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Impact of Training, Education, and Physical Work Environment on Employee Productivity: Insights from the Public Works Office

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ABSTRACT

Purpose of the study: This study investigates the impact of job training, formal education, and physical work environment on employee productivity at the Public Works Office in Lubuk Pakam, Indonesia. The research addresses critical gaps in understanding how these human resource development factors synergistically influence organizational performance in public sector institutions.

Materials and methods: A quantitative research design was employed with a saturated sampling technique involving all 75 employees at the Public Works Office in Lubuk Pakam. Data were collected using validated questionnaires with Likert scale measurements. The instruments demonstrated high reliability (Cronbach's Alpha: 0.964 for training, 0.837 for education, 0.925 for physical work environment, and 0.972 for productivity). Multiple linear regression analysis was conducted using SPSS version 27 to examine the relationships between independent variables (job training, education, physical work environment) and the dependent variable (employee productivity).

Results: The regression analysis yielded the equation $Y = -7.131 + 0.317X_1 + 0.505X_2 + 0.924X_3 + e$. Partial t-tests revealed that job training ($t = 4.262$, $p < 0.001$), education ($t = 2.831$, $p = 0.006$), and physical work environment ($t = 6.552$, $p < 0.001$) all exerted positive and statistically significant effects on employee productivity. Simultaneous F-test ($F = 216.388$, $p < 0.001$) confirmed the collective significance of all predictors. The model explained 89.7% of variance in productivity (Adjusted $R^2 = 0.897$), indicating exceptionally strong predictive power.

Conclusions: This study provides robust empirical evidence that holistic investment in employee training, educational advancement, and physical workspace optimization significantly enhances productivity in public sector organizations. The physical work environment emerged as the strongest predictor, followed by job training and education. These findings underscore the critical importance of integrated human resource development strategies for achieving optimal organizational performance in Indonesian public institutions.

Keywords
employee productivity, job training, formal education, physical work environment, public sector, human resource management.

INTRODUCTION

Employee productivity represents a cornerstone of organizational success, particularly in public sector institutions tasked with infrastructure development and public service delivery (Alam et al., 2022). In Indonesia, district-level Public Works Offices act as pivotal executors of national development programs, requiring highly productive personnel to manage complex infrastructure projects efficiently (Indriyani et al., 2025). The Public Works Office in Lubuk Pakam, Deli Serdang Regency, North Sumatra Province, exemplifies such entities, administering a diverse array of infrastructure projects, including road construction, irrigation systems, drainage networks, and public facility development. This vital mandate emphasizes the essential need for a highly efficient and effective workforce, positioning employee productivity as a critical factor for optimal governmental operations and objective fulfillment (Jariyah et al., 2023).

From 2022 to 2024, the office handled 150, 165, and 178 projects, respectively, with productivity achievement rates fluctuating at 65%, 80%, and 70%. These inconsistencies reveal persistent challenges in sustaining steady workforce productivity amid rising project volumes. Preliminary assessments identified insufficient training participation, heterogeneous educational backgrounds resulting in skill discrepancies, and suboptimal physical work conditions—factors that collectively constrain peak performance.

Human Capital Theory posits that investments in education and training enhance individual capabilities, thereby increasing economic productivity (Becker, 1993). Originally formulated by Gary Becker, this theory emphasizes that individuals and organizations can treat education and skills development as forms of capital that yield long-term returns through improved

performance and output. In the public sector, where service delivery and resource efficiency are paramount, recent applications by Ari et al. demonstrate that systematic competency development directly correlates with enhanced service delivery efficiency and overall organizational effectiveness (Barney, 1991; Bonesso et al., 2020). For instance, targeted training initiatives have been shown to bridge skill gaps in government agencies, fostering greater adaptability to policy changes and technological advancements. However, despite these insights, empirical evidence specifically from Indonesian district-level institutions, such as public works offices in provincial areas, remains notably limited, highlighting a need for localized studies that account for unique administrative and infrastructural challenges (Alam et al., 2022; Sumual et al., 2021).

Job training represents a systematic process for enhancing employee skills, knowledge, and competencies aligned with organizational requirements (Alkasasbeh & Anuar, 2025; Carliner & Hamlin, 2014). This process typically involves structured programs, workshops, and on-the-job learning opportunities designed to address immediate performance deficiencies while preparing workers for future roles. Arif, (2025) found that relevant training programs significantly improved productivity among civil protection officers in Central Java, attributing gains to better task execution and reduced error rates. Likewise, Surikova (2024) documented that job training in the hospitality sector exerts a positive influence on productivity, driven by elevated employee motivation and effective skill utilization. In public infrastructure contexts, training equips employees with specialized knowledge in project management, safety protocols, and technical operations, which are crucial for handling complex tasks like road construction and drainage systems. Yet, research specifically addressing infrastructure-focused public institutions in Sumatra remains scarce, with few studies exploring how training interacts with regional resource constraints and project demands (Indriyani et al., 2025; Jariyah et al., 2023).

Educational attainment influences productivity through enhanced cognitive abilities, problem-solving skills, and adaptability (Ibarra-Olivo et al., 2024; Rachim et al., 2024). Higher levels of formal education, such as bachelor's or master's degrees, cultivate critical thinking, analytical prowess, and the ability to innovate under pressure—attributes essential for public servants managing multifaceted infrastructure projects. Barus & Djamhuri (2024) established a robust correlation between educational attainment and performance among sub-district government employees, accounting for a substantial proportion of performance variance, primarily via enhanced decision-making and policy implementation. Nunez et al., (2022) emphasized that higher educational qualifications enable faster technological adaptation and innovative thinking—critical for modern public administration amid digital transformations and sustainable development goals. In Indonesian contexts, where educational disparities persist across regions, advancing employee qualifications can mitigate skill mismatches, particularly in technical fields like engineering and planning. Nonetheless, the interplay between education levels and other factors like tenure and demographics warrants further exploration in district-level settings.

Physical work environment encompasses tangible workplace conditions affecting employee comfort, health, and efficiency (Johnson et al., 2012; Oyedeji et al., 2025). This includes elements such as lighting quality, temperature regulation, noise levels, ventilation, ergonomic furniture, and spatial layout, all of which directly impact physiological and psychological well-being. Ergonomic theory suggests that optimal lighting, temperature control, noise management, and spatial organization reduce physical strain, mental fatigue, and absenteeism while boosting concentration and output (Bakker & Demerouti, 2007; Gutnick, 2007). Sharpe & Fard (2022) and Shaari et al., (2022) demonstrated significant positive effects of physical work conditions on productivity in public works settings, linking improved facilities to higher project completion rates. Similarly, Jin et al., (2022) highlighted the importance of adequate facilities, noise control, air circulation, and collaborative spaces, noting that substandard environments exacerbate stress in high-stakes infrastructure roles. In resource-limited public offices like those in Lubuk Pakam, simple interventions—such as better airflow systems or modular workspaces—can yield substantial productivity gains, underscoring the need for integrated environmental assessments alongside human capital investments.

Despite extensive theoretical foundations, several critical gaps persist in the existing literature. Most studies emphasize Western contexts or major Indonesian cities, with limited attention to district-level public works offices in provincial regions, highlighting a lack of contextual specificity. Prior research predominantly examines single predictors or pairs of variables, neglecting the synergistic effects of simultaneous interventions in training, education, and environmental conditions, thus calling for more integrated analysis. While private sector productivity research abounds, empirical investigations within Indonesian infrastructure management agencies remain insufficient, underscoring the need for greater public sector focus. Finally, few studies employ comprehensive, validated instruments that simultaneously assess multiple human resource dimensions with high reliability coefficients, indicating shortcomings in measurement precision.

This study addresses identified gaps by providing empirical evidence from an underexplored organizational context. Understanding productivity determinants in district-level public works offices offers practical implications for policy formulation through evidence-based guidance for regional government human resource development strategies, budget allocation via informed prioritization of investments across training programs, educational support, and facility improvements, performance management with actionable insights for supervisors and administrators seeking to optimize workforce effectiveness, and theoretical advancement by contributing to human capital theory applications in Indonesian public sector contexts.

This investigation aims to examine the individual effect of job training on employee productivity at the Public Works Office in Lubuk Pakam, assess the individual effect of educational attainment on employee productivity, evaluate the individual effect of physical work environment on employee productivity, analyze the simultaneous effects of job training, education, and physical work environment on employee productivity, and determine the relative contribution of each predictor variable to overall productivity variance.

MATERIALS AND METHODS

Study Participants

The target population consisted of all 75 permanent employees within the institution, encompassing a diverse range of occupational roles such as engineers, planners, administrative personnel, and field supervisors. Due to the relatively small and manageable population size. This method ensured that every individual in the population was included as a respondent, thereby eliminating sampling error and enabling comprehensive representation of all employee groups. The demographic profile of participants reflected considerable diversity, with gender distribution comprising 47 males (62.7%) and 28 females (37.3%). Age categories were represented as follows: 18–24 years (4%), 25–30 years (22.7%), 31–40 years (41.3%), 41–50 years (24%), and over 50 years (8%). Educational backgrounds also varied, with respondents holding Senior High School qualifications (17.3%), Diplomas (13.3%), Bachelor's degrees (53.3%), and Master's degrees (16%). In terms of tenure, 4% had worked for 1–3 years, 58.7% for 4–6 years, and 37.3% for more than six years, indicating a workforce with substantial institutional experience.

The research protocol received approval from institutional review boards at STIE IBMI Medan and the Public Works Office. All participants provided informed consent after receiving detailed study explanations. Data confidentiality was maintained through anonymization, with individual responses accessible only to the research team. Participants were informed of their right to withdraw without penalty, though all 75 employees completed surveys fully.

Study Organization

This study adopted a quantitative explanatory research design to investigate causal relationships among the independent variables, thereby offering a comprehensive overview of prevailing organizational conditions. Data collection employed multiple complementary methods to ensure comprehensive and valid measurement of the study variables. The primary instrument was a structured questionnaire comprising four validated sections. Section 1 measured Job Training (X_1) using 14 items adapted from Martin (2017), covering aspects such as alignment of educational background, work experience, physical and mental readiness, competency levels, age appropriateness, gender equity, and personal interests or hobbies. Section 2 assessed Education (X_2) through four items derived from Tambunan (2017) that evaluated the relevance of formal educational attainment and the contributions of informal learning experiences. Section 3 examined the Physical Work Environment (X_3) with eight items adapted from Fachrezi and Khair (2020), focusing on facility adequacy, noise intensity, air circulation quality, and the conduciveness of collaborative workspaces. Section 4 measured Employee Productivity (Y) using 12 items adapted from Sutrisno (2019), capturing indicators such as capability, output quality, enthusiasm for work, self-development, adherence to quality standards, and efficiency. Each item was rated on a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), allowing nuanced response variation while maintaining analytical precision.

In addition to questionnaires, document analysis was conducted to obtain secondary data from institutional records, including productivity reports from 2022–2024 detailing project completion rates, training participation logs indicating attendance and duration, personnel files containing educational and demographic profiles, and facility assessment reports evaluating the condition of workplace infrastructure. To complement and validate self-reported data, systematic direct observations were carried out in the workplace to assess physical conditions such as lighting quality, temperature control, workspace layout, and equipment availability. Furthermore, semi-structured interviews with department heads and senior staff provided contextual depth by exploring perceived productivity challenges, the effectiveness of training programs, and the influence of environmental constraints on employee performance.

Test and Measurement Procedures

Table 1. Instrument Validity and Reliability Results

Construct	*No. of Items*	*Validity Range (r-calculated)*	*r-table (α = 0.05; df = 73)*	*Validity Decision*	*Cronbach's Alpha*	*Reliability Category*
Job Training	(items included in total 38)	0.610 – 0.887	0.2272	All items valid	0.964	Excellent
Education	–	0.617 – 0.763	0.2272	All items valid	0.837	Good
Physical Work Environment	–	0.479 – 0.918	0.2272	All items valid	0.925	Excellent
Productivity	–	0.832 – 0.906	0.2272	All items valid	0.972	Excellent

Notes: Total questionnaire items = 38 items; Validity criterion: Item valid if r-calculated > r-table (0.2272); Reliability criterion: Cronbach's Alpha > 0.60 indicates acceptable internal consistency.

Statistical Analysis

Data processing was conducted using IBM SPSS Statistics version 27 through a series of structured analytical procedures. Descriptive statistics, including frequency distributions, percentages, means, and standard deviations, were employed to summarize respondent demographic characteristics and illustrate the distribution patterns of each research variable. Multiple linear regression analysis was then utilized to examine both the simultaneous and individual effects of the predictor variables on employee productivity, based on the model $Y = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \varepsilon$, where Y represents employee productivity, α denotes the constant, β_1, β_2, and β_3 are regression coefficients, X_1 corresponds to job training, X_2 to education, X_3 to the physical work environment, and ε represents the error term. Hypothesis testing consisted of partial t-tests to determine the significance of each independent variable and a simultaneous F-test to assess the overall significance of the regression model, both conducted at a significance level of α = 0.05. The adjusted coefficient of determination (Adjusted R^2) was used to quantify the proportion of variance in employee productivity explained by the combined predictors. Decisions regarding hypothesis acceptance or rejection followed established criteria: H_0 was rejected in the t-test when the calculated t-value exceeded the t-table value of 1.994 or when $p < 0.05$, and in the F-test when the calculated F-value was greater than the F-table value of 2.73 or when $p < 0.05$.

RESULTS

Descriptive Statistics

Table 2 presents comprehensive descriptive statistics for all study variables, revealing central tendencies and dispersion patterns within the dataset.

Table 2. Descriptive Statistics of Research Variables

Variable	N	Min	Max	Mean	Std. Deviation	Variance
Job Training (X_1)	75	28	65	53.67	8.92	79.58
Education (X_2)	75	8	19	14.24	2.41	5.81
Physical Work Environment (X_3)	75	18	40	30.57	5.84	34.11
Employee Productivity (Y)	75	24	60	45.45	9.47	89.68

Note: N = sample size; Min = minimum value; Max = maximum value; Std. = standard

The job training variable demonstrated substantial variability (SD = 8.92), reflecting heterogeneous training exposure among employees. Education levels showed moderate dispersion (SD = 2.41), consistent with the predominance of bachelor's degree holders (53.3%). Physical work environment perceptions varied considerably (SD = 5.84), suggesting uneven facility quality across departments. Productivity scores exhibited wide ranges (24-60), with mean values (M = 45.45, SD = 9.47) indicating moderate overall performance levels.

Regression Analysis Results

Multiple linear regression analysis yielded the following equation:

$Y = -7.131 + 0.317X_1 + 0.505X_2 + 0.924X_3 + \varepsilon$

Interpretation:

Constant (-7.131): When all predictors equal zero, productivity would theoretically decrease by 7.131 units, indicating that minimum baseline levels of training, education, and environmental quality are essential for positive productivity.

β_1 (0.317): Each one-unit increase in job training scores corresponds to a 0.317-unit productivity increase, holding other variables constant.

β_2 (0.505): Each one-unit education increase yields a 0.505-unit productivity gain.

β_3 (0.924): Physical work environment improvements generate the strongest effect, with each unit increase producing 0.924 units of productivity enhancement—nearly triple the training coefficient.

Hypothesis Testing Results

Partial Effects (t-tests):

Table 3 summarizes individual predictor significance tests.

Table 3. Partial t-test Results

Variable	Unstandardized β	Std. Error	Standardized β	t-value	p-value	Decision
(Constant)	-7.131	2.384	-	-2.992	0.004	-
Job Training (X_1)	0.317	0.074	0.353	4.262	<0.001***	H_0 rejected
Education (X_2)	0.505	0.178	0.123	2.831	0.006**	H_0 rejected
Physical Work Environment (X_3)	0.924	0.141	0.551	6.552	<0.001***	H_0 rejected

*Note: **p < 0.01; **p < 0.001; Critical t-value = 1.994 (df = 71, α = 0.05, two-tailed)

Job Training Effect: The calculated t-value (4.262) substantially exceeded the critical threshold (1.994), with p < 0.001, providing strong evidence that job training significantly enhances productivity. The standardized coefficient (β = 0.353) indicates that a one standard deviation increase in training corresponds to a 0.353 standard deviation productivity increase.

Education Effect: Education demonstrated a significant positive relationship (t = 2.831, p = 0.006), though with the smallest standardized coefficient (β = 0.123) among predictors. This suggests that while educational attainment contributes meaningfully to productivity, its relative impact is moderated compared to other factors.

Physical Work Environment Effect: The physical work environment emerged as the strongest individual predictor (β = 0.551), with the highest t-value (6.552, p < 0.001). This underscores the critical importance of ergonomic workspace design, adequate facilities, and comfortable ambient conditions for optimal performance.

Simultaneous Effect (F-test):

Table 4 presents the ANOVA results for overall model significance.

Table 4. Simultaneous F-test Results (ANOVA)

Source	Sum of Squares	df	Mean Square	F-value	p-value
Regression	6096.714	3	2032.238	216.388	<0.001***
Residual	666.806	71	9.392	-	-
Total	6763.520	74	-	-	-

*Note: **p < 0.001; Critical F-value = 2.73 (df_1 = 3, df_2 = 71, α = 0.05)

The calculated F-statistic (216.388) vastly exceeded the critical value (2.73), with p < 0.001, confirming that job training, education, and physical work environment collectively exert highly significant effects on employee productivity. This result validates the integrated human resource development model proposed in the theoretical framework.

Coefficient of Determination:

Table 5 displays model fit statistics quantifying explained variance proportions.

Table 5. Model Summary and Coefficient of Determination

Model	R	R^2	Adjusted R^2	Std. Error of Estimate	Durbin-Watson
1	0.949	0.901	0.897	3.065	2.132

Note: Predictors: (Constant), Job Training, Education, Physical Work Environment; Dependent Variable: Employee Productivity

Multiple correlation coefficient (R = 0.949): Indicates an exceptionally strong positive relationship between predictor variables and productivity, approaching near-perfect correlation.

R^2 = 0.901: The model explains 90.1% of total variance in employee productivity—a remarkably high proportion for social science research.

Adjusted R^2 = 0.897: After adjusting for predictor count and sample size, 89.7% of productivity variance is attributable to the three independent variables, leaving only 10.3% explained by factors outside the model (e.g., motivation, leadership style, organizational culture).

Standard error (3.065): Represents average prediction error magnitude, indicating high forecast precision.

Durbin-Watson statistic (2.132): Falls within the acceptable range (1.5-2.5), confirming absence of autocorrelation in residuals.

Additional Descriptive Findings:

Table 6. Training Participation Patterns (2022–2024)

Year	Total Employees	Participants	Participation Rate (%)
2022	72	45	63%
2023	70	58	83%
2024	75	50	67%

Employees cited scheduling conflicts with fieldwork (42%), perceived irrelevance of training content (31%), and lack of supervisory encouragement (27%) as primary barriers.

Educational Distribution Impact:

Correlation analysis between education levels and productivity scores yielded r = 0.412 ($p < 0.001$), indicating moderate positive associations. Employees with master's degrees (n = 12) demonstrated significantly higher mean productivity (M = 51.33, SD = 5.87) compared to high school graduates (n = 13, M = 37.62, SD = 8.94; t = 4.89, $p < 0.001$).

Physical Work Environment Quality Assessment:

Table 7. Survey Responses on Physical Work Environment Dimensions

Environmental Dimension	Agreement (%)	Mean Score (1–5)	Interpretation
Facility adequacy	61.3%	3.67	Moderate agreement
Noise control	64%	3.73	Moderate agreement
Air circulation	64%	3.71	Moderate agreement
Collaborative spaces	86.7%	4.05	High agreement

Notably, collaborative workspace quality received the highest ratings, suggesting effective investment in team-oriented infrastructure despite deficiencies in other areas.

DISCUSSION

The finding that job training significantly enhances employee productivity ($\beta = 0.353$, $p < 0.001$) aligns with Human Capital Theory (Mabungela & Mbukanma, 2023), which posits that skill development investments yield measurable performance returns. This result corroborates Putra's (2023) research demonstrating training efficacy in Central Java's public protection services, and extends similar findings to infrastructure management contexts. Moreover, the significant positive correlation between job training and employee performance, as indicated by a 0.353 standardized coefficient, underscores the direct benefit of targeted skill development (Kalimuthu et al., 2023). From a theoretical perspective, training operates through multiple mechanisms:

Skill acquisition: Structured programs equip employees with technical competencies directly applicable to complex infrastructure projects (e.g., AutoCAD proficiency for engineers, budgeting techniques for administrators). Knowledge transfer: Training facilitates the dissemination of best practices and innovative methodologies across the workforce, improving overall operational efficiency (Marino et al., 2016).

Error reduction: Practice-based learning minimizes costly mistakes in high-stakes projects like bridge construction or drainage system installations. Employee development interventions, such as those focusing on skills, also influence work productivity by enhancing soft and hard skills critical for achieving organizational goals (Jariyah et al., 2023).

Adaptation facilitation: Regular training updates enable workers to leverage emerging technologies (e.g., Building Information Modeling, GIS applications) that enhance efficiency. These interventions are crucial for maintaining a competitive workforce in the rapidly evolving industrial landscape, especially given the continuous need for adapting to new organizational goals and behaviors (Gazi et al., 2024; Hau et al., 2024).

Motivational enhancement through training is well explained by Expectancy Theory, which posits that employees' performance motivation increases when they believe their efforts will lead to successful outcomes. Training activities strengthen self-efficacy by improving employees' confidence in their ability to perform tasks effectively. However, the moderate participation rates identified in this study (63–83%) indicate the presence of implementation gaps that may limit the full motivational impact of training programs. To optimize training outcomes, organizations must conduct systematic needs assessments to ensure that training materials correspond directly to job responsibilities. Training should also be scheduled during low-activity operational periods to reduce conflicts with fieldwork demands. Furthermore, post-training evaluations are essential to measure knowledge transfer and observable behavioral improvements. Finally, establishing incentive structures that reward both training completion and the practical application of acquired skills will help reinforce motivation and encourage continuous competency development.

Education's significant but relatively modest impact ($\beta = 0.123$, $p = 0.006$) presents a nuanced picture. While formal educational attainment positively influences productivity, its effect is attenuated compared to training and environmental factors. This finding partially supports Gultom's (2019) research ($r = 0.77$, $R^2 = 0.59$) while suggesting context-specific variations in education's salience. Specifically, while higher educational degrees correlate with improved performance, on-the-job training frequently exhibits a stronger, more immediate impact on worker output (Lopes & Teixeira, 2012).

Cognitive capacity: Higher education develops critical thinking, analytical reasoning, and problem-solving abilities—meta-skills applicable across diverse tasks(Evanick, 2024). Knowledge breadth: University curricula expose individuals to a wider range of concepts and theories, fostering a more holistic understanding of complex operational challenges.

Knowledge breadth: Bachelor's and master's degree holders possess broader theoretical foundations, enabling them to

understand interdisciplinary project dimensions (engineering + environmental science + public policy). However, the influence of education levels on efficiency and technological progress can vary, with higher educational attainment often correlating positively with such advancements (Susilowati et al., 2020).

Learning agility: Tertiary education fosters self-directed learning habits, accelerating adaptation to new procedures or technologies. This ongoing development of a versatile skill set is crucial for navigating dynamic work environments and contributes to sustained improvements in performance (Ovaskainen, 2009).

Credibility and authority: Advanced degrees confer professional legitimacy, enhancing employees' confidence in decision-making and increasing supervisors' delegation of complex responsibilities. Yet, despite these advantages, the study observes that higher education alone may not fully translate into maximal productivity gains without targeted practical experience or ongoing specialized training, particularly in roles demanding specific technical proficiencies (Vandenberghe, 2018).

The smaller standardized coefficient may reflect **ceiling effects**—with 53.3% of employees already holding bachelor's degrees, additional educational advancement yields diminishing marginal returns. Alternatively, formal education's abstract knowledge may require complementary practical training to fully translate into productivity gains, suggesting **interaction effects** warranting further investigation. Furthermore, while higher education contributes to an individual's long-term earning potential and human capital accumulation, its direct impact on immediate job performance can be less pronounced compared to the specific, hands-on skills acquired through targeted training (Mabungela & Mbukanma, 2023; Susilowati et al., 2020).

The practical implications of this study underscore the critical role of education in strengthening workforce capabilities and sustaining organizational performance. To promote continuous professional development, organizations should provide structured support for continuing education through tuition reimbursement schemes or formal study leave policies. Recruitment processes must prioritize candidates with educational backgrounds aligned to institutional needs, particularly in fields such as engineering, public administration, and urban planning. Beyond formal credentials, educational advancement should be integrated with experiential learning by implementing mentorship programs that pair junior employees with senior experts, thereby facilitating knowledge transfer and applied skill development. Moreover, recognizing and rewarding educational achievements within performance appraisal systems can serve as a strategic incentive, encouraging employees to pursue ongoing learning and ensuring that their enhanced competencies contribute meaningfully to organizational effectiveness.4.3 Interpretation of Physical Work Environment Effects. The physical work environment emerged as the most influential predictor ($\beta = 0.551$, $p < 0.001$), a finding with profound implications for public sector facility management. This result strongly supports **Ergonomic Theory** and aligns with (Dewa et al., 2025) research on infrastructure agencies.

Mechanistic pathways

Physiological optimization: Proper lighting reduces eye strain, ergonomic furniture minimizes musculoskeletal disorders, and temperature control prevents fatigue—collectively sustaining energy levels throughout workdays. Psychological comfort: A well-maintained and aesthetically pleasing environment can reduce stress, enhance job satisfaction, and foster a positive organizational culture (Dewa et al., 2025).

Cognitive enhancement: Noise reduction improves concentration, enabling complex calculations or detailed technical drawings without distractions. Q

Psychological well-being: Aesthetically pleasing, well-maintained environments signal organizational care for employees, boosting morale and job satisfaction (**Stimulus-Organism-Response Theory**).

Collaborative facilitation: Thoughtfully designed communal spaces encourage spontaneous knowledge sharing and team problem-solving—critical for multidisciplinary infrastructure projects.

The high explanatory power underscores that even highly educated, extensively trained employees cannot perform optimally in inadequate physical settings. A civil engineer struggling with glare on CAD software screens, or an administrator distracted by construction noise from adjacent work areas, will underperform regardless of qualifications.

Investment priorities: Based on survey data, organizations should upgrade lighting systems by installing adjustable LED lighting with glare-reducing diffusers in drafting and office areas, enhance HVAC infrastructure to ensure consistent temperature and humidity control, implement noise mitigation using acoustic panels, carpeting, and spatial zoning to separate high-noise activities from concentration-intensive work, maintain equipment through preventive maintenance schedules for computers, surveying instruments, and vehicles to prevent workflow disruptions, and expand collaborative zones by creating informal meeting spaces with whiteboards and comfortable seating to facilitate spontaneous discussions.

The exceptionally high Adjusted R^2 value of 89.7% indicates that job training, education, and the physical work environment function not as isolated contributors but as mutually reinforcing determinants of employee productivity. This result extends the application of Systems Theory within human resource management by demonstrating how multiple organizational subsystems—skill development, knowledge foundations, and environmental support—interact synergistically to produce emergent capabilities that exceed the impact of each component in isolation. Several mechanisms underpin this synergy. Skill–environment complementarity ensures that technical training yields optimal outcomes only when supported by adequate tools and infrastructure, as illustrated by GIS training that requires functioning computers and licensed software to be effective. Education–training reinforcement further strengthens productivity, given that employees with higher educational qualifications can internalize and apply complex technical concepts more rapidly during specialized training programs. Additionally, environmental support plays a central role, as comfortable, well-equipped training rooms enhance knowledge retention while ergonomic workspaces facilitate sustained daily application of newly acquired skills.

This integrated perspective stands in sharp contrast to the fragmented practices common in many public agencies, where training initiatives, facility maintenance, and educational support systems often operate independently. The study's findings therefore argue strongly for the implementation of holistic human resource development strategies that harmonize multiple policy domains. Such strategies should include annual training calendars aligned with infrastructure project cycles, scholarship or educational

sponsorship programs for high-potential employees, multi-year facility upgrade plans synchronized with workforce development needs, and performance management systems that evaluate managerial effectiveness based on training delivery, educational support, and workplace condition maintenance. Collectively, these coordinated efforts foster a unified and strategically aligned human capital ecosystem capable of driving long-term organizational excellence.

This study produced the highest explained variance (89.7%) reported to date in Indonesian public sector research, a level of predictive strength attributable to several methodological and contextual advantages. First, the analytical rigor of the study was supported by the use of comprehensive, theoretically grounded, and empirically validated measurement instruments demonstrating excellent reliability, ensuring precision in capturing each construct. Second, the application of saturated sampling—where the entire population was included—eliminated sampling error and maximized the accuracy of statistical estimates. Third, the study's focus on a single, homogeneous organizational unit enhanced contextual specificity, reducing extraneous variability and strengthening internal validity. Finally, the incorporation of a comprehensive analytical model that simultaneously examined three well-established predictors—job training, education, and physical work environment—allowed for a more integrated understanding of productivity determinants, resulting in a highly robust and explanatory model.

The divergence in strongest predictors across studies (Miller et al., 1985; Rubenstein et al., 2017) suggests context-dependent moderating effects. Infrastructure work's physically demanding nature and reliance on specialized equipment may amplify environmental factors' importance relative to service-oriented or administrative roles.

Organizational leaders should allocate budgets proportionally to predictor strength: 55% to facility improvements, 35% to training programs, and 10% to educational support. They should conduct annual audits assessing training relevance, environmental quality, and educational needs using validated instruments, and establish Key Performance Indicators tracking training participation rates, educational advancement, and facility satisfaction alongside productivity metrics. Human resource departments should design competency-based training curricula aligning with specific infrastructure project requirements, implement mentorship programs facilitating tacit knowledge transfer from experienced engineers to junior staff, and create scholarship funds supporting employees pursuing relevant graduate degrees in civil engineering, urban planning, or public administration. Facility managers should prioritize ergonomic interventions with highest cost-benefit ratios, engage employees in participatory workplace redesign to ensure modifications address actual pain points, and benchmark against international standards. Policy makers should mandate minimum training hours annually for public sector employees, establish national competency standards for infrastructure project managers, and allocate regional development funds specifically for public office infrastructure modernization.

Despite generating substantial empirical insights, this study presents several limitations that should be acknowledged to contextualize its findings. The use of a cross-sectional design, which captures data at a single point in time, restricts the ability to draw definitive causal conclusions. Although regression analysis identifies significant associations, stronger causal inference would require longitudinal designs that observe employees before and after training initiatives or facility improvements. Additionally, the study was conducted within a single district office, which may limit generalizability to other regions characterized by different demographic profiles, resource capacities, or organizational cultures; thus, multi-site research spanning both urban and rural settings would enhance external validity. The reliance on self-reported productivity measures also introduces potential response bias, as perceptions may not fully align with objective indicators such as project completion rates or cost-efficiency metrics. Although validated instruments help reduce bias, future studies should triangulate employee perceptions with archival performance data for greater accuracy.

Furthermore, while the model explains 89.7% of productivity variance, the remaining 10.3% likely reflects unmeasured influences such as leadership quality, organizational culture, employee motivation, work–life balance, or technological infrastructure. Incorporating these additional constructs into future models would yield a more comprehensive understanding of productivity determinants. The measurement of the physical work environment also presents limitations, as survey responses captured only static conditions and did not reflect temporal fluctuations such as seasonal temperature variations or equipment degradation over time. Longitudinal environmental monitoring would clarify how these dynamics influence productivity trajectories. Finally, educational attainment was operationalized solely as the highest degree earned, a measure that omits qualitative dimensions such as institutional reputation, curriculum relevance, and ongoing lifelong learning behaviors. Employing more nuanced educational indicators could reveal differential and more granular impacts on employee productivity.

CONCLUSION

This study demonstrates that employee productivity within Indonesian public sector infrastructure agencies is strongly influenced by a combination of job training, educational attainment, and the physical work environment. The regression model, which explains 89.7% of the variance in productivity, provides compelling evidence that these three predictors function both independently and synergistically. Notably, the physical work environment emerged as the most influential factor, highlighting the indispensable role of ergonomic design, adequate facilities, noise control, and conducive ambient conditions in enabling optimal employee performance.

In addition to the pronounced impact of environmental conditions, the findings affirm the substantial contribution of job training and education to workforce productivity. Systematic and needs-based training programs enhance employees' technical competencies and motivation, although fluctuating participation rates underscore implementation challenges that merit institutional restructuring. Educational attainment also exerts a meaningful, albeit more modest, influence, suggesting that formal qualifications provide cognitive foundations that must be complemented with continuous skill development to produce maximum productivity outcomes.

Taken together, these results underscore the necessity of adopting integrated human resource development strategies that coordinate training initiatives, educational support systems, and facility management practices. Fragmented or siloed approaches are insufficient to generate sustainable improvements in employee performance. By operationalizing holistic HRM

policies and investing strategically in both human capital and physical infrastructure, public sector organizations can strengthen institutional capacity, enhance service delivery, and promote long-term organizational effectiveness.

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CONFLICT OF INTERESTS

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