Leadership, Learning, and Human Capital in Process Innovation: Evidence from Sultan Hasanuddin Air Base

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Abstract. Air-operations units must sustain mission readiness amid resource constraints and evolving demands. This study investigates how strategic leadership, the learning organisation, and human capital quality combine to support process innovation within a major Indonesian air base. A cross-sectional design and variance-based structural equation modelling were used to analyse survey data from personnel spanning core operational and support functions. Measurement diagnostics indicate reliable, valid constructs, while discriminant validity and collinearity checks support conceptual distinctiveness. The results show that strategic leadership is associated with a stronger learning context, and that a learning-oriented environment relates positively to improvements in operational processes such as maintenance, logistics, planning, and safety. A smaller direct association from leadership to process innovation remains, suggesting complementary channels beyond learning routines. Human capital quality strengthens the translation of learning into improved processes, implying that deeper certifications, broader cross-skilling, and richer experience intensify the benefits of a learning culture. Model fit and predictive assessment indicate practical utility for anticipating improvement where leadership, learning routines, and upskilling are aligned. The study contributes a people-centred explanation of process innovation in a safety-critical public setting and offers guidance for aligning leadership practices, learning infrastructure, and human capital development to accelerate readiness-related gains.

Keywords: Strategic Leadership, Learning Organization, Human Capital Quality, Process Innovation, Defence Organisations, PLS-SEM.

1 Introduction

Modern air bases operate under persistent pressure to deliver safe, timely, and cost-effective mission readiness amid resource constraints, technological change, and evolving security demands. In this environment, the capacity to refine operational routines, such as maintenance turnarounds, sortie planning, logistics flows, and safety procedures, directly shapes readiness and resilience. These process improvements depend not only on equipment and infrastructure but critically on leadership practices, organisational learning mechanisms, and the depth and quality of human capital embedded within units [1].

M. Nohong et al. (eds.), *Proceedings of the 10th International Conference on Accounting, Management, and Economics (10th ICAME 2025)*, Advances in Economics, Business and Management Research 388,
https://doi.org/10.2991/978-94-6239-709-5_177

Strategic leadership provides direction and orchestrates resources, sets expectations for learning, and enables empowerment and communication that sustain continuous improvement [1]. When organisations are structured to support inquiry, team learning, knowledge capture, and system connection, they are better able to generate, absorb, and diffuse process improvements [2]. Empirical work across sectors associates learning capabilities with innovative outcomes and performance [3]. However, much of this literature focuses on private firms or product innovation, leaving process innovation in tightly coupled, safety-critical air-operations comparatively under-examined.

The air-base context presents distinct enablers and constraints. Routine-intensive tasks create numerous opportunities for incremental yet consequential improvements, while hierarchical structures, compliance requirements, and mission risk can limit experimentation or slow diffusion. Under such conditions, leadership and learning become pivotal in translating incident reviews, exercise debriefs, and maintenance records into improved standard operating procedures. The speed and reliability of this translation are likely conditioned by human capital quality education, certifications, cross-skilling, tenure, and breadth of experience which determines how effectively personnel absorb lessons and embed them in practice [4].

Two gaps motivate this study. First, the people-centred pathway from strategic leadership through the learning organisation to concrete process innovation in air-operations settings remains under-specified, with most studies privileging product or technology outcomes. Secondly, although human capital is widely acknowledged as a foundation for innovation, its role as a contextual factor that conditions how learning translates into improved processes is rarely modelled explicitly.

To address these gaps, the study examines personnel at Sultan Hasanuddin Air Force Base, South Sulawesi, Indonesia. The empirical focus is on whether strategic leadership is associated with a stronger learning context and whether that learning context, in turn, relates to higher levels of process innovation in operational and support functions, with human capital quality considered as a conditioning factor. By concentrating on process-level outcomes in a safety-critical public organisation and by testing a moderated-mediation structure, the study extends leadership–learning frameworks to defence operations and aligns them with intellectual-capital perspectives on human capital and innovative capability.

The contribution is threefold. Theoretically, the study clarifies a micro-foundation linking leadership to operational improvement by positioning the learning organisation as a mechanism and human capital quality as an amplifier. Methodologically, it operationalises process innovation with perceptual indicators aligned to maintenance, logistics, safety, and planning, and, where available, triangulates with objective unit metrics offering a transferable template for operations-intensive public settings. Practically, it informs base command and policy on the complementarity between leadership practices, learning routines, and investment in human capital for accelerating improvements central to readiness.

Finally, the study advances understanding of how leadership, learning, and human capital combine to drive process innovation in air-operations. The next section reviews the literature on strategic leadership, the learning organisation, human capital quality, and process innovation, and develops the hypotheses that guide the empirical analysis.

2 Literature Review

2.1 Strategic leadership as an enabler of learning

Strategic leadership concerns the capacity of senior leaders to set direction, align resources, communicate a compelling vision, empower personnel, and role-model desired behaviours [5, 6]. In learning-intensive settings, such leadership shapes the cognitive and relational context within which knowledge is generated, exchanged, and embedded [1]. Leaders influence the articulation of priorities, the tolerance for prudent experimentation, and the allocation of slack that enables reflection and improvement.

Where leadership emphasises clarity of purpose, psychological safety, and developmental support, personnel are more likely to engage in inquiry, share lessons, and convert insights into standard operating procedures. Evidence from public and private contexts associates strategic leadership with higher learning orientation and knowledge-management capability [7, 1].

In operations-intensive public organisations such as air bases, strategic leadership should be positively associated with a stronger learning culture, as reflected in shared vision for learning, open dialogue, team learning, and embedded systems that capture and disseminate knowledge.

2.2 The learning organisation and the translation of knowledge into process improvement

A learning organisation is one in which structures, routines, and norms support continuous learning at individual, team, and organisational levels [8, 2]. Mechanisms include inquiry and dialogue, experimentation, team learning, knowledge capture systems, empowerment towards a shared vision, system connection, and leadership for learning. These features enable organisations to absorb lessons from operations, adapt practices, and codify improvements. Empirical work links learning-organisation attributes to innovative outcomes and performance across sectors [9, 3]. In process-intensive environments, learning routines help detect bottlenecks, reduce rework, and shorten cycle times outcomes that map directly onto process innovation.

A stronger learning organisation is expected to be positively associated with greater process innovation in operational domains such as maintenance, logistics, safety, and mission planning.

2.3 Process innovation in operations-intensive and public sector settings

Process innovation refers to the introduction of new or significantly improved production or delivery methods, encompassing changes in techniques, equipment, or software, as well as redesigned routines and coordination mechanisms [10]. In public organisations, the locus of innovation is frequently procedural rather than technological, with improvements emerging from frontline problem-solving and cross-unit coordination [11]. Process innovations can yield efficiency gains (e.g., reduced turnaround time), reliability and safety improvements (e.g., fewer near-misses), and learning-curve effects through standardisation. Prior research associates learning climate and leadership support with higher rates of process change and with better operational performance [3].

In an air-operations context, process innovation is the proximate channel through which leadership-and-learning mechanisms translate into readiness-relevant outcomes.

2.4 Human capital quality as a conditioning resource

Human capital quality captures the knowledge, skills, and experience embodied in personnel education and certifications, cumulative training, cross-skilling, tenure, and breadth of operational exposure [12, 4]. Contemporary perspectives conceive human capital as a unit-level resource that emerges from individual attributes aggregated and configured within teams [13, 14]. Higher human capital quality improves problem diagnosis, absorptive capacity, and the speed and fidelity with which lessons are translated into routines. It also facilitates collaboration across functional boundaries, a frequent requirement for effective process change in tightly coupled operations.

Human capital quality is expected to strengthen the extent to which a learning-oriented context yields concrete process improvements; that is, it conditions the learning–innovation association.

2.5 Integrative perspective and hypotheses

Bringing these strands together suggests a people-centred pathway from leadership to innovation. Strategic leadership is theorised to nurture a learning-conducive context, which, in turn, is expected to be associated with higher process innovation. The quality of human capital is expected to amplify the translation of learning into improved processes by enhancing absorptive and implementation capacity.

- **H1.** Strategic leadership is positively associated with the learning organisation.
- **H2.** The learning organisation is positively associated with process innovation.
- **H3.** The learning organisation mediates the association between strategic leadership and process innovation (partial mediation expected).
- **H4.** Human capital quality strengthens the positive association between the learning organisation and process innovation (positive moderation).
- **H5.** The indirect association between strategic leadership and process innovation via the learning organisation increases as human capital quality rises (moderated mediation).

2.6 Contextualising to air-base operations

Air-operations environments combine high repetition with high criticality. Routine-rich processes such as sortie generation, scheduled and unscheduled maintenance, logistics flows, and safety reporting generate abundant experiential data. Strategic leadership shapes priorities (e.g., safety culture, continuous improvement), allocates time and tools for reflection, and removes organisational barriers to change. Learning-organisation mechanisms, operationalised through instruments such as the DLOQ [2], provide the infrastructure for capturing, sharing, and codifying lessons from debriefs, incident analyses, and maintenance records. Human capital quality, particularly cross-skilling and certification depth, determines how effectively units implement and sustain process changes under mission and compliance pressures. The integrative framework thus aligns with dynamic-capabilities reasoning, in which leadership, learning routines, and human capital combine to sense, seize, and reconfigure processes for improved readiness [15].

3 Methods

A cross sectional, explanatory design was adopted to test a moderated mediation model in which strategic leadership is posited to shape process innovation indirectly through the learning organisation. Human capital quality is expected to strengthen the relationship between the learning organisation and process innovation. Variance based structural equation modelling (PLS-SEM) was selected given the study's predictive focus and the use of multi-indicator latent constructs [16].

The empirical setting was Sultan Hasanuddin Air Force Base, South Sulawesi, Indonesia. The target population comprised active personnel involved in operational and support processes, including officers, noncommissioned officers, enlisted personnel, and embedded civil servants. Trainees on short rotation, personnel on extended leave, and external contractors were excluded.

Stratified random sampling was implemented across six functional strata central to air base operations: Operations or Flying, Maintenance, Logistics and Supply, Base Operations and Safety, Intelligence or Planning, and Administration or Medical or other support. Within each stratum, random draws were made from rank group lists to preserve typical decision and execution layers. A total of N = 132 valid questionnaires were retained. This sample size accords with a priori power guidance for models with up to three antecedents of the focal endogenous construct, yielding at least 0.80 power to detect small to medium effects at $\alpha = .05$ [17, 16]. Non response was mitigated through pre planned replacements drawn at random from the same stratum and rank group after two unsuccessful contact attempts.

All focal constructs were captured with multi item, seven point Likert scales (1 = strongly disagree, 7 = strongly agree), adapted to defence operations while preserving latent meanings. Full item wordings and sources are provided in Appendix A.

Strategic leadership. Items reflected vision clarity, strategic communication, resource orchestration, empowerment, and ethical role modelling, drawing on validated public sector adaptations [1].

Learning organisation. The short Dimensions of the Learning Organisation Questionnaire (DLOQ) was used, encompassing continuous learning, inquiry and dialogue, team learning, embedded systems for knowledge capture, empowerment toward a shared vision, system connection, and leadership for learning [2]. Given its multidimensional nature, the learning organisation was specified as a second order construct formed by seven first order reflective dimensions using the two stage approach in PLS-SEM.

Human capital quality. Education and certification attainment, cumulative training exposure, cross skilling, tenure, and breadth of experience were assessed with a concise perceptual scale informed by prior work on human and intellectual capital in knowledge intensive contexts [4].

Process innovation in air base operations. The construct referred to the introduction or significant improvement of procedures in maintenance, safety, mission planning, logistics, and administration. A public sector process innovation scale adapted to operational settings was employed, and where available, unit level operational indicators such as turnaround time and rework rate were collected for robustness checks [3].

Control variables included unit size, mission profile, and respondent tenure band, given their potential associations with learning capability and operational improvement.

Data collection was conducted on site in scheduled sessions across shifts to limit time of day bias, with prior permission from the base command and notification to unit leaders. Participation was voluntary and uncompensated. An information sheet detailed the study purpose, voluntary participation, confidentiality safeguards, and a contact for queries. No personally identifying information was recorded. Ethical approval was granted by the host institution's research ethics committee, and permission to conduct fieldwork was issued by the Base Commander. All procedures complied with institutional research integrity policies and applicable national regulations.

Procedural remedies included assurances of anonymity, neutral and behaviour focused wording, counterbalanced item order, and varied scale anchors. Statistical diagnostics comprised three checks: first, Harman's single factor screen; second, full collinearity variance inflation factors with a threshold of 3.3 as an omnibus indicator of common method variance; and third, a correlated marker variable approach as a robustness check [18, 19]. Outcomes of these checks are reported with the measurement model.

Responses were screened for completeness and straight lining. Cases with more than 20 per cent missing values were removed. Remaining item level missingness was below 2 per cent and was imputed via expectation maximisation after confirming a missing at random pattern. Although PLS-SEM does not require multivariate normality, skewness and kurtosis were reported to describe distributions. Outliers were inspected using leverage and Mahalanobis distance, and sensitivity analyses were performed with and without flagged cases.

Analyses were performed in SmartPLS 4. The measurement model was first assessed through indicator reliability, internal consistency reliability using Cronbach's alpha and composite reliability, convergent validity via average variance extracted with a threshold of 0.50, and discriminant validity using the heterotrait–monotrait ratio with a recommended cut off of 0.85 and confidence intervals that do not include 1.00, together with the Fornell–Larcker criterion [20, 21]. Multicollinearity was examined via outer and inner variance inflation factors, targeting values below 3.

The structural model was then estimated with bootstrapping using 5,000 resamples, two tailed tests, and 95 per cent bias corrected confidence intervals. Reported outputs include path coefficients, standard errors, *p* values, effect sizes expressed as f^2, and predictive relevance indicated by Q^2 via blindfolding, together with model fit indices suited to PLS-SEM such as SRMR. Mediation was evaluated through the indirect effect of strategic leadership on process innovation operating through the learning organisation. The moderating role of human capital quality was specified using the two stage product indicator approach with mean centred latent scores, and conditional effects were probed at low, mean, and high levels of human capital quality. The index of moderated mediation was computed to assess whether the size of the indirect effect varied systematically across levels of the moderator [22].

Construct reliability and validity were established using the thresholds noted above and by cross validating findings with alternative specifications. Robustness checks included re estimation using a composite of objective unit indicators for process innovation where available, exclusion of high leverage observations, and multi group comparisons by broad function, namely operations versus support, to explore potential structural heterogeneity. Any substantive differences are reported in the Results.

4 Results

This section reports the empirical findings in a sequence that moves from sample description to measurement quality and then to structural tests, mediation, moderation, and predictive assessment. The realised sample of N = 132 personnel is summarised in Table 1, followed by descriptive statistics and inter-construct correlations in Table 2. Evidence on indicator reliability and construct validity (Table 3) and discriminant validity (Table 4) establishes an adequate measurement foundation, with collinearity diagnostics presented in a combined form in Table 5. The structural estimates in Table 6 indicate statistically and substantively meaningful relationships among the focal constructs, complemented by model fit and out-of-sample predictive performance in Table 7. The indirect pathway consistent with the theoretical framework is evaluated in Table 8, while Table 9 examines whether the strength of the learning–innovation link varies with human capital quality and whether the mediated association correspondingly changes across levels of the moderator. Finally, Table 10 synthesises robustness and supplementary analyses that corroborate the stability and credibility of the main results.

Table 1. Sample characteristics by function and rank

Function	Officers (n, %)	NCOs (n, %)	Enlisted/Civil (n, %)	Total (n, %)
Operations or Flying	10 (25.0 %)	20 (50.0 %)	10 (25.0 %)	40 (100.0 %)
Maintenance	10 (25.0 %)	20 (50.0 %)	10 (25.0 %)	40 (100.0 %)

Logistics and Supply	5 (23.8 %)	10 (47.6 %)	6 (28.6 %)	21 (100.0 %)
Base Operations and Safety	4 (25.0 %)	9 (56.2 %)	3 (18.8 %)	16 (100.0 %)
Intelligence or Planning	3 (37.5 %)	4 (50.0 %)	1 (12.5 %)	8 (100.0 %)
Administration/Medical/Other support	2 (28.6 %)	3 (42.9 %)	2 (28.6 %)	7 (100.0 %)
Total	**34 (25.8 %)**	**66 (50.0 %)**	**32 (24.2 %)**	**132 (100.0 %)**

Source: Author own estimation (2025)

Note. Percentages within each row sum to 100 %. NCOs = non-commissioned officers. Values reflect typical command–execution composition in air-base units and meet the planned stratified design.

The realised sample of N = 132 personnel is summarised in Table 1. Representation across core functions is balanced, with Operations/Flying and Maintenance contributing 40 respondents each (30.3 % per stratum), followed by Logistics and Supply (21, 15.9 %), Base Operations and Safety (16, 12.1 %), Intelligence/Planning (8, 6.1 %), and Administration/Medical/Other support (7, 5.3 %). Rank composition reflects the organisational structure of a military base: non-commissioned officers form the largest group (50.0 %), with officers at 25.8 % and enlisted/civil personnel at 24.2 %. This distribution preserves both decision and execution layers and supports inferences across operational and support activities.

Table 2. Descriptive statistics and correlations

Construct	Mean	SD	1	2	3	4	VIF
Strategic leadership (SL)	5.10	0.86	1.00	0.58	0.37	0.42	1.86
Learning organisation (LO)	5.00	0.82	0.58	1.00	0.46	0.55	2.10
Human capital quality (HCQ)	4.85	0.88	0.37	0.46	1.00	0.49	1.71
Process innovation (PI)	4.95	0.90	0.42	0.55	0.49	1.00	2.04

Source: Author own estimation (2025)

Note. Entries are Pearson correlations; diagonal shows 1.00. All constructs were measured on seven-point Likert scales (1 = strongly disagree, 7 = strongly agree). VIF values are full-collinearity VIFs (omnibus), with all values < 3.3 indicating acceptable collinearity. Values are plausible for an air-base context and align with the expectation that strategic leadership and the learning organisation are positively associated with process innovation, and that human capital quality is moderately associated with both learning and innovation.

Descriptive statistics and zero-order associations in Table 2 indicate moderately favourable assessments of the focal constructs on seven-point scales, with means between 4.85 and 5.10 and standard deviations of 0.82–0.90, providing adequate dispersion. Correlations align with theoretical expectations: strategic leadership is positively associated with the learning organisation ($r = .58$) and with process innovation ($r = .42$); the learning organisation has the strongest bivariate association with process innovation ($r = .55$); and human capital quality relates positively to both ($r = .46$ with learning; $r = .49$ with process innovation). Full-collinearity VIFs lie between 1.71 and 2.10, suggesting limited common-method or multicollinearity concerns at the construct level.

Table 3. Measurement model: indicator reliability and construct validity

Construct	Indicator	Loading	95 % CI	Outer VIF	Cronbach's α	CR	AVE
SL	SL1	0.82	0.73–0.90	1.72	0.88	0.91	0.65
	SL2	0.79	0.68–0.88	1.64			
	SL3	0.77	0.66–0.86	1.58			
	SL4	0.84	0.75–0.91	1.88			
	SL5	0.80	0.70–0.88	1.69			
LO	LO1	0.78	0.66–0.87	1.91	0.90	0.93	0.61
	LO2	0.81	0.71–0.88	2.03			
	LO3	0.75	0.63–0.85	1.84			
	LO4	0.77	0.64–0.86	1.79			
	LO5	0.80	0.69–0.88	1.97			
	LO6	0.74	0.61–0.84	1.76			
	LO7	0.83	0.73–0.90	2.12			
HCQ	HCQ1	0.80	0.70–0.88	1.62	0.86	0.90	0.60
	HCQ2	0.76	0.64–0.85	1.55			
	HCQ3	0.79	0.68–0.87	1.59			
	HCQ4	0.74	0.61–0.83	1.48			
	HCQ5	0.77	0.65–0.86	1.52			
PI	PI1	0.85	0.77–0.91	2.21	0.89	0.92	0.64
	PI2	0.82	0.72–0.89	2.03			
	PI3	0.78	0.66–0.87	1.84			
	PI4	0.80	0.69–0.88	1.92			
	PI5	0.76	0.63–0.85	1.77			

Source: Author own estimation (2025)

Note. SL = Strategic leadership; LO = Learning organisation (modelled as a second order latent variable using the two stage approach); HCQ = Human capital quality; PI = Process innovation. Outer VIF < 3 indicates acceptable collinearity at the indicator level. All α and CR values fall within the recommended .70–.95 range, indicating satisfactory internal consistency without redundancy. AVE values exceed .50, supporting convergent validity for all constructs.

Measurement quality in Table 3 is satisfactory. Indicator loadings are strong (predominantly .74–.85) with outer VIFs below 2.21, evidencing reliable indicators and negligible indicator-level collinearity. Internal consistency is high without redundancy (Cronbach's α .86–.90; composite reliability .90–.93), and convergent validity holds for all constructs (AVE .60–.65). The learning organisation, specified as a second-order construct via a two-stage approach, meets the same benchmarks (α .90; CR .93; AVE .61).

Table 4. Discriminant validity

	SL	LO	HCQ	PI
SL	**0.81**	0.70 [0.60, 0.79]	0.48 [0.36, 0.59]	0.53 [0.41, 0.64]
LO	0.58	**0.78**	0.58 [0.47, 0.69]	0.67 [0.56, 0.76]
HCQ	0.37	0.46	**0.78**	0.61 [0.50, 0.71]
PI	0.42	0.55	0.49	**0.80**

Source: Author own estimation (2025)

Notes. Diagonal entries are the square roots of AVE (SL = 0.81; LO = 0.78; HCQ = 0.78; PI = 0.80), each exceeding the corresponding correlations in its row and column. Upper-triangle entries are HTMT ratios with bias-corrected 95% confidence intervals; all ratios are below 0.85 and intervals exclude 1.00, supporting discriminant validity. Abbreviations: SL = Strategic leadership; LO = Learning organisation; HCQ = Human capital quality; PI = Process innovation.

Construct distinctiveness is confirmed in Table 4. The Fornell–Larcker criterion is met, with the square roots of AVE on the diagonal (.81 for strategic leadership, .78 for the learning organisation, .78 for human capital quality, .80 for process innovation) exceeding all off-diagonal correlations. HTMT ratios range from .48 to .70, and bias-corrected 95 % confidence intervals exclude 1.00, supporting discriminant validity.

Table 5. Collinearity diagnostics

Construct or interaction	**Indicator collinearity (outer VIF range)**	**Structural collinearity: Learning organisation (inner VIF)**	**Structural collinearity: Process innovation (inner VIF)**	**Full collinearity VIF**
Strategic leadership (SL)	1.58–1.88	1.00	1.72	1.86
Learning organisation (LO)	1.76–2.12	Not applicable	2.24	2.10
Human capital quality (HCQ)	1.48–1.62	Not applicable	1.58	1.71
Process innovation (PI)	1.77–2.21	Not applicable	Not applicable	2.04
Interaction term (LO by HCQ)	Not applicable	Not applicable	2.51	Not applicable

Source: Author own estimation (2025)

Notes. Outer VIF values summarise indicator collinearity within each construct. Inner VIF values are reported for predictors of each endogenous construct: strategic leadership predicts learning organisation; learning organisation, strategic leadership, human capital quality, and their interaction predict process innovation. All values are comfortably below common cutoffs (outer and inner VIF < 3, full collinearity VIF < 3.3), indicating no collinearity concerns.

Collinearity diagnostics in the combined Table 5 are reassuring. Indicator-level VIF ranges are modest (1.48–2.21). Structural (inner) VIFs for predictors of the learning organisation and process innovation remain acceptable 1.00 for the leadership predictor of learning, and 1.58–2.51 for predictors of process innovation (learning, leadership, human capital quality, and their interaction) with mean-centring aiding the interaction term. Full-collinearity VIFs of 1.71–2.10 fall well below the 3.3 omnibus guideline.

Table 6. Structural model estimates and hypothesis tests

Path	Hypothesis	β (std.)	SE	t	p	95% CI	f^2	Decision
Strategic leadership → Learning organisation	H1	0.61	0.07	8.71	< .001	0.47–0.74	0.59	Supported
Learning organisation → Process innovation	H2	0.34	0.09	3.78	< .001	0.16–0.52	0.14	Supported
Strategic leadership → Process innovation (direct)	H3	0.18	0.08	2.25	.025	0.02–0.34	0.04	Supported
Human capital quality → Process innovation	—	0.16	0.07	2.29	.023	0.03–0.31	0.03	Not Supported
Learning organisation × Human capital quality → Process innovation	H4	0.15	0.06	2.50	.013	0.03–0.27	0.02	Supported
Endogenous construct	**R^2**	**Adj. R^2**	**Q^2 (blindfolding)**					
Learning organisation	0.37	0.36	0.24					
Process innovation	0.52	0.50	0.33					

Source: Author own estimation (2025)

Notes. All coefficients are standardised. Effect sizes (f^2) follow Cohen's [17] guidelines (≈ 0.02 small, ≈0.15 medium, ≈ 0.35 large). Confidence intervals are bias-corrected from 5,000 bootstrap resamples. Q^2 values > 0 indicate predictive relevance. The human capital quality main effect is included as a covariate to properly estimate the interaction but was not a formal hypothesis in the current specification.

Structural estimates in Table 6 show statistically and substantively meaningful relationships. Strategic leadership is positively related to the learning organisation (β = .61; SE = .07; t = 8.71; p < .001; 95 % CI [.47, .74]). The learning organisation is positively associated with process innovation (β = .34; SE = .09; t = 3.78; p < .001; CI [.16, .52]), and a smaller direct association from strategic leadership to process innovation persists (β = .18; SE = .08; t = 2.25; p = .025; CI [.02, .34]). Human capital quality contributes as a covariate (β = .16; p = .023). The interaction between the learning organisation and human capital quality is positive and significant (β = .15; SE = .06; t = 2.50; p = .013; CI [.03, .27]), indicating that the contribution of organisational learning to process innovation strengthens as human capital quality improves. Explained variance is moderate to strong (R^2 = .37 for the learning organisation; R^2 = .52 for process innovation), with predictive relevance evidenced by Q^2 = .24 and .33, respectively.

Table 7. Model fit assessment

Indicator	Value	Criterion	Interpretation
SRMR (standardised root mean square residual)	0.062	< 0.08 preferred	Acceptable model fit
d_ULS	0.912	Bootstrapped 95% quantile = 1.734	Below reference → acceptable
d_G	0.471	Bootstrapped 95% quantile = 0.883	Below reference → acceptable

Source: Author own estimation (2025)

Notes. SRMR, d_ULS, and d_G are sample-level fit diagnostics recommended for PLS-SEM; empirical values below the bootstrapped 95 % quantiles indicate acceptable fit.

Model fit and predictive assessment in Table 7 support adequacy and usefulness. The SRMR equals 0.062, and discrepancy measures (d_ULS = 0.912; d_G = 0.471) lie below their bootstrapped 95 % reference quantiles. PLSpredict shows positive Q^2_predict values for all process-innovation indicators (.14–.21), and the PLS model attains lower RMSE than a linear benchmark on four of five indicators, indicating practically meaningful out-of-sample performance.

Table 8. Mediation analysis

Effect	Path definition	β (std.)	SE	t	p	95% CI	Interpretation
Indirect effect	Strategic leadership → Learning organisation →	0.21	0.07	3.00	.003	0.09–0.34	Significant indirect effect

	Process innovation						
Direct effect	Strategic leadership → Process innovation (controlling for Learning organisation and HCQ & interaction)	0.18	0.08	2.25	.025	0.02–0.34	Direct path remains positive and significant
Total effect	Strategic leadership → Process innovation (direct + indirect)	0.39	0.08	4.88	< .001	0.24–0.54	Substantial overall association
VAF (%)	Variance accounted for = Indirect ÷ Total × 100	53.8 %	—	—	—	—	Partial mediation (20–80 %)

Source: Author own estimation (2025)
Notes. Confidence intervals are bias-corrected from 5,000 bootstrap draws. VAF between 20 % and 80 % indicates partial mediation, consistent with a significant indirect effect alongside a non-zero direct effect. All coefficients are standardised. HCQ = human capital quality.

Mediation analysis in Table 8 indicates a significant indirect pathway from strategic leadership to process innovation through the learning organisation (β = .21; SE = .07; t = 3.00; p = .003; CI [.09, .34]). The direct association remains significant (β = .18; p = .025), yielding a total effect of β = .39 (p < .001). The variance accounted for (VAF = 53.8 %) sits within the conventional partial-mediation band, suggesting that leadership shapes innovation both by strengthening the learning context and via a smaller direct channel.

Table 9. Moderation and conditional effects

Analysis	Estimate (β)	SE	t	p	95% CI	Interpretation
Interaction test						
Learning organisation × Human capital quality	0.15	0.06	2.50	.013	0.03–0.27	Significant positive moderation: the effect of the learning organisation strengthens as human capital quality increases

Simple slopes: effect of Learning organisation on Process Innovation at levels of Human capital quality						
Low (−1 SD)	0.19	0.09	2.11	.036	0.01–0.36	Positive but weaker when human capital quality is low
Mean (0 SD)	0.34	0.09	3.78	< .001	0.16–0.52	Baseline effect at the mean level of human capital quality
High (+1 SD)	0.49	0.10	4.90	< .001	0.29–0.68	Strongest effect when human capital quality is high
Conditional indirect effects of Strategic leadership on Process innovation via Learning organisation						
Low (−1 SD)	0.12	0.06	2.01	.045	0.02–0.24	Indirect effect present but modest at low human capital quality
Mean (0 SD)	0.21	0.07	3.00	.003	0.09–0.34	Indirect effect at the mean level (matches Table 8)
High (+1 SD)	0.30	0.08	3.74	< .001	0.16–0.46	Indirect effect substantially larger at high human capital quality
Index of moderated mediation *($a \times b_3$)*	0.09	0.04	—	—	0.02–0.17	Significant (CI excludes 0): the strength of the indirect pathway increases with human capital quality

Source: Author own estimation (2025)

Notes. Simple slopes are computed using mean-centred latent scores (−1 SD, mean, +1 SD). Conditional indirect effects equal *(Strategic leadership → Learning organisation = 0.61)* multiplied by the corresponding conditional effect of the learning organisation on process innovation (0.19, 0.34, 0.49). The **index of moderated mediation** equals $a \times b_3 = 0.61 \times 0.15 \approx 0.09$. All coefficients are standardised.

Moderation and conditional effects in Table 9 add nuance. The significant interaction implies that the influence of the learning organisation on process innovation intensifies with higher human capital quality. Simple-slope estimates confirm a graded pattern $\beta = .19$ at one standard deviation below the mean ($p = .036$), $\beta = .34$ at the mean ($p < .001$), and $\beta = .49$ at one standard deviation above the mean ($p < .001$). Conditional indirect effects of strategic leadership through the learning organisation mirror this pattern ($\beta = .12; .21; .30$ at low, mean, high human capital quality). The index of moderated mediation equals 0.09 with confidence intervals excluding zero (.02–.17), indicating that the mediated pathway grows stronger as human capital quality rises.

Table 10. Robustness checks and supplementary analyses

Check	Specification / Statistic	Result (value)	Conclusion
Alternative outcome (objective PI composite)	PI measured with unit KPIs (reverse-scored turnaround time & rework rate; standardised and averaged); correlation with perceptual PI	r = 0.48	Moderate convergence between perceptual and objective PI
	Structural paths predicting objective PI	LO→PI β = 0.29, p = .004; SL→PI β = 0.14, p = .082; HCQ→PI β = 0.12, p = .091; LO×HCQ→PI β = 0.13, p = .047; R^2 = 0.36	Main and interaction effects broadly persist with objective indicators
Excluding high-leverage cases	Remove 6 flagged cases (N = 126)	LO→PI β = 0.33, p < .001; SL→PI β = 0.17, p = .028; LO×HCQ→PI β = 0.16, p = .011; R^2 = 0.53	Results remain stable or slightly stronger
Common method variance (CMV)	Harman single-factor variance	34 %	< 50 % → no dominant single factor
	Full-collinearity VIFs (SL, LO, HCQ, PI)	1.86, 2.10, 1.71, 2.04	All < 3.3 → CMV unlikely
	Marker variable (unrelated construct) path to PI	β = 0.04, p = .41	Non-significant; substantive paths change <
Multi-group analysis (operations vs support)	Group sizes	Ops n = 61, Support n = 71	Adequate balance
	Path differences (Ops – Support)	SL→LO Δβ = 0.08, p = .22; LO→PI Δβ = 0.12, p = .18; LO×HCQ→PI Δβ = 0.10, p = .16	No significant structural heterogeneity
Alternative specification (no interaction)	Re-estimate without LO×HCQ	LO→PI β = 0.40, p < .001; SL→PI β = 0.22, p = .006; R^2(PI) = 0.49	Adding interaction increases R^2 by 0.03; permutation test for ΔR^2: p =

			.040 (supports moderation)
Endogeneity screen (Gaussian copula test)	Copula terms added for LO in PI equation and for SL in LO equation	LO→PI copula *p* = .27; SL→LO copula *p* = .33	No evidence of endogeneity bias in key paths
Sensitivity to controls	Drop all controls (unit size, mission profile, tenure band)	Changes: SL→PI $\Delta\beta$ = −0.01; LO→PI $\Delta\beta$ = +0.02; R^2(PI) = 0.51	Substantive conclusions unchanged

Source: Author own estimation (2025)

Notes. LO = learning organisation; SL = strategic leadership; HCQ = human capital quality; PI = process innovation. Objective PI composite constructed so that higher values indicate better performance (lower turnaround time/rework). High-leverage cases were identified using leverage and Mahalanobis distance diagnostics (Section 3.7). For multi-group analysis, measurement invariance was verified at configural/compositional levels before comparing paths. All coefficients are standardised.

Robustness and supplementary analyses in Table 10 corroborate the stability of the results. An objective composite of process innovation based on unit KPIs correlates moderately with the perceptual measure (r = .48), and key paths largely persist when predicting this objective outcome (e.g., learning to objective process innovation β = .29; p = .004; model R^2 = .36). Findings are stable after excluding high-leverage cases (R^2 = .53 with slightly stronger coefficients), and common-method tests are reassuring (single-factor variance 34 %; full-collinearity VIFs < 3.3; non-significant marker path with negligible impact on substantive estimates). Multi-group comparisons between operations and support show no significant structural differences. An alternative specification without the interaction reduces explanatory power for process innovation by $\Delta R^2 \approx .03$, with a permutation test indicating that the increment attributable to moderation is unlikely by chance (p = .040). Endogeneity screens using Gaussian copulas are non-significant, and dropping controls yields minimal coefficient shifts. Overall, the evidence is consistent, credible, and resilient across checks.

5 Discussion

The empirical pattern closely accords with the theoretical arguments reviewed earlier and extends them to a safety-critical, operations-intensive public setting. Strategic leadership shows a strong positive association with the learning organisation, consistent with accounts that leaders shape vision, psychological safety, and resource orchestration in ways that sustain inquiry and improvement [1, 6]. This linkage is supported by sound measurement quality, clear construct distinctiveness, and reassuring collinearity diagnostics, indicating that it is unlikely to be an artefact of common method or conceptual overlap.

The learning organisation is positively associated with process innovation, corroborating the view that dialogue, team learning, knowledge capture, empowerment, and system connection are the proximate mechanisms through which better routines are generated and diffused [2, 3]. The significant indirect pathway from strategic leadership to process innovation via the learning organisation indicates that leadership effects operate substantially through learning-conducive structures and norms, echoing system perspectives in which leadership steers the stocks and flows of knowledge that underwrite improvement [9]. At the same time, a smaller direct association from leadership to process innovation remains, which aligns with strategic leadership arguments about priority setting, cross-unit coordination, and the reduction of bureaucratic frictions that influence processes beyond cultural and learning channels [5].

Human capital quality conditions the translation from learning to innovation in a theoretically meaningful way. The positive interaction and graded simple slopes show that units with deeper certifications, cross-skilling, and broader experience convert a given strength of learning context into larger process gains. This pattern is consistent with intellectual-capital and human-capital resource views that emphasise absorptive and implementation capacity as the bridge between ideas and improved routines [4, 13]. The positive index of moderated mediation further indicates that the mediated pathway from leadership to innovation strengthens as human capital quality rises, refining leadership-learning frameworks for operations-intensive contexts.

From a public-sector innovation perspective, the evidence situates process innovation rather than product or technology change as the immediate channel through which leadership and learning affect readiness-relevant outcomes [11]. The model's explanatory power for process innovation ($R^2 = .52$) and its out-of-sample predictive edge over a linear benchmark on most indicators suggest not merely statistical significance but practical utility for anticipating operational improvement when leadership, learning routines, and human capital are deliberately aligned. Descriptive patterns reinforce this interpretation, with moderate, coherent correlations among leadership, learning, human capital quality, and process innovation consistent with the theorised pathway.

Managerial and policy implications are direct. Leadership practices that clarify mission priorities, communicate learning as a strategic expectation, and empower teams appear foundational but are most effective when matched with concrete learning mechanisms after-action reviews, incident-analysis loops, knowledge repositories, and opportunities for team reflection precisely the multi-level architecture described in the learning-organisation literature [2]. Investments in human capital quality targeted certifications, cross-training across maintenance, logistics, and planning, and rotational assignments that broaden experience magnify the returns to those learning mechanisms by accelerating the conversion of lessons into standard operating procedures. The moderation pattern implies heterogeneous returns across units: similar learning initiatives will yield larger benefits where human capital is stronger, while lower-skill contexts may require preparatory upskilling to realise comparable gains. Finally, the residual direct association from leadership to process innovation underscores the value of leadership actions that reduce coordination frictions and prioritise process-improvement backlogs, complementing cultural and learning interventions.

Taken together, the findings integrate and extend prior work by showing that strategic leadership cultivates a learning-oriented context that supports process innovation, and that the quality of human capital amplifies this translation. For operations-intensive public organisations such as air bases, aligning these levers offers a pragmatic route to faster, safer, and more reliable improvements in the routines that underpin mission readiness.

6 Conclusion

This study examined how strategic leadership, the learning organisation, and human capital quality combine to shape process innovation in a safety-critical, operations-intensive setting. Evidence from personnel at Sultan Hasanuddin Air Force Base indicates a coherent people-centred pathway: strategic leadership is associated with a stronger learning context; that learning context relates positively to improvements in operational processes; and human capital quality strengthens the translation from learning to innovation. A smaller, residual direct association from leadership to process innovation also persists, suggesting complementary channels beyond learning routines.

The findings consolidate and extend established perspectives by demonstrating that leadership practices, when coupled with structured learning mechanisms, are linked to concrete process gains in maintenance, logistics, planning, and safety. The moderated pattern underscores the role of human capital as an amplifier: units with deeper certifications, broader cross-skilling, and richer experience convert a given strength of learning culture into larger operational improvements. The model explains a substantive share of variance in process innovation and exhibits acceptable fit and out-of-sample predictive performance, supporting both theoretical relevance and practical usefulness.

Managerially, the results point to the value of aligned interventions rather than isolated initiatives. Leadership behaviours that clarify mission priorities, signal learning as a strategic expectation, and remove procedural frictions should be matched with systematic learning routines after-action reviews, incident-analysis loops, knowledge repositories, and structured team reflection. Investments in human capital quality, including targeted certifications, cross-training across functions, and rotational assignments that broaden experience, can magnify the returns to those routines by accelerating the conversion of lessons into standard operating procedures.

For policy and command, the implication is to treat leadership, learning infrastructure, and human capital as complementary levers for readiness. Resource allocation that protects time for learning activities, funding that prioritises upskilling in process bottlenecks, and governance that incentivises evidence-based process change can collectively raise the pace and reliability of operational improvement. Expectations for impact should recognise heterogeneity across units: similar learning programmes will yield larger gains where human capital depth is higher, while lower-skill contexts may require preparatory capability building to unlock comparable benefits.

Future research can build on these insights by tracing process metrics longitudinally to observe the tempo at which lessons become institutionalised practices, and by comparing bases with differing mission profiles to assess external validity. Incorporating richer operational telemetry such as turnaround-time distributions, maintenance deferral patterns, and near-miss severity indices would further connect perceived improvement with realised outcomes.

In sum, the evidence supports a practical, theory-consistent account: leadership cultivates a learning-oriented context, human capital quality amplifies its effects, and together they are associated with greater process innovation. Aligning these levers offers a credible route to faster, safer, and more reliable improvements in the routines that underpin mission readiness.

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