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The Role of Training, Certification, and Employee Education in Improving Employee Performance

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ABSTRACT

Training, certification, and education play a crucial role in improving employee performance at the Asam-Asam Power Plant (PLTU Asam-Asam), as these three aspects enhance the competencies, skills, and knowledge required to address the company's operational challenges. The study aims to determine the influence of training, certification, and education on improving employee performance at PLTU Asam-Asam. This research employs a quantitative method with a hypothesis testing design to examine the causal relationship between the variables of Training, Certification, Education, and Employee Performance at PLTU Asam-Asam. It uses saturated sampling techniques and data analysis through SEM-PLS to test the validity, reliability, and influence among variables. The analysis shows that training has the highest influence, with a beta coefficient of 0.396 and a t-statistic value of 4.588, followed by certification with a beta coefficient of 0.240 and a t-statistic value of 2.482, and education with a beta coefficient of 0.233 and a t-statistic value of 2.543. These human resource development programs are deemed effective, with respondents' average perceptions of the training, certification, and education variables at 4.47, 4.46, and 4.48, respectively, on a Likert scale. The study also notes that the model's Goodness of Fit value of 0.583 indicates a good model fit, while the Q^2 predictive relevance value of 0.466 demonstrates the model's predictive capability in explaining the influence of independent variables on employee performance.

1. INTRODUCTION

Labor or human resources (HR) play a vital role in determining the success of an organization (Sukmo Hadi Nugroho, 2022), including companies operating in the steam power plant (PLTU) sector. Employee performance is crucial as it directly impacts productivity and operational efficiency. PLTU Asam-Asam, as one of the power generation companies in Indonesia, faces challenges in ensuring that its employees can effectively fill structural positions. Performance is an attitude possessed by an individual to produce work in accordance with their responsibilities in the company (Silas et al., 2019). Performance reflects the results of an individual's efforts achieved through their skills and behavior (Muhtadin & Frianto, 2020). Employee performance is a key factor in determining the success of an organization. In 2024, PLTU Asam-Asam faced various challenges that affected its performance. Based on performance data up to November 2024, as shown in Table 1, the set targets have not been fully achieved, requiring further attention:

Table 1. Asam-Asam PLTU Performance Data November 2024

Indicator	Target until November 2024	Realization until November 2024	Achievement (%)	Notes
EFOR (Equivalent Forced Outage Rate)	3,20%	5,61%	175,31%	The high EFOR was caused by technical problems such as desuperheater line leaks.
EBIT/Employee	Rp. 972.29 million	Rp. 909.38 million	93,53%	Employee productivity has not reached the target.
ROI HC (Human Capital)	2,51	2,35	93,83%	Investment in human resource development has not provided optimal results.
Maintenance Cost Absorption	100%	91,28%	91,28%	The maintenance budget is not optimally absorbed.

Source: Asam Asam PLTU Performance Report (2025)

The performance of the Asam-Asam coal-fired power plant (PLTU) in 2024 faces significant challenges, with the Equivalent Forced Outage Rate (EFOR) reaching 5.61%, far exceeding the target of 3.20%. This is due to recurring technical issues such as desuperheater line leaks and turbine oil cooler failures, which impact the plant's reliability. Employee productivity has also not yet reached optimal levels, as indicated by EBIT per employee achieving only 93.53% of the target. Meanwhile, investment in human resources through the Return on Investment in Human Capital (ROI HC) was realized at only 93.83% of the target, highlighting the need for more effective workforce development. Additionally, maintenance cost absorption reached only 91.28% of the target, indicating that budget allocation has not been fully optimized to support operations. As a strategic power plant within the South and Central Kalimantan interconnection system, contributing 26.86% of the total 738 MW capacity, PLTU Asam-Asam holds a significant responsibility in ensuring a reliable and efficient electricity supply.

Training is one of the most commonly applied methods to improve employees' skills (Mehner

et al., 2024). At the Asam-Asam coal-fired power plant (PLTU Asam-Asam), training can focus on mastering the latest power generation technologies and implementing workplace safety protocols. Through training, job demands can be met, thereby enhancing work performance (Muhtadin & Frianto, 2020). Training plays a role in motivating employees to be more proactive in carrying out their duties in the company (Girdwichai & Sriviboon, 2020). Many organizations believe that active employee participation is one of the key factors in building a competitive advantage (Ruhiyat et al., 2022).

Certification also plays an important role in improving employee performance. Certification is an effort to continuously enhance professionalism, particularly through performance improvement of learners via activities such as self-development, scientific publications, and the creation of innovative works (Lakapung et al., 2023). Certification encourages employees to perform their duties diligently, utilizing their thoughts and creativity for the advancement of education (Hasanuddin & Normasunah, 2021).

Formal education also plays a highly significant role. In the context of the Asam-Asam Coal-Fired Power Plant (PLTU Asam-Asam), higher formal education, such as a bachelor's degree in Mechanical Engineering or a related field, can provide substantial added value in enhancing employees' analytical and problem-solving skills. Education, in general, is a structured and continuous effort (Azizah, 2019). The education process includes development as a learning activity aimed at supporting individual growth, the application of information, knowledge, and skills (Suwarga & Resmiati, 2023).

Training, certification, and education play a significant role in improving employee performance at PLTU Asam-Asam, as evidenced by various previous studies. Training has been proven to have a positive impact on enhancing skills, competencies, and employee productivity. Research by (Muhtadin & Frianto, 2020)(Ruhiyat et al., 2022)(Harefa et al., 2024)(Selviyanti et al., 2023)(Rosmayati et al., 2021) it shows that targeted training can bridge the gap in knowledge and skills required for the job. Certification serves as an official recognition of employees' expertise, which not only strengthens their confidence but also enhances their credibility in the workplace (Osborne & Hammoud, 2017). Research conducted by (Lakapung et al., 2023)(Hasanuddin & Normasunah, 2021)(Nawawi, 2022)(Latief et al., 2022)(Latiana, 2019) it emphasizes that certification not only provides formal recognition of employees' competencies but also enhances their confidence and credibility in the workplace, ultimately leading to better performance. In the power generation sector, a deep understanding of technology and fundamental operational principles is key to improving performance. As stated in the research by (Azizah, 2019)(Suwarga & Resmiati, 2023)(Hamzali, 2024)(Umiyati et al., 2020)(Hartati et al., 2021) which states that education provides a theoretical and analytical foundation that supports decision-making and enhances problem-solving abilities.

Previous studies have tended to discuss training, certification, and education separately, while the synergistic interaction between these three aspects in the context of the strategic energy sector has not been explored in depth. Therefore, this study aims to fill that gap by analyzing

the integrated impact of training, certification, and education on employee performance, which is not only relevant to PLTU Asam-Asam. This research is of interest to scholars as it addresses a gap in previous studies that primarily examined training, certification, and education in isolation, without exploring how these three factors interact synergistically in a strategic energy sector like PLTU Asam-Asam. The uniqueness of this study lies in its integrative analysis of the simultaneous impact of these factors on employee performance, enabling a more comprehensive understanding of optimal human resource development strategies.

2. RESEARCH METHODS

This research employs a quantitative method with a design oriented toward hypothesis testing. The main objective of this study is to analyze the causal relationship between the examined variables through the hypothesis testing process (Sugiyono, 2019). In this study, the independent variables are Training, Certification, and Education, while the dependent variable is Employee Performance. A questionnaire and a specific measurement scale are applied to ensure that the data obtained is quantitative and can be analyzed statistically.

This study involves all employees working at the Asam Asam Coal-Fired Power Plant (PLTU Asam Asam) as the population, totaling 183 individuals. Due to the relatively small population size, the sampling method applied is the saturated sampling technique, which means that all members of the population are included as research samples. The respondents in this study are employees of PLTU Asam Asam, selected based on their relevance to the phenomenon related to the research needs. The number of respondents is considered sufficient to represent the research sample. Data was collected using a Likert scale with five rating levels: 1 (Very Poor), 2 (Poor), 3 (Fair), 4 (Good), and 5 (Very Good) (Priadana & Sunarsi, 2021). The data analysis process includes grouping data based on variables and respondent categories, creating data tables for each variable from all respondents, and presenting data related to the variables being studied.

Research Procedure: (1) Initial Data Processing. Data from the collected questionnaires is entered into statistical software (e.g., SmartPLS or SPSS). Ensure there is no missing or invalid data by performing an initial check. (2) Validity and Reliability Testing. Convergent Validity: Measures the suitability of indicators to latent variables based on the loading factor value. A loading factor value > 0.7 is considered valid. Discriminant Validity: Ensures that each indicator only measures the intended latent variable, using the Average Variance Extracted (AVE) value > 0.5. Reliability: Tested using Composite Reliability and Cronbach's Alpha, with values > 0.7 indicating good consistency. (3) Structural Model Evaluation (Inner Model). R-Square Measurement: Assesses the ability of independent variables (training, certification, education) to explain the dependent variable (employee performance). R-Square values are assessed based on the following categories: 0.75 (strong), 0.50 (moderate), and 0.25 (weak). Q-Square Predictive Relevance: Measures the predictive ability of the model. A Q-Square value > 0 indicates the model has predictive relevance. Goodness of Fit (GoF): Assesses the overall model fit. (4)

Hypothesis Testing. Statistical Test: Uses the t-statistic value to test the significance of relationships between variables. The hypothesis is accepted if t-statistic > t-table (at a significance level of 5%). P-Value: The probability value (p-value) is analyzed. The hypothesis is accepted if p-value ≤ 0.05. (5) Result Analysis. Interprets the path coefficient to determine the magnitude of the impact of training, certification, and education on employee performance. Identifies whether the relationships are significant or not based on the testing results.

The data analysis technique used in this study is SEM PLS. Below is the research framework in the form of a matrix that aligns with the Structural Equation Modeling - Partial Least Squares (SEM-PLS) approach to analyze the impact of training, certification, and education on employee performance at PLTU Asam-Asam. To further understand the relationships between variables in this study, the research matrix is presented, detailing the independent and dependent variables along with indicators, codes, operational definitions, and their sources. This matrix aims to provide a comprehensive overview of the aspects measured in the study, thereby assisting in the data analysis process using the Structural Equation Modeling - Partial Least Squares (SEM-PLS) method.

Table 2. Research Matrix

Variables	Indicator	Code	Operational Definition	Source
Training (X1)	Training methods based on group discussions, simulations, and study visits	X1.1	Training provided to employees to improve technical and managerial skills that support their duties.	Muhtadin & Frianto (2020), Ruhiyat et al. (2022)
	Relevance of training materials to job needs	X1.2	Suitability of training to operational challenges at Asam-Asam PLTU	Harefa et al. (2024)
	Improvement of technical skills after attending training	X1.3	Effectiveness of training in improving employee competency	Rosmayati et al. (2021)
Certification (X2)	Ownership of official certification in the field of power generation	X2.1	Validation of employee skills through formal certification	Lakapung et al. (2023), Hasanuddin & Normasunah (2021)
	Active participation in scientific and self-development forums	X2.2	The impact of involvement in certification on improving performance	Nawawi (2022)
	The impact of certification on increasing work credibility	X2.3	How certification increases employee confidence in carrying out tasks	Latief et al. (2022)
Education (X3)	Alignment of educational majors with work	X3.1	The relationship between educational background and work effectiveness	Azizah (2019), Suwarga & Resmiati (2023)
	Improving analytical skills through formal education	X3.2	The contribution of higher education to problem-solving skills in the workplace	Hartati et al. (2021)

Variables	Indicator	Code	Operational Definition	Source
	The influence of education on strategic decision making	X3.3	How education supports understanding in the operational management of PLTU	Umiyati et al. (2020)
Employee Performance (Y)	Employee work productivity according to company targets	Y1	The level of employee achievement in meeting work targets	Priadana & Sunarsi (2021)
	Ability to complete tasks with high quality	Y2	Employee evaluation of their work quality standards	Hamzali (2024)
	Efficiency in completing operational tasks	Y3	The time and resources employees use in carrying out their duties	Hartomo & Luturlean (2020)

Source: Processed by Researchers (2025)

The research matrix in Table 2 above serves as the basis for data analysis to test causal relationships between variables. Using the SEM-PLS approach, each indicator in the table is tested for its validity and reliability before further analysis. The results of this analysis will show the extent to which training, certification, and education influence employee performance at the Asam-Asam Power Plant, as well as how the interactions between these three factors can improve productivity and work efficiency.

This model will be analyzed using the Partial Least Squares Structural Equation Modeling (PLS-SEM) method to test causal relationships and assess the influence of each independent variable on employee performance at the Asam-Asam PLTU. The PLS method does not rely on many assumptions and can be applied to both small and large samples. Additionally, PLS is effective for testing theories and discovering relationships without requiring a very clear theoretical foundation. The Partial Least Squares (PLS) approach involves two main stages in the analysis: the evaluation of the measurement model (outer model) and the structural model (inner model).(Hair, J. F., Hult, G. T. M., Ringle, C. M., & Sarstedt, 2021) The measurement model is used to test the validity and reliability of variables based on their indicators, while the structural model functions to analyze the relationships between latent variables. Additionally, hypothesis testing is carried out by comparing the t-statistic value to the t-table to determine the significance of the research results. The evaluation of the measurement model includes several criteria such as convergent validity, discriminant validity, composite reliability, and Cronbach's alpha. Meanwhile, the structural model is analyzed through R-square, Q-square, and Goodness of Fit (GoF) values. In hypothesis testing, the comparison between the probability values of the t-table and t-statistic is conducted at a significance level of $\alpha = 5\%$. If the t-statistic exceeds the t-table, the hypothesis is considered accepted or supported:(Joseph F. Hair et al., 2022)

a. If the probability of the result ≥ 0.05, then the hypothesis is rejected.
b. If the probability of the result ≤ 0.05, then the hypothesis is accepted.

3. RESULTS & DISCUSSION

Description of Research Subjects. The description of the research subjects in this study includes gender and age. Below, Figure 1 presents the characteristics of the research sample:

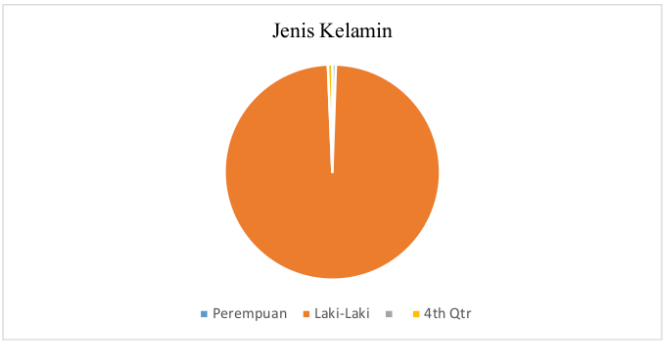

Figure 1. Research Subjects by Gender

Source: Processed by Researchers (2025)

In this study, the research subject based on gender shows a significant dominance of males. Out of the total respondents, 182 are male, while only one is female. This imbalance indicates that the electricity industry, particularly at the Asam-Asam coal-fired power plant (PLTU), is still dominated by male workers. This phenomenon reflects the general condition in the electricity industry, which tends to attract more male workers due to the technical expertise required for the job and the physically demanding work environment.

The dominance of male workers in this study has implications for various operational aspects and decision-making at the Asam-Asam coal-fired power plant. With a lack of gender diversity, there is a possibility that perspectives on innovation and the formulation of strategic policies become less varied. Therefore, the company may consider adopting a more inclusive recruitment strategy to enhance female participation in the industry. One step that can be taken is to provide specialized training and education programs that are more appealing to female workers, enabling them to participate more actively in the electricity sector.

Moreover, in terms of workforce effectiveness, the majority of respondents, who are males aged between 31–40 years, indicate that the workforce at PLTU Asam-Asam is within the productive age range. This provides an advantage for the company in terms of workforce stability and operational efficiency. However, with a very minimal number of female employees, there is a risk of limited perspectives in human resource management and innovation in energy management. Therefore, enhancing more diverse and inclusive workforce development programs should be part of the company's strategy to address future human

resource regeneration challenges.

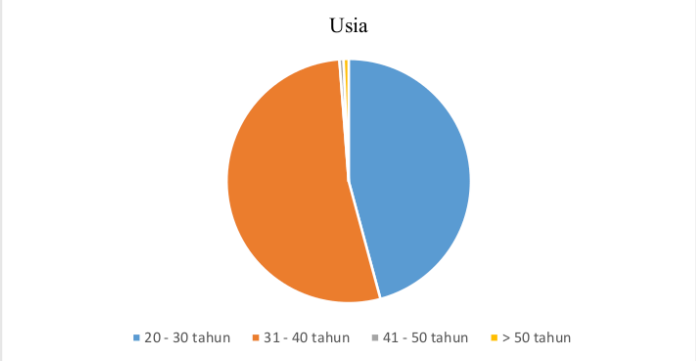

Figure 2. Research Subjects by Age

Source: Processed by Researchers (2025)

In this study, the research subjects based on age indicate that the majority of respondents fall within the 31–40 age range, totaling 96 individuals. This age group dominates the workforce at PLTU Asam-Asam, reflecting that most employees are in their productive phase and have gained substantial work experience. With this background, they possess a greater capacity to adopt new technology and complete operational tasks with high efficiency. However, as they age, challenges such as adapting to technological advancements become an important factor that the company must manage.

Moreover, the age group of 20–30 years also has a significant number, totaling 83 individuals. The presence of young workers is crucial for the regeneration of human resources at PLTU Asam-Asam. Employees in this category generally have a high enthusiasm for learning and adapt more easily to technological changes. However, the challenge they face is a lack of work experience, which can hinder their effectiveness in completing complex tasks. Therefore, training programs focused on enhancing technical and leadership skills for young workers should be one of the strategies implemented by the company.

On the other hand, the age groups of 41–50 years and above 50 years have significantly fewer employees, with only 1 and 4 individuals, respectively. The minimal number of employees in these age groups indicates that the company has few senior workers who can serve as mentors for younger employees. This could result in a lack of knowledge transfer from experienced employees to the next generation. Therefore, the company needs to implement an HR management strategy that ensures senior employees contribute to the learning process of younger workers, such as through mentoring programs or experience-based training.

Overall, the age distribution of the workforce at PLTU Asam-Asam demonstrates a balance between experienced workers and younger employees who are still in the development phase. However, to ensure operational sustainability and address future challenges in the electricity industry, the company needs to optimize its human resource management strategy, including training programs, skills development, and intergenerational knowledge transfer.

Descriptive Analysis. Table 3 presents the results of the descriptive analysis of the variables of training, certification, education, and employee performance at PLTU Asam-Asam based on respondents' perceptions. These results illustrate how employees assess the effectiveness of the HR development programs implemented by the company, as shown in Table 3.

Table 3. Descriptive Analysis

No.	Variables	Average	Percentage (%)
1	Training	4,47	99,55%
2	Certification	4,46	99,33%
3	Education	4,48	99,77%
4	Employee Performance	4,49	99,95%

Source: Processed data, 2025

Descriptive analysis is used to illustrate how respondents assess the variables of training, certification, education, and employee performance in this study. Based on the results in Table 3, the training variable obtained an average score of 4.47, equivalent to 99.55% of the maximum scale of 5.00, indicating that the majority of respondents rated the effectiveness of the training programs implemented at PLTU Asam-Asam as very good. The certification variable received an average score of 4.46, or 99.33% of the maximum scale, suggesting that respondents consider certification an important factor in enhancing employee competence and professionalism. Furthermore, the education variable achieved the highest average score of 4.48, equivalent to 99.77%, signifying that education is perceived as playing a crucial role in improving employees' skills and analytical abilities. Lastly, the employee performance variable recorded the highest average score of 4.49, or 99.95%, demonstrating that, in general, employees at PLTU Asam-Asam exhibit excellent performance with high levels of productivity and work quality. Based on this analysis, it can be concluded that training, certification, and education have positively contributed to improving employee performance, with program effectiveness reaching over 99% of respondent expectations. This reflects well-executed implementation, which should be maintained and further enhanced.

Analysis of Measurement Model. The data analysis approach in this research utilizes Partial Least Squares (PLS), which is based on Smart PLS version 4. Essentially, PLS is a more comprehensive Structural Equation Modeling (SEM) approach compared to previous methods. SEM provides a deeper level of analysis in research by integrating theory and data, as well as allowing the tracing of paths through latent variables. Therefore, SEM is commonly used in social science research.

Feasibility Test of the Instrument (Outer Model). The purpose of SmartPLS measurement

is to determine the relationship between latent variables and various indicators. This measurement model is divided into two tests: validity testing and reliability testing, as follows: Validity Testing This validity test includes several aspects of data testing using the SmartPLS 4 application to process data in detail, referring to relevant references, limitations, and conditions required for each test. The processed data results are as follows: (a) Convergent Validity Test The Convergent Validity Test verifies the accuracy of questionnaire statements. This stage includes a validity test that examines convergent validity and the AVE (Average Variance Extracted) score. The Convergent Validity Test assesses the Outer Loading, while the AVE score is checked through the Construct Reliability and Validity, as presented in Table 4 below:

Table 4. Average Results of Convergent Validity Test (Outer Loading)

Components	Convergence Test Results (average)
Employee Performance	0.8306
Training	0.780
Certification	0.767
Education	0827

Source: Data Processing (2025)

The results of the convergent validity test displayed in Table 4 show that all indicators used in this study have an Outer Loading value above the minimum threshold of 0.7. This indicates that each indicator makes a significant contribution in explaining the measured latent variable. Thus, all indicators used in this study have met the requirements for convergent validity, meaning that these indicators have a high correlation with the variable they measure.

Each variable in this study employee performance, training, certification, and education shows an Outer Loading value ranging from 0.717 to 0.871. The training variable has the highest Outer Loading value of 0.871, indicating that the training aspect significantly contributes to explaining the measured latent variable. Meanwhile, the indicator with the lowest value of 0.717 still meets the minimum threshold of 0.7, making it eligible for use in the analysis.

This convergent validity test is important in the measurement model because it ensures that the research instrument used has a strong ability to measure the intended concept. With strong convergent validity, research results can be more reliable and used for more accurate decision-making. These results are also consistent with the Average Variance Extracted (AVE) values shown in Table 5, where each latent variable has an AVE value above the 0.5 threshold, further strengthening the conclusion that the research instrument has good validity.

To ensure the quality of measurement in this research model, a convergent validity test was conducted using the Average Variance Extracted (AVE) value. This test aims to assess the extent to which the indicators used can explain the latent variable being measured, as outlined in Table 5 below:

Table 5. Results of the Average Variance Extracted (AVE) Validity Test

	Average variance extracted (AVE)	Information
Employee Performance (Y)	0.691	Valid
Training (X1)	0.611	Valid
Education (X3)	0.683	Valid
Certification (X2)	0.589	Valid

Source: Data Processing (2025)

Convergent Validity Testing, as explained in the Data Analysis Techniques, requires that the Outer Loading values exceed the predetermined critical value of >0.7. Referring to Table 1, the Outer Loading contains the values of each loading factor, all of which are highlighted in "Green," indicating that they meet the required threshold (>0.7). Furthermore, in Table 5, the Average Variance Extracted (AVE) values for each Latent Variable exceed the specified threshold (>0.5). Therefore, it can be concluded that all statement items are deemed "Convergent Valid." Additionally, the variables exhibit good convergent validity since the AVE values surpass 50%, meaning that the variance explained by the indicators is adequately represented by the latent variable.

Discriminant Validity Test. The discriminant validity test in this study uses the Fornell-Larcker method, which aims to ensure that each construct is more correlated with its own indicators than with other constructs. The results of the discriminant validity test are presented in Table 6 as follows:

Table 6. Discriminant Validity – Fornell Larcker

	Employee Performance (Y)	Training (X1)	Education (X3)	Certification (X2)
Employee Performance (Y)	0.831			
Training (X1)	0.613	0.782		
Education (X3)	0.539	0.370	0.827	
Certification (X2)	0.588	0.455	0.701	0.768

Source: Data Processing (2025)

Discriminant Validity Test. This discriminant validity test uses the Fornell-Larcker criterion as a parameter to assess data validity. The discriminant validity test requires that each construct must have a square root of the AVE value greater than its correlation with other constructs. Referring to Table 6, the square root of the AVE values for each construct is greater than their correlation with other constructs. Therefore, it can be concluded that all variables are considered "Discriminantly Valid."

Reliability Test. The reliability test in this study uses two main indicators, namely Cronbach's Alpha and Composite Reliability (rho_c), as shown in Table 7 below:

Table 7. Construct Reliability and Validity

	Cronbach's alpha	Composite reliability (rho_c)
Employee Performance (Y)	0.888	0.918
Training (X1)	0.896	0.916
Education (X3)	0.769	0.866
Certification (X2)	0.923	0.935

Reliability testing includes tests that typically consist of two important aspects, each with crucial value requirements that must be met, namely: Cronbach's Alpha (>0.7) and Composite Reliability (>0.8). In the following table, it can be confirmed that each value of the variables has exceeded the crucial value requirements. Therefore, it can be stated that all data are reliable and have passed the reliability test.

Structural Model (Inner Model). After conducting the Instrument Feasibility Test (Outer Model) and reviewing the results above, it can be confirmed that all variables have passed the first stage of testing. Next, the researcher will proceed to the second stage, which is the Structural Model Test (Inner Model). In this stage, the testing process aims to examine the relationships between latent variables, as illustrated in the image below:

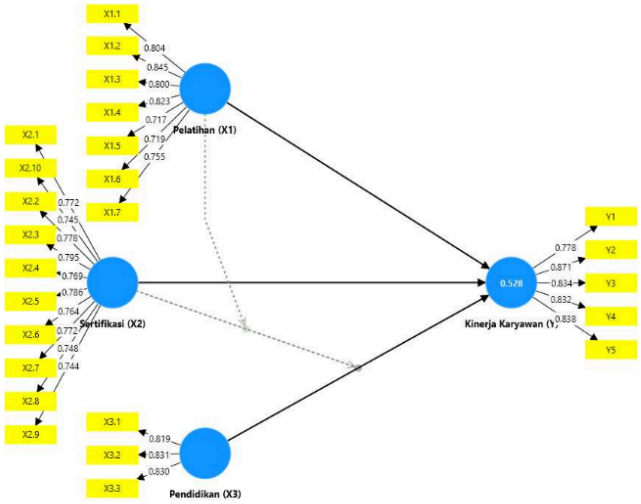

Figure 3. Structural Model Analysis (Inner Model)

Source: Data Processing (2025)

Beta Coefficient Value. The Beta Coefficient (β) is a parameter that describes the extent to which an independent variable influences a dependent variable. This value indicates the strength and direction of the relationship between the two variables. The Beta Coefficient value can be understood from Table 8 below:

Table 8. Beta Coefficient Value Test Results (β)

	Original sample (O)	Relationship
Training (X1) -> Employee Performance (Y)	0.396	Positive
Education (X3) -> Employee Performance (Y)	0.233	Positive
Certification (X2) -> Employee Performance (Y)	0.240	Positive
Training (X1) x Certification (X2) x Education (X3) -> Employee Performance (Y)	0.211	Positive

Source: Data Processing (2025)

From the obtained data, there are two indications in this study. All values show a positive value, indicating that a positive relationship occurs when an increase in the independent variable is followed by an increase in the dependent variable.

T-Test. The T-Test is a data testing process used to determine or test the statistical significance of the Beta Coefficient. The T-statistic value is the ratio between the Beta Coefficient and its Standard Error. The critical value of this T-statistic is 1.973 with a p-value (<0.05). Once this threshold is met, the Beta Coefficient indicates a significant effect. The results of the T-Test can be seen in Table 9 below.

Table 9. T-Test Results

	T statistics (|O/STDEV|)	P values	Significant (Sig)
Training (X1) -> Employee Performance (Y)	4.588	0.000	Significant
Education (X3) -> Employee Performance (Y)	2.543	0.011	Significant
Certification (X2) -> Employee Performance (Y)	2.482	0.013	Significant
Training (X1) x Certification (X2) x Education (X3) -> Employee Performance (Y)	2.397	0.016	Significant

Source: Data Processing (2025)

Each relationship between variables shows a T-statistic value higher than the crucial value of 1.973, accompanied by p-values indicating <0.05. Therefore, it can be concluded that the Beta Coefficient value from the T-Test results is significant (Sig).

Coefficient of Determination (R^2) Value. The coefficient of determination (R-square) is used to assess the extent to which the total variation in the dependent variable can be explained by the independent variable. The R^2 value ranges between 0 and 1. According to Chin, if the R^2 value for the latent dependent variable in a structural model reaches 0.75 or higher, the influence of the independent variable on the dependent variable is considered strong. Meanwhile, an R^2 value of 0.50 is categorized as a moderate influence, whereas a value of only 0.25 is considered weak.

Based on the results of the R-square (R^2) test, it can be concluded that the dependent variable, namely Employee Performance, shows an R^2 value greater than 0. From this, we can conclude that the dependent variable can be explained by the independent variables. The R^2 value for Employee Performance is 0.528 or 52.8%, which means that the influence of the independent variables Training, Certification, and Education on Employee Performance is 52.8%, categorized as Moderate. Meanwhile, the remaining 47.2% is influenced by other variables not discussed in this study.

Goodness of Fit (GoF). Goodness of Fit (GoF) is a measure that combines the quality of the structural model and the measurement model to assess the overall model fit in PLS-SEM, with model fit values ranging from 0 to 1 as follows: 0.1 (low), 0.25 (moderate), and 0.36 (good). In the Goodness of Fit (GoF) testing process, the average value of the Communality Index and the average R^2 (Coefficient of Determination) value for the dependent variable in the model are required. The Communality Index in this context refers to AVE (Average Variance Extracted).

To calculate the Communality Index or AVE (Average Variance Extracted) for each construct, it is determined as the average of the squared loading factor of each indicator within that construct. The formula to calculate the average Communality Index is:

$$\textbf{Average AVE} = \frac{\sum \textbf{AVE}}{\textbf{k}}$$

- ∑AVE is the sum of all AVE values of the construct.
- k is the number of constructs in the model

Selanjutnya, untuk menghitung rata-rata R^2 untuk semua variabel dependen dalam model. Rumus menghitung rata-rata nilai R^2 untuk semua variabel dependen dalam model adalah sebagai berikut:

$$\textbf{Average } \mathbf{R^2} = \frac{\sum \mathbf{R^2}}{\mathbf{m}}$$

- $\sum R^2$ is the sum of all R2 values for the dependent variable.
- m is the number of dependent variables in the model.

And, the final step is to calculate the Goodness of Fit (GoF) value. GoF is the square root of the product of the average AVE and the average R^2. The formula used to calculate the Goodness of Fit value is as follows:

$$\textbf{GoF} = \sqrt{\textbf{Rata-rata AVE} \times \textbf{Rata-rata } \mathbf{R^2}}$$

After knowing all the formulas used in the Goodness of Fit testing process, the actual GoF

testing will now be conducted as follows:

$$\textbf{Rata – rata AVE} = \frac{2{,}574}{4} = \textbf{0,6435}$$

$$\textbf{Rata – rata } R^2 = \frac{0{,}528}{1} = \textbf{0,528}$$

$$\textbf{Goodness Of Fit} = \sqrt{(0{,}60575 \times 0{,}555)} = \sqrt{0{,}339768} = \textbf{0,583}$$

From the testing and calculation of Goodness of Fit above, a calculation result of 0.583 was obtained. Based on this, it can be concluded that the Goodness of Fit in this research model is considered to have a good model fit.

Q^2 (*Predictive Relevance*). Q^2, or Predictive Relevance, is a measure used to assess the predictive ability of a model in PLS-SEM. Q^2 evaluates how well the observed values can be reconstructed by the model and its estimated parameters. A variable or data is considered to have good predictive capability if the Q^2 value is greater than 0. Conversely, if the Q^2 value is less than 0, the variable or data is deemed unable to predict the model effectively.

The results of the Q2 test (Predictive Relevance) include a Q2 value for Purchase Decision of 0.466. This indicates that the Employee Performance variable, which is influenced by the variables of Training, Certification, and Education, can predict the model well and aligns with the research model observed in the field, as it obtained a Q2 value greater than 0.

Hypothesis Testing. In hypothesis testing, there are two effects: the first is Direct Effect Hypothesis Testing, and the second is Indirect Effect Hypothesis Testing. The results of the testing will be explained below:

Testing Direct Hypothesis Influence. Based on the results of data analysis conducted using SmartPLS v4, findings were obtained to test the hypotheses formulated in this study. Hypothesis testing was carried out by observing the Path Coefficient values, T-statistics, and P-values obtained through the Bootstrapping technique in SmartPLS. A hypothesis is considered accepted if the obtained P-value is less than 0.05. The results of the direct hypothesis influence test are presented in Table 10 below.

Table 10. Results of Direct Effect Hypothesis Test

Hypothesis	Path Coefficient	T-values	P-values	Conclusion
Training (X1) -> Employee Performance (Y)	0.396	4.588	0.000	
Certification (X2) -> Employee Performance (Y)	0.240	2.482	0.013	Accepted
Education (X3) -> Employee Performance (Y)	0.233	2.543	0.011	

Source: Data Processing (2025)

Training on Employee Performance (H1). The statistical test results can be seen in Table 10, where the obtained coefficient value for the Training variable on Employee Performance is 0.396. The T-value is 4.588, which is greater than the T-table value (1.97), with a P-value of 0.000, which is less than the significance level (< 0.05). These results indicate that Training influences Employee Performance, demonstrating that Training has a positive and significant effect on Employee Performance.

Certification on Employee Performance (H2). The statistical test results can be seen in Table 10, showing that the coefficient value of the Certification variable on Employee Performance is 0.240, with a T-value of 2.482, which is greater than the T-table value (1.97). The obtained P-value is 0.013, which is less than the significance level (< 0.05). These results indicate that Certification has an impact on Employee Performance, confirming that Certification has a positive and significant effect on Employee Performance.

Education on Employee Performance (H3). The statistical test results can be seen in Table 10, where the coefficient value of the Education variable on Employee Performance is 0.233. The T-value is 2.543, which is greater than the T-table value (1.97), and the P-value is 0.011, which is less than the significance level (< 0.05). These results indicate that Education influences Employee Performance, showing that Education has a positive and significant effect on Employee Performance.

Hypothesis Testing of Indirect Effects. The hypothesis testing of indirect effects (mediation) is conducted using the SmartPLS v4 application through the Bootstrapping Calculation technique. The results of the hypothesis testing for indirect effects can be found in the "Specific Indirect Effects" section. The results are presented in Table 11 as follows:

Table 11. Results of Indirect Effect Hypothesis Testing

Hypothesis	Path Coefficient	T-values	P-values	Conclusion
Training (X1) x Certification (X2) x Education (X3) -> Employee Performance (Y)	0.211	2.397	0.016	Accepted

Source: Data Processing (2025)

Training (X1) x Certification (X2) x Education (X3) on Employee Performance (H4). The statistical test results can be seen in Table 11, where the obtained coefficient value for the Training (X1) x Certification (X2) x Education (X3) variable on Employee Performance is 0.211. The T-value is 2.397, which is greater than the T-table value (1.97), with a P-value of

0.016, which is less than the significance level (< 0.05). These results indicate that Training (X1) x Certification (X2) x Education (X3) influences Employee Performance (Y), demonstrating that Training (X1) x Certification (X2) x Education (X3) has a positive and significant effect on Employee Performance (Y).

The Influence of Training on Employee Performance. The statistical test conducted shows that the training variable has a significant impact on employee performance, with a coefficient of 0.396. The obtained T-statistic value is 4.588, which exceeds the critical T-table value of 1.97, and the P-value is 0.000, which is far smaller than the significance level of 0.05. These findings confirm that training contributes positively and significantly to improving employee performance. This result is further supported by questionnaire data indicating that indicators such as "training methods based on group discussions, simulations, and study visits make me more actively participate and understand the material" received the highest responses, with the majority of participants strongly agreeing. Active participation in training contributes to better understanding and application of the material in daily tasks, ultimately enhancing employee performance. Furthermore, this interactive training method has proven effective in creating a more engaging learning environment, allowing employees to better understand the material through hands-on experience and discussion. This reflects that training not only improves technical skills but also builds confidence and problem-solving abilities among participants in addressing operational challenges at PLTU Asam-Asam. With a structured and relevant approach, training becomes one of the key strategies in developing a competent, efficient, and productive workforce, ultimately contributing to the overall achievement of the company's performance targets.

The dominance of male employees, totaling 182 individuals, and the age group of 31–40 years, comprising 96 individuals in this study, reinforces the finding that training plays a significant role in improving employee performance at PLTU Asam-Asam. With the majority of the workforce in their productive years and possessing substantial work experience, the training provided can be more focused on enhancing advanced technical skills and developing leadership competencies for employees with the potential to fill strategic positions in the future. Additionally, with only 83 employees in the 20–30 age range and minimal representation of female employees, training can also be directed at accelerating the regeneration of human resources and increasing the involvement of underrepresented groups in the power generation industry. Training programs based on hands-on experience, such as operational simulations and real-world case studies, become more relevant for the dominant age group, who already have a technical knowledge foundation but still require skill enhancement in handling complex operational challenges.

Besides the technical aspects, training also plays a role in overcoming resistance to technological change, especially for employees who have been working with the old system for a long time and face challenges in adapting to new innovations. In the context of PLTU Asam-Asam,

the modernization of power generation systems and the implementation of digital-based technology require more specific skill enhancements. Therefore, training programs must be designed to ensure that employees not only understand theoretical aspects but are also capable of applying the technology in their daily tasks. Effective and continuous training can also help reduce the potential for stagnation in employee performance, considering that the dominant age group is prone to staying in their comfort zone if not given challenges or continuous skill development. Therefore, training focused on developing technical skills, leadership, and technological adaptation is a key factor in ensuring that the workforce at PLTU Asam-Asam remains competitive and productive in optimally supporting the company's operations.

The findings of this study align with research conducted by Hartomo & Luturlean (2020), which indicates that respondents rated the implementation of employee training at the Head Office of PT. Pos Indonesia (Persero) Bandung is good, with a percentage of 80.3%. However, although empirical data suggests that the employee training variable at the office is considered adequate, its implementation has not fully achieved the targets set by the company. On the other hand, the results of this study contradict the findings of Herani & Agusria (2021), who concluded that the training variable does not affect employee performance. This is evidenced by the significance value of competence exceeding 0.05. As a result, hypothesis H1 was rejected, indicating that there is no significant relationship between training and team member performance at PT. Kharisma Gunamakmur. This suggests that training has not become a direct factor influencing employee performance. Essentially, employees require specific competencies relevant to their job descriptions, making competence more important than training.

The Influence of Certification on Employee Performance. The results of statistical analysis indicate that the Certification variable has a positive and significant effect on Employee Performance at PLTU Asam-Asam. This is demonstrated by a coefficient value of 0.240, with a T-value of 2.482, which is higher than the T-table value (1.97), and a P-value of 0.013, which is below the significance level of 0.05. These findings confirm that Certification has a significant impact on improving Employee Performance. In other words, the implementation of a certification program that recognizes employees' technical competencies contributes to enhancing their confidence and skills, thereby supporting efficiency in performing job tasks. Additionally, the results of a questionnaire distributed to PLTU Asam-Asam employees also show that the statement indicator, "I actively participate in scientific forums related to my field of work," received the highest response score. The majority of respondents stated "Strongly Agree," indicating that active participation in scientific activities supports performance improvement. This highlights the importance of employee involvement in professional development through scientific forums as one of the key factors driving the successful execution of their duties, ultimately enhancing overall productivity.

Moreover, the dominance of employees aged 31–40, totaling 96 individuals, indicates that the majority of the workforce obtaining certification is in their peak career and productivity phase. At this age, employees generally have sufficient work experience and well-developed technical

skills, making certification an increasingly important factor in enhancing their credibility and confidence in performing their duties. With certification, they not only gain recognition for their existing expertise but also receive motivation to continuously improve their competencies, supporting the efficient operational sustainability of PLTU Asam-Asam. However, with only 83 employees aged 20–30, there is a potential gap in workforce regeneration. Therefore, it is necessary to implement early certification strengthening strategies for younger employees to better prepare them for strategic positions in the future.

Furthermore, the dominance of male employees, totaling 182 individuals, also indicates that the majority of certification recipients come from this group, potentially creating a less inclusive work environment for women. Considering the importance of diversity in decision-making and innovation, the company may consider more inclusive recruitment strategies and certification training for female employees. Thus, certification not only enhances individual competencies but can also serve as an instrument to create a more diverse and adaptable work environment in the power plant industry. Therefore, the certification strategy at PLTU Asam-Asam needs to be aligned with the existing workforce requirements, ensuring that employees across all age groups have equal opportunities to improve their skills and contribute optimally to achieving the company's targets.

This study aligns with the findings presented by Istianah (2024), which explain that there is a positive and significant influence between training and employee performance. This is evidenced by the significance value of the training variable, which is less than 0.05, specifically 0.002. Training includes a series of activities designed to improve employee performance, both in carrying out current tasks and in facing future challenges. Training plays an important role for employees, whether they are newly hired or experienced. The positive influence of training on employee performance occurs because training enhances the skills, knowledge, and technical competencies required for the job. Additionally, training helps employees develop the specific abilities needed to complete tasks effectively, enabling them to work according to the company’s operational standards and contribute to overall performance improvement.(Istianah, 2024) On the other hand, the findings of this study contradict the results of research conducted by Widianingrum & Nurhayati (2017). Their study showed that training does not have a significant impact on the performance of ship crews, as indicated by a Critical Ratio (C.R) value of -0.345 with a probability of 0.730, which exceeds the significance level of alpha 0.10. This suggests that training does not have a noticeable effect on improving the performance of ship crews.(Widianingrum & Nurhayati, 2017)

The Influence of Education on Employee Performance. The results of statistical tests show that the education variable has a coefficient of 0.233, with a T-value of 2.543, which is greater than the T-table value of 1.97, and a P-value of 0.011, which is lower than the significance level of 0.05. These results indicate that education has a positive and significant influence on employee performance at PLTU Asam-Asam. Education plays a crucial role in enhancing employ-

ees' competencies and understanding of their job responsibilities. This is evident from employees' positive responses to the indicator stating, "My field of education is relevant to my current position or job responsibilities," which received a dominant response of "Strongly Agree." This supporting data reflects that the alignment between education and job responsibilities serves as a key driver in improving employee productivity and efficiency. Most employees with an educational background that aligns with job requirements are able to contribute optimally to achieving organizational targets. Therefore, investing in education whether through formal education development or specific training programs is a significant strategy in building individual performance while also supporting the overall success of the company.

The influence of education on employee performance at PLTU Asam-Asam becomes increasingly relevant when considering the characteristics of the respondents, who are predominantly employees aged 31–40 years (96 individuals) and 20–30 years (83 individuals). With the majority of employees in this productive phase, the need for higher education and advanced training becomes even more urgent to help them adapt to technological developments in power generation. Employees in this age group generally have sufficient work experience but still require improvements in technical and managerial competencies to face industry challenges. Formal education, such as backgrounds in mechanical and electrical engineering, can provide employees with a deeper analytical understanding, while specific training can enhance their technical skills, making them more efficient in carrying out operational tasks. Additionally, with only four employees over the age of 50, it is crucial for the company to ensure knowledge transfer from senior employees to the younger generation to maintain operational continuity and reduce the risk of losing expert personnel in the future.

Moreover, the dominance of male employees, with 182 men compared to only 1 female employee, indicates that women's participation in this industry remains very low. This presents an opportunity for the company to further promote access to education and training for women in the electricity sector, fostering a more diverse and inclusive workforce. Gender diversity in the workplace can bring new perspectives to decision-making and drive innovation in energy resource management. Therefore, investment strategies in education should not only focus on enhancing the technical competencies of existing employees but also aim to attract more female workers by providing more inclusive education and certification programs. This approach will help the company address human resource regeneration challenges while increasing competitiveness in the steam power generation sector.

This study aligns with the research conducted by Hartati, Saputra, and Andriani (2022), which found that the constant value and variable coefficients can be observed in the Unstandardized Coefficients B column. Based on the data in the table, the obtained regression equation model is as follows: Y = 41.045 + 2.769X1. Additionally, the table indicates the influence of the education variable on employee performance. The data analysis conducted using SPSS shows that the significance value for the education variable is 0.000. Since this value is smaller than the

probability threshold of 0.005, the alternative hypothesis (Ha) is accepted, indicating a significant influence of education on employee performance at the Kampar Kiri Hulu District Office, while the null hypothesis (Ho) is rejected.(Hartati et al., 2021) Conversely, the study conducted by Setiawan (2015) found that employees' educational background does not have a partial influence on their performance. Data analysis using SPSS 16.0 for Windows yielded a t-calculated value of 1.039, which is smaller than the t-table value of 1.99394, along with a p-value of 0.302, which is greater than the significance level $\alpha = 0.05$. Based on these results, the alternative hypothesis (Ha) is rejected, while the null hypothesis (Ho) is accepted. Therefore, it can be concluded that educational background does not have a significant impact on employee performance at PT. FIF Group, Singaraja Branch.(Setiawan, 2015)

The Influence of Training, Certification, and Education on Employee Performance. Based on statistical analysis, the interaction coefficient between Training (X1), Certification (X2), and Education (X3) on Employee Performance (Y) is 0.211. The T-calculated value of 2.397 is higher than the T-table value (1.97), and the P-value of 0.016 is lower than the significance level of 0.05. These findings indicate that the combination of Training, Certification, and Education has a positive and significant impact on Employee Performance at PLTU Asam-Asam. The interaction of these three independent variables has been proven to enhance employee competence and productivity, supporting the achievement of organizational goals. The questionnaire results show that the statement indicator, "I am able to complete my work with a level of perfection that meets the established standards," received the highest response value. The majority of respondents answered "Strongly Agree," indicating that well-implemented training, certification, and education programs have increased employees' confidence and ability to complete tasks with high quality. These findings emphasize the importance of holistic human resource development to support organizational performance improvement, particularly in the energy industry, which requires strong technical and managerial competencies.

Furthermore, the results of this study also need to be analyzed in the context of the respondents' demographic characteristics, which are predominantly male (182 individuals) and employees aged 31–40 years (96 individuals). This age group is in its peak productivity phase, enabling them to adopt training and certification outcomes more quickly to enhance their technical and managerial skills. However, the near-total dominance of male workers, reaching almost 100%, indicates a lack of gender diversity, which could limit perspectives in innovation and strategic decision-making. Therefore, human resource development strategies including training, certification, and education must take workforce diversity into account to be more inclusive and accommodate various perspectives in improving the company's efficiency and competitiveness. Additionally, with only 83 employees in the 20–30 age range and very few workers over 50, workforce regeneration presents a unique challenge for PLTU Asam-Asam. Training and education programs should not only focus on enhancing the skills of existing employees but also on preparing younger workers to take over senior roles in the future. Without an effective regeneration strategy, the company may face a skills gap that could negatively impact long-term productivity. Hence, the integration of training, certification, and education must be designed

sustainably to ensure optimal knowledge transfer from experienced employees to the next generation, maintaining the stability and reliability of PLTU Asam-Asam's operations.

4. CONCLUSION & SUGGESTION

Based on the findings of this study, training, certification, and education have a significant impact on improving employee performance at PLTU Asam-Asam. These three variables collectively contribute to increasing productivity and work efficiency, although other factors outside this study also influence employee performance. Overall, training has the greatest impact on enhancing employees' technical skills, followed by certification, which plays a role in validating competencies, and education, which strengthens analytical and problem-solving abilities. The human resource development programs that have been implemented have proven effective and received positive responses from employees, reflecting that competency improvement efforts have been well-executed. However, challenges remain, such as reducing operational disruptions to enhance power plant reliability and optimizing work productivity to achieve the set targets. With continuous improvements, PLTU Asam-Asam has a significant opportunity to enhance operational efficiency and strengthen its contribution to supporting national energy security.

To improve the performance of PLTU Asam-Asam, management needs to optimize maintenance strategies with a more structured approach to reduce the Equivalent Forced Outage Rate (EFOR) and enhance plant reliability. Technical training programs for employees should be better aligned with operational needs and supported by relevant certifications to ensure competence in handling power plant equipment and systems. Additionally, investments in human resource development must be more effective by tailoring training and education programs to industry demands, thereby optimizing the Return on Investment in Human Capital (ROI HC). The utilization of the maintenance budget should also be improved to maximally support operational improvements. By implementing these strategies sustainably, PLTU Asam-Asam is expected to achieve better performance targets and maintain the stability of electricity supply in South and Central Kalimantan.

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