Impact of Training on Maintenance Performance Effectiveness

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Abstract

Industry accepted that maintenance is a key function in sustaining long-term profitability for organizations. In order to optimize maintenance performance, several aspects of skill and competency maintenance team needed to be concerned in maintenance management. Training is an important element in increasing skills, competency and creating high work performance culture. This research aims to assess impact of training to improve effectiveness of maintenance performance in order to provide information to formulate the right decision for the training programs. The empirical data for this research were drawn from some manufacturing companies in order to address the research problem. Factor analysis was used to test validity of the conceptual model. According to the presumption of the proposed link between training and maintenance, measuring the association of variable was correlation analysis. Finally, regression analysis was conducted to measure overall relationships that lie within the model. This research reveals the relationships among training and performance in the maintenance department.

Keywords:

Training; Maintenance Performance; Factor Analysis, Correlation Analysis

1. Introduction

Maintenance provides critical support for heavy and capital-intensive industry by keeping machinery and equipment in a safe operating condition (Parida & Kumar, 2006). Basically, the maintenance function is the tactical role of maintaining, servicing and fixing facilities already in place (Tsang, 1998). Maintenance group is responsible for the development, implementation, and periodic evaluation of an effective asset maintenance plan (Mobley et al., p. 1.20, 2008). Since the efficiency and effectiveness of the maintenance system are essential for organizations success and survival, Parida and Kumar (2006) highlight the need for measuring the system performance of maintenance.

Measurement of maintenance performance is an assessment that helps to identify the strengths and weaknesses of the maintenance activities (Au-Yong et al., 2014). According to Groote (1995), the competency of the maintenance labor force is an important factor that affecting the maintenance performance. Its mean that successful of maintenance performance, depend on the skill and knowledge maintenance personnel. Training will provide maintenance team with the additional skills and underpinning knowledge effectively to motivate and organize a multi skilled work force (Kempton, 1996). Khan et al. (2011), explain that training is important to enhance the capabilities of employees. Training will add the employee knowledge and skill, so they can apply them to their day-to-day activities (Noe, p. 5, 2010).

2. Literature Review

According ISO 14224 (2016), maintenance is combination of all technical and management actions intended to retain an item in, or restore it to, a state in which it can perform as required. Most devices will deteriorate over time due to wear, fatigue, aging, and corrosion (Li et al., 2017). Maintenance is defined as a set of activities or tasks used

to restore an item to a state in which it can perform its designated functions (Ahmad and Kamaruddin, 2012). The importance role of maintenance, there is need for empirical research investigating the operational use of performance management systems in the maintenance process (Tatila et al., 2014).
Maintenance performance measurement is defined as the multidisciplinary process of measuring and justifying the value created by maintenance investment and taking care of the organizations stockholders requirements viewed strategically from the overall business perspective (Parida and Chattopadhyay, 2007). Maintenance performance measurement allows companies to understand the value created by maintenance, to re-evaluate and revise their maintenance policies and techniques, to justify investment in new trends and techniques, revise resource allocations, and to understand the effects of maintenance on other functions and stakeholders as well as on health and safety (Parida and Kumar, 2006).
Campbell (1995) classifies the commonly used measures of maintenance performance into three categories based on their focus (Tsang et al., 1999):

1) Measures of equipment performance (availability, reliability).
   Availability is defined as the ability of an item to be in a state to perform a required function under given conditions at a given instant of time, or in average over a given time interval, assuming that the required external resources are provided (ISO 20815, 2008; Dai et al., 2015). Furthermore, in addition to availability, reliability is also key parameter in measuring of equipment performance. Reliability defined as probability that a component will not fail to perform within specified limits in a given time while working in a stated environment (Ebeling, 1997; Moubray, 1997; Neubeck, 2004; O'Connor, 2002; Smith, 2005; Karanikas, 2013).
2) Measures of cost performance (labor and material cost)

   Labor cost

   Labor cost is the sum of all paid to employees such as wages and salaries, bonuses, other compensation, termination benefits and post-retirement benefits (Kim & Taylor, 2011). Control of maintenance labor costs may be accomplished by targeting on estimated standards set by management to limit overtime, regulate crew size, and provide a full work load (Mobley et al., 2008).

   Material cost

   Material cost or spare parts cost becomes main indicator in the measurement of maintenance cost. Maintenance spare parts required in order to repairing, replacement, or restores on a machine or a facility after the occurrence of a failure. Spare parts should always be available, but with an effective amount to keep inventory costs at a low level. Cost of spare parts, number of stocks, and lifespan of maintenance parts or items have been proven to be factors that influence maintenance performance (Au-Yong, et al., 2016).
3) Measures of process performance (ratio of planned and unplanned work, schedule compliance). Maintenance performance ratio is comparison between planning maintenance activities with actual implementation. Higher performance ratio indicates a good degree of accuracy in the planning and implementation of maintenance activities

Meanwhile, Coetzee (1997) outlines four categories of maintenance performance measures:

1) The first category is maintenance results, measured by availability / overall equipment effectiveness (OEE), mean time between failure (MTBF), breakdown frequency, mean time to repair (MTTR) and production rate.

   Overall equipment effectiveness (OEE)

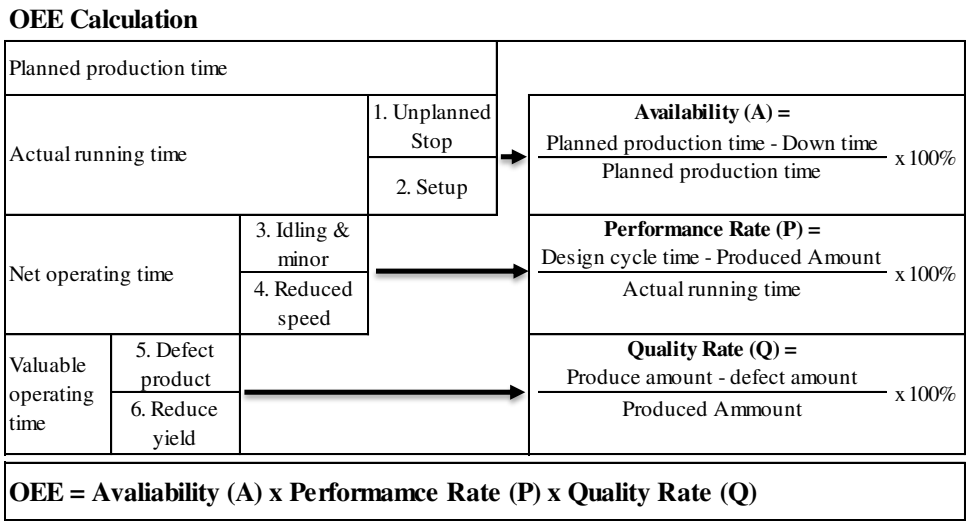
   OEE is a performance measurement approach that has been increasingly used in industry not only for controlling and monitoring the equipment's performance but also as indicator and driver of process and performance improvements (Eldridge et al., 2005; Kumar et al., 2014; Reyes 2015). Three key OEE performance are defined as availability (A), performance efficiency (P) and quality rate (Q) (Jain, Bhatti & Singh, 2015). Relationship between OEE elements, shown in Figure 1.

   Mean Time Between Failures (MTBF)

   MTBF is the indicator used in equipment reliability by observe failure rate (Karanikas, 2013). As explained before, reliability is probability that a component will not fail to perform within specified limits in a given time while working in a stated environment. MTBF calculated cumulative operational time divided by total number of failures.

   Mean Time to Repair (MTTR)

   MTTR is a maintainability indicator (Silva et al., 2008). Maintainability reflects the ease of maintenance and thus, the objective is to ensure that maintenance tasks can be performed safely, easily, and effectively (Gulati et al., 2012). MTTR formulated by calculated cumulative breakdown time divided by total number of failure.



Source: Based on Nakajima (1998)

Figure 1. OEE formulation

2) The second maintenance performance is maintenance productivity, measured by manpower utilization, manpower efficiency and maintenance cost component over total production cost
3) The third is maintenance operational purposefulness, measured by scheduling intensity (scheduled tasks time over clocked time), breakdown intensity, (time spent on breakdown over clocked time), breakdown severity, work order turnover, schedule compliance, and task backlog
4) The fourth is maintenance cost justification, measured by maintenance cost intensity (maintenance cost per unit production), stock turnover and maintenance cost over replacement value.

Generally, maintenance performance measurement is used by industries to assess progress against set goals and objectives in a quantifiable way for effectiveness and efficiency of maintenance (Baluch et al., 2010). Achievement of maintenance performance will be obtained when the implementation process is done by personnel who have the high level of ability and adequate skill. Lack of technical knowledge and inadequate training were among the most likely reasons for the maintenance errors (Dalkilic, 2017). Training is one of the solutions that enable organizations to achieve a high work performance culture (Ibrahim et al., 2017).

According to the International Labor Organization (ILO) (2009), training is the process of developing knowledge, skills and abilities. The importance of training is associated with constant global changes that make organizational environments increasingly competitive, requiring organizations to be continuously prepared (Ferraz & Vazquez, 2016). The knowledge and skills possessed by an organizations workforce are becoming more and more important to its performance competitiveness (Garcia et al., 2013).

Nikandrou et al., (2009) have been identified training success factors toward achieving performance improvement:

- Trainee characteristic
- Training design
- Organizational characteristic

Trainee characteristics

Characteristics of the trainee's personality directly affect the training process, training transfer and training result (Dirani, 2012). The ability of the person to learn, synthesize, and connect what he has learnt to practice and transfer the skills and knowledge to work is the next factor for training transfer (Bell et all., 2017). Previous studies have identified the following trainee characteristics as affecting training transfer.

- Affect training motivation of the person to learn and transfer the skills to their work (Aziz & Ahmad, 2011)
- Add new skills and knowledge (Switzer & Kleiner,1996)
- Support in career goals (Fojt, 1995).

Training design

To accomplish organizational tasks and improve employee performance, training programs should be designed in such a way that they create a win-win situation for both organizations and employees (Bhatti & Kaur, 2010). This

training should be easily transferred from trainer to trainee. Transfer of training has been defined as the generalization of the skills acquired during the training phase to the work environment and the maintenance of these acquired skills over time (Baldwin and Ford, 1988). The objectives and the extent of training, the training methods and means, as well as the training place and equipment, are important factors related to training program planning (Nikandrou et al., 2009). The final goal from training is applied training result in work practice and contributed to preparing the organization for change and equipping staff with additional skills to enable them undertake new roles (Kempton, 1996).

Organizational characteristic

The organizational climate committed to education and training greatly influences the transfer of knowledge and skills (Wills, 1994). A supportive climate increases the adoption of transfer strategies by the trainees as well as the transfer in general (Burke and Baldwin, 1999; Nikandrou et al., 2009). Superiors and colleagues are another important factor mentioned in the literature as affecting training transfer (Baldwin and Ford, 1988). Moreover, in a highly humane-oriented organizational culture, practices reflect individualized consideration and informal relationships provide development opportunities to employees (Schloesser et el., 2012). Characteristics of the trainee, design training transfer and climate in the organization affecting in training transfer to their work

Meanwhile, Brinia and Efstathiou (2012), mention that there are nine factors construct the training based on trainee characteristic and design work climate shown in table 1.

Table 1. Key factor for effectiveness training

	Factor
Trainee characteristic	Motivation to learn
	Motivations to transfer training
	Opportunity to use training
	Personal career goals
	Motivation from work
Training design	Content of training
Work Climate	Organizational commitment
	Colleagues support
	Superior support

Source based Brinia and Efstathiu (2012)

Required training program planning provides effective results (Berkhof et al., 2011). These programs include process of determining objectives, preparing actions and allocating resources for successful implementation of training (Burke & Jarratt, 2004). Maintenance crew and staff are better equipped with skills and training on a regular basis (Pintelon et all., 2014), because they are expected to quickly adapt to new technologies and deeply understand the existing equipment. In the current business world, skills training for employees can be generally divided into two main categories, hard skills and soft skills (Ibrahim and Boerhannoeddin, 2016). Hard skills normally refer to technical or administrative procedures related to an organizations business, and soft skills refers to the personal qualities, habits, attitudes and social graces that make someone a good employee. For superior maintenance performance, organization must be able to develop employees becoming competent and skillful through training (Shanmugam and Robert, 2015). The effectiveness of the maintenance programs will be greatly influenced by the ability of maintenance personnel and the lack of personnel maintenance capability, will impact on the poor performance of the maintenance (Au-Yong et al., 2014).

The fact that most organizations show that not all maintenance personnel are fully skilled (Higgins and Mobley, 2001, p. 1.69). The main barriers to get effective maintenance management is lack of skill and knowledge (Kangwa and Olubodun, 2003; Au-Yong et al., 2014). Training will facilitate learning for organizational members about the skills, knowledge, or behaviors that contribute to the success of the organization (Noe, 2010, p. 5). Based on this condition, it is needed a research to study the impact of training to improve maintenance performance (Velmurugan & Dhingra, 2015). In order to conduct this research, various statistical tools provide to measure the relationship between training and maintenance performance. According to the presumption of the proposed link between training and maintenance, measuring the association of variable was correlation analysis. Finally, regression analysis was conducted to measure overall relationships that lie within the model.

3. Research Methodology

The type of data collected for this research through questionnaires survey. Selection criterion for respondent based on manufacturing companies. Out of a total of 130 questionnaires distributed to the respondents (maintenance personnel), 123 questionnaires have been received. Respondent profile shown on table 2. Detail Questionnaire has

been designed based on the observations from papers, literatures and discussions. Various related issues were included maintenance performance, training, expectations of maintenance training and benefits gained by successful implementation of maintenance training.All variables were used todevelop a self-explanatory questionnaire using a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

The following research methods were used in the study:

1) Factor analysis used to validate the measurement.The main requirement of factor analysis for the variables to be analyzed further is that the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO-MSA) value should be greater than 0.5 and the probability (sig.) less than 0.05.
2) Correlation analysis. According to the presumption of the proposed link between training and maintenance performance, the test of measuring the association of variable is Pearson correlation (γ).
3) Regression analysis used in order to analyze the relationship between a dependent variable (maintenance performance) and independent variable (training).

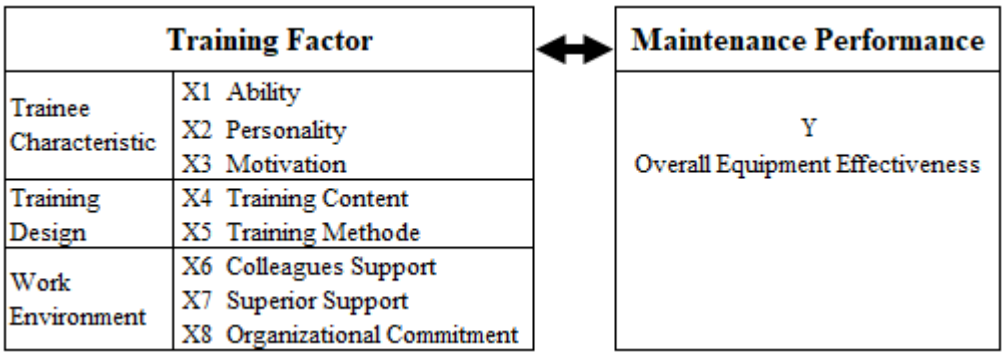


Figure 2. Correlation between training factor and maintenance performances

In order to ensure the maintenance performance result by an effective training, it becomes important to carefully ivestigated the different training success factor and maintenance performance parameter. In this present research, based on literature review, eight item training succes factors have been determined (T1, T2, and T3). Meanwhile OEE (P) is used as maintenance performance indicator that have been identified as powerfull and siginificant indicator for analyzing overall maintenance performance effectiveness (Nakajima, 1988; Bamber et al., 2003; Jain et al., 2015; Reyes, 2015).

Table 2. Respondent's demographic information

Manufacturing sector	Number of Respondents	Cumulative (%)
Automotive	28	22.8%
Consumer Good	21	17.1%
Chemicals	16	13.0%
Metals	14	11.4%
Food & Beverage	14	11.4%
Pulp & Paper	11	8.9%
Packaging	8	6.5%
Cigarette	7	5.7%
Electronic	4	3.3%
Total	**123**	**100.0%**

Level of Position	Number of Respondents	Cumulative (%)
Maintenance Manager	27	22.0%
Maintenance Engineer	16	13.0%
Maintenance Supervisor	45	36.6%
Maintenance Leader	14	11.4%
Maintenance Technician	21	17.1%
Total	**123**	**100.0%**

Work Experience (years)	Number of Respondents	Cumulative (%)
0 - 5	15	12.2%
6 - 10	28	22.8%
11 - 15	47	38.2%
16 - 20	23	18.7%
> 20	10	8.1%
Total	**123**	**100.0%**

Figure 2. shows the relationship between the dependent variable (training factor) and the independent variable (OEE). The classification of dependent and independent variable has been critically examined and finalized through extensive literature review (Campbell, 1995; Coetzee, 1997; Tsang et al., 1999; Brinia and Efstathiou, 2012; Asfaw et al., 2015).

4. Results

4.1. Construct validity and reliability

In order to confirm the latent factor structure for measured variables, factor analysis was performed. To test the reliability, the internal consistency of the questionnaire was measured using Cronbach's alpha coefficient. The results of validity and reliability are presented in Table 3.

Table 3. Construct validity and reliability

Factor	Item	KMO-MSA	Sig.	Cronbach's Alpha
Trainee Characteristic	X1. Ability	0.562	0.001	0.835
	X2. Personality	0.587	0.012	
	X3. Motivation	0.657	0.000	
Training Design	X4. Training Content	0.641	0.000	0.803
	X5. Training Method	0.726	0.004	
Work Environment	X6. Colleagues Support	0.667	0.000	0.859
	X7. Superior Support	0.714	0.000	
	X8. Organizational Commitment	0.671	0.000	
Maintenance Performance Indicator	Y. OEE Achievement	0.664	0.000	0.697

As can be seen in the Table 3, Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO-MSA) value for overall variables greater than 0.5 and the probability (sig.) less than 0.05. Its mean that all variables valid and can be analyzed further. To test the reliability, the internal consistency of the questionnaire was measured using Cronbach's alpha coefficient. The Cronbach's Alpha values for all the input and output categories, in excess of 0.65, indicates the significantly high reliability of data for various input and output categories.

4.2. Correlation Analysis

Correlation analysis by Pearson correlation matrix (Table 4) shows that all training variables are positively and significantly related with maintenance performance. As can be seen in Table 4, the strongest relationship was found between trainee characteristic and maintenance performance ($\gamma = 0.546$, $p < 0.01$). Variable work environment is also strongly related to maintenance performance ($\gamma = 0.491$, $p < 0.01$). However, the correlation analysis revealed that weakest correlation is between training design and maintenance performance ($\gamma = 0.404$, $p < 0.01$), but it is still significantly positive.

Table 4. Correlation Matrix

Correlations Matrix

	Variable	1	2	3	4
1	Trainee Characteristic	1			
2	Training Design	0.450**	1		
3	Work Environment	0.529**	0.328**	1	
4	Maintenance Performance	0.546**	0.404**	0.491**	1

**. Correlation is significant at the 0.01 level (2-tailed).

4.3. Regression Analysis

In order to investigate critical success factors for achieving maintenance performance results through training, the significant correlations thus obtained as a result of Pearson's Correlation and t Test are validated through "Multiple Regression Analysis" as depicted in Table 5. As shown by the regression results on Table 5, training is an important predictor for maintenance performance. Trainee Characteristic (sig. 0.000) and Work Environment (sig. 0.003) are positively and significantly contributed to the maintenance performance. Meanwhile, training design also has an effect on maintenance performance with significant (sig. 0.039). Based on R Square value, all training factors will contribute 37.7% to the effectiveness of maintenance performance. The R square value is a significant number considering the maintenance performance is influenced by many other factors that are not discussed in this research.

Table 5. Regression Analysis

Independent variable	Standardized Coefficients (Beta)	t	Sig.
(Constant)		2.460	0.015
Trainee Characteristic	0.332	3.655	0.000
Training Design	0.170	2.083	0.039
Work Environment	0.260	3.027	0.003

Notes:
Independent variable: Training; Dependent variable: Maintenance performance

R-Square = 0.377; *F*-change = 24.038; N = 123; Sig. *F*-change = 0.000

5. Conclusion

The research highlights the contributions of training on the maintenance performance for accruing strategic benefits for meeting the challenges posed by global competition. The empirical analysis has been employed in this study to investigate the role of training factors in achieving significant maintenance performances in the manufacturing organizations. For the purpose, various training success factor and maintenance performance parameter categories have been established in the research. The empirical evidence has been presented to support relationships between training success factors and key maintenance performance enhancement parameters. The findings of this research provide empirical evidence that training significantly and positively contributes to maintenance performance, in terms of maintenance processes efficiency and effectiveness. Training is shown to be an effective way of improving maintenance performance and create skilled technician. Author recommended the future research from this study is how to optimize number of skilled technician in order to improve maintenance performance.

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