01$).

The interaction between organizational environment and social identity showed a significant negative effect (β = -0.16, $p < 0.05$). This negative interaction indicates that the effect of organizational environment on training outcomes is weaker for employees with stronger professional identity. Simple slopes analysis demonstrated that for employees with strong social identity (Mean + 1SD), organizational environment showed a moderate effect (β = 0.27, $p < 0.05$), while for those with weak social identity (Mean - 1SD), the effect was substantially stronger (β = 0.59, $p < 0.001$). This suggests that strong professional identity may partially compensate for lower organizational support, providing an internal source of motivation for training transfer.

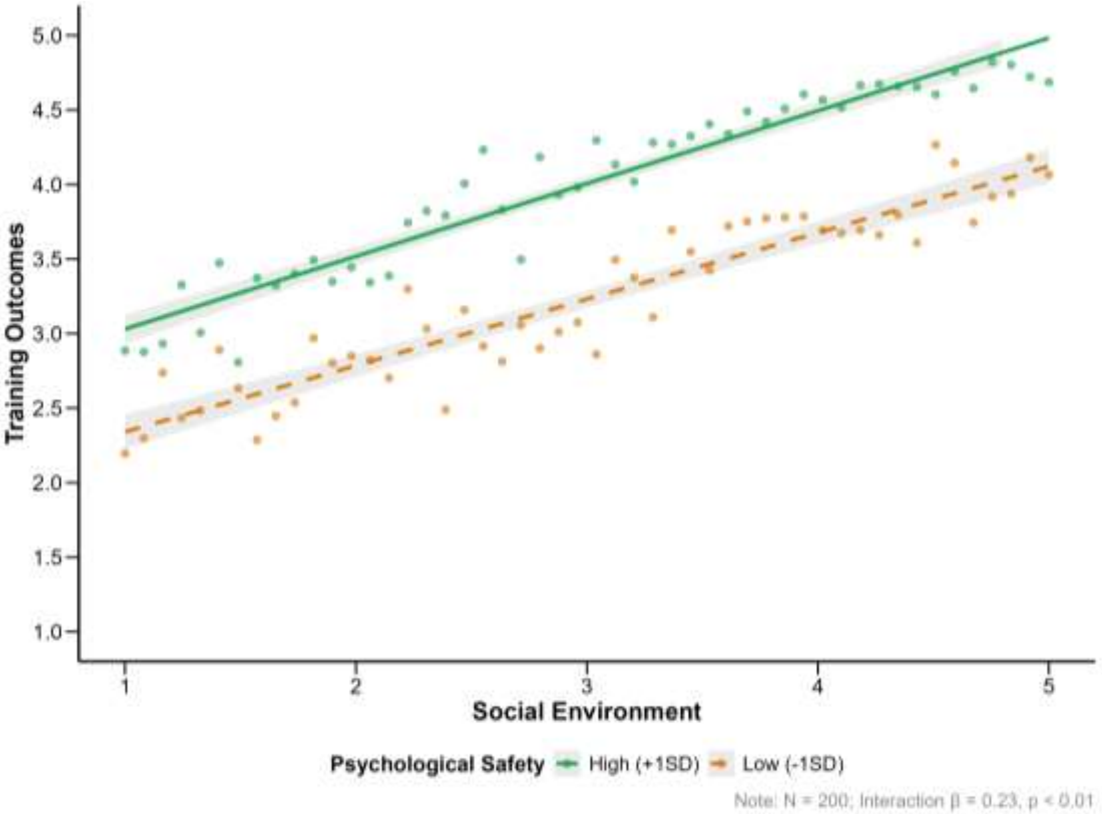

Figure 4. Interaction effect: Social environment × psychological safety

Figure 4 illustrates the interaction between social environment and psychological safety, which demonstrated the strongest interaction effect ($\beta = 0.23$, $p < 0.01$). The significant positive interaction between social environment and psychological safety indicates that when psychological safety is high, the positive effect of social environment on training outcomes is amplified. This synergistic relationship suggests that creating both supportive social learning environments and psychologically safe contexts produces particularly favorable conditions for training effectiveness.

The interaction model explained an additional 6% of variance beyond the main effects model ($\Delta R^2 = 0.06$, $p < 0.01$), bringing the total explained variance to 65%. This substantial explanatory power demonstrates the importance of considering both environmental and psychological factors together rather than in isolation when designing training systems for knowledge workers in engineering consulting contexts.

These interaction findings provide important insights for training system optimization, suggesting that environmental interventions may have differential effects depending on individual psychological characteristics, and that certain combinations of environmental and psychological factors create synergistic effects that enhance training effectiveness beyond what either factor could achieve independently.

4.5. Qualitative findings

The thematic analysis of 12 semi-structured interviews revealed key insights that support and elaborate the quantitative findings. Three main themes emerged: environmental influence mechanisms, psychological response patterns, and training transfer facilitators.

Regarding environmental factors, participants consistently emphasized the critical role of management support in creating enabling training conditions. A senior engineer noted: "Physical facilities are adequate, but what really matters is whether your supervisor encourages you to apply what you've learned. Some managers see training as time away from billable projects and don't create opportunities for practice." This finding supports the quantitative result showing organizational environment as the strongest predictor of training outcomes.

Psychological response patterns revealed the importance of psychological safety in training participation and knowledge sharing. A junior engineer explained: "In some training sessions, I hesitate to ask questions or share experiences because I worry about looking incompetent. When facilitators create a supportive atmosphere, I learn much more." This aligns with the significant effect of psychological safety found in the structural model analysis.

The negative interaction between organizational support and social identity was illuminated through interview responses. Participants with strong professional identity demonstrated internal motivation that reduced dependence on external organizational support. A project manager stated: "Even without strong company support, my commitment to engineering excellence drives me to apply new knowledge. Professional pride motivates continuous learning." This provides context for understanding why the interaction effect was negative, suggesting that professional identity serves as a compensatory mechanism.

Training transfer facilitators included peer collaboration and external professional networks. Participants described how informal discussions with colleagues helped translate abstract training concepts into context-specific applications, supporting the quantitative findings regarding social environment effects on training outcomes.

5. Discussion

This study examined the complex relationships between environmental and social psychological factors in training effectiveness for knowledge workers in engineering consulting, revealing several important findings that advance both theoretical understanding and practical optimization strategies. The results demonstrate that training effectiveness is determined by a sophisticated interplay between environmental conditions and psychological processes, with significant interaction effects that challenge traditional single-factor approaches to training system design.

The quantitative analysis revealed a clear hierarchy of influences on training outcomes, with organizational environment emerging as the strongest predictor ($\beta = 0.43$, $p < 0.001$), followed by psychological safety ($\beta = 0.33$, $p < 0.001$) and self-efficacy ($\beta = 0.29$, $p < 0.001$). These findings align with contemporary research emphasizing the critical role of organizational support in knowledge-intensive professional environments. The qualitative interviews provided deeper context, with participants consistently emphasizing that physical facilities, while important, are secondary to management commitment and organizational culture in determining training success. As one senior engineer noted, "Physical facilities are adequate, but what really matters is whether your supervisor encourages you to apply what you've learned." This convergence of quantitative and qualitative evidence supports the prioritization of organizational environmental factors in training system optimization efforts.

The interaction effects uncovered in this research provide particularly valuable theoretical insights. The positive interaction between social environment and psychological safety ($\beta = 0.23$, $p < 0.01$) demonstrates a synergistic relationship where supportive social learning contexts amplify the benefits of psychological safety. This finding suggests that creating both collaborative learning opportunities and psychologically safe environments produces multiplicative rather than additive benefits for training effectiveness. More intriguingly, the negative interaction between organizational support and social identity ($\beta = -0.16$, $p < 0.05$) reveals a compensatory mechanism whereby strong professional identity partially mitigates the need for external organizational support. Simple slopes analysis confirmed that employees with strong professional identity maintained effective training transfer even under lower organizational support conditions ($\beta = 0.27$, $p < 0.05$), while those with weaker professional identity showed greater dependence on organizational support ($\beta = 0.59$, $p < 0.001$). This finding extends social identity theory by demonstrating how professional identification can serve as an internal motivational resource that reduces dependence on external organizational interventions.

From a theoretical perspective, this research makes several significant contributions to training and organizational learning literature. First, it establishes an integrated environmental-psychological framework that moves beyond traditional single-perspective analyses to examine the complex interdependencies between contextual and individual factors. Second, it identifies professional identity as a moderating variable that can fundamentally alter the relationship between organizational support and training outcomes, providing new insights into the boundary conditions of organizational intervention effectiveness. Third, it demonstrates the importance of considering industry-specific characteristics, particularly the project-driven nature of engineering consulting, in training system design and evaluation.

The practical implications for engineering consulting firms are substantial and actionable. Organizations should prioritize management support and time allocation policies over physical infrastructure investments, given the stronger effects of organizational factors. The significant interaction between social environment and psychological safety suggests that firms should simultaneously invest in collaborative learning structures and psychological safety initiatives rather than treating these as separate interventions[30]. For example, creating cross-functional project review sessions that explicitly encourage learning from failures can leverage both social learning mechanisms and psychological safety benefits. The negative interaction between organizational support and professional identity suggests that training approaches should be differentiated based on employees' professional identification levels. High-identity employees may benefit more from autonomous learning opportunities and professional development resources, while low-identity employees require stronger organizational scaffolding and management guidance.

The engineering consulting industry context presents unique challenges that emerged from both quantitative patterns and qualitative insights. The project-driven nature of work creates tensions between training schedules and client deliverable pressures, requiring innovative approaches such as embedded learning within project cycles. The multidisciplinary nature of engineering consulting work demands training systems that can address both technical depth and cross-functional integration capabilities. The rapid pace of technological change, particularly with Industry 4.0 developments, necessitates continuous learning systems rather than episodic training interventions.

Several limitations must be acknowledged in interpreting these findings. The single-organization case study design, while enabling deep contextual understanding, limits generalizability across different organizational cultures and industry segments[31]. The cross-sectional design prevents definitive causal inferences about the relationships identified. The self-report nature of data collection may introduce common method bias, although statistical tests suggested this was not a significant concern. The slightly lower reliability of the social identity scale ($\alpha = 0.72$) indicates the need for improved measurement instruments in future research.

Future research should extend this framework across multiple organizations and cultural contexts to establish broader generalizability. Longitudinal studies would provide stronger evidence for causal relationships and enable examination of how environmental-psychological interactions evolve over time. Investigation of additional moderating variables, such as career stage and technological orientation, could further refine the framework. Finally, experimental studies manipulating specific environmental or psychological factors could provide more definitive evidence for the causal mechanisms identified in this correlational study.

This research provides a foundation for understanding how environmental and psychological factors interact to influence training effectiveness in knowledge-intensive professional environments, offering both theoretical insights and practical guidance for optimizing training systems in the evolving landscape of engineering consulting services.

6. Conclusion

This study investigated the influence of environmental and social psychological factors on training effectiveness for knowledge workers in engineering consulting firms through an integrated theoretical framework. Using mixed-methods research with 200 participants and 12 interviews at Company J, the research revealed that training effectiveness is determined by complex interactions between environmental conditions and psychological processes rather than isolated factor influences. The findings demonstrate a clear hierarchy of effects, with organizational environment ($\beta = 0.43$) emerging as the strongest predictor of training outcomes, followed by psychological safety ($\beta = 0.33$) and self-efficacy ($\beta = 0.29$). Significantly, the study identified important interaction effects, particularly the synergistic relationship between social environment and psychological safety ($\beta = 0.23$) and the compensatory mechanism whereby professional identity moderates organizational support effects ($\beta = -0.16$). These interactions explain an additional 6% of variance beyond main effects, highlighting the importance of considering environmental and psychological factors jointly rather than separately. Theoretically, this research contributes to training and organizational learning literature by establishing an integrated environmental-psychological framework that extends beyond traditional single-perspective analyses. The identification of professional identity as a compensatory mechanism provides new insights into social identity theory applications in professional service contexts. Practically, the findings offer evidence-based strategies for engineering consulting firms to optimize training systems through coordinated attention to both environmental conditions and psychological enablers. The study's focus on a single organization limits generalizability, and future research should examine these dynamics across diverse organizational and cultural contexts. Despite these limitations, the research provides a foundation for understanding how environmental and psychological factors interact to influence training effectiveness in knowledge-intensive professional environments, offering valuable guidance for organizations seeking to enhance their training system capabilities in an increasingly competitive and rapidly evolving industry landscape.

Conflict of interest

The authors declare no conflict of interest

References

1. Ke, G., Comprehensive Engineering Consulting Company to Carry out Whole-process Consulting Research. Journal of Civil Engineering and Urban Planning, 2023. 5(9): p. 10-15.
2. Wang, Q.e. and M. Ding, A study on the impact of digital management on willingness to transfer knowledge in whole-process engineering consulting projects. Buildings, 2023. 13(4): p. 943.
3. Kintu, G.J., Theorizing knowledge worker productivity: utilizing a multi-theoretical approach. Journal of Work-Applied Management, 2025.
4. Micheli, G., et al., Workforce planning in project-driven companies: a high-level guideline. Frontiers in Industrial Engineering, 2023. 1: p. 1267244.

5. Muzam, J., The challenges of modern economy on the competencies of knowledge workers. Journal of the Knowledge Economy, 2023. 14(2): p. 1635-1671.
6. Amoah, A. and F. Marimon, Project managers as knowledge workers: competencies for effective project management in developing countries. Administrative Sciences, 2021. 11(4): p. 131.
7. Shukla, A., S. Dash, and A. Kumar, Factors affecting transfer of online training: A systematic literature review and proposed taxonomy. 2024, Wiley Online Library.
8. Association, A.P., 2024 work in America survey: psychological safety in the changing workplace. 2024.
9. Bell, B.S., et al., 100 years of training and development research: What we know and where we should go. Journal of Applied Psychology, 2017. 102(3): p. 305.
10. Mehner, L., S. Rothenbusch, and S. Kauffeld, How to maximize the impact of workplace training: a mixed-method analysis of social support, training transfer and knowledge sharing. European Journal of Work and Organizational Psychology, 2025. 34(2): p. 201-217.
11. Kaliannan, M., et al., Inclusive talent development as a key talent management approach: A systematic literature review. Human resource management review, 2023. 33(1): p. 100926.
12. Kauffeld, S., J. Decius, and C. Graßmann, Learning and transfer in organisations: how it works and can be supported. 2025, Taylor & Francis. p. 161-174.
13. Li, L., Reskilling and upskilling the future-ready workforce for industry 4.0 and beyond. Information Systems Frontiers, 2024. 26(5): p. 1697-1712.
14. Wahyuningrum, D.D., Optimization of Employee Knowledge Through Training And Course Development In Learning System Management PT. Petrokimia Gresik. 2022, Universitas Muhammadiyah Surakarta.
15. Ning, Y. and Y.H. Kwak, How do consulting firms with different project experience configure dynamic capabilities? Journal of Management in Engineering, 2022. 38(4): p. 04022029.
16. Patterer, A.S., et al., Daily receiving and providing of social support at work: identifying support exchange patterns in hierarchical data. European Journal of Work and Organizational Psychology, 2023. 32(4): p. 489-505.
17. Decius, J., M. Knappstein, and K. Klug, Which way of learning benefits your career? The role of different forms of work-related learning for different types of perceived employability. European Journal of Work and Organizational Psychology, 2024. 33(1): p. 24-39.
18. Blume, B.D., J.K. Ford, and J.L. Huang, Transfer of informal learning: The role of manager support in linking learning to performance. Business Horizons, 2024. 67(2): p. 125-136.
19. McCausland, T., Creating psychological safety in the workplace. 2023, Taylor & Francis. p. 56-58.
20. Higgins, M.C., et al., When is psychological safety helpful in organizations? A longitudinal study. Academy of Management Discoveries, 2022. 8(1): p. 77-102.
21. Shahzadi, A., et al., The dynamic relationship of knowledge management processes and project success: modeling the mediating role of knowledge worker satisfaction. Business Process Management Journal, 2021. 27(6): p. 1657-1676.
22. Óskarsdóttir, H.G., et al., Towards a holistic framework of knowledge worker productivity. Administrative sciences, 2022. 12(2): p. 50.
23. Khaksar, S.M.S., et al., Knowledge-based dynamic capabilities and knowledge worker productivity in professional service firms the moderating role of organisational culture. Knowledge Management Research & Practice, 2023. 21(2): p. 241-258.
24. Yasmin, F., et al., How does knowledge based human resource management practices enhance organizational performance? The mediating role of knowledge workers productivity. J. Infrastruct. Policy Dev, 2024. 8: p. 9383.
25. Kirkpatrick, D. and J. Kirkpatrick, Evaluating training programs: The four levels. 2006: Berrett-Koehler Publishers.
26. Alsalamah, A. and C. Callinan, The Kirkpatrick model for training evaluation: bibliometric analysis after 60 years (1959–2020). Industrial and Commercial Training, 2022. 54(1): p. 36-63.
27. Itoe Mote, N.J. and G. Karadas, The impact of automation and knowledge workers on employees' outcomes: Mediating role of knowledge transfer. Sustainability, 2022. 14(3): p. 1377.
28. Urbancová, H., et al., Effective training evaluation: The role of factors influencing the evaluation of effectiveness of employee training and development. Sustainability, 2021. 13(5): p. 2721.
29. Sato, T., S. Kondoh, and Y. Umeda, Empowering unskilled production systems consultants through on-the-job training support: A digital triplet approach. Systems, 2024. 12(5): p. 179.
30. Abdelaal, F. and B.H. Guo, Knowledge, attitude and practice of green building design and assessment: New Zealand case. Building and Environment, 2021. 201: p. 107960.
31. Edmondson, A., Psychological safety and learning behavior in work teams. Administrative science quarterly, 1999. 44(2): p. 350-383.