Working System Improvement by Macroergonomics Approach

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Abstract. Companies are required to provide good service for the sake of continuity of production activities in the company. Such demands cause workers to always work optimally, but not aligned with the workload received by workers. This causes workers can not maintain good health so as to trigger the absence of workers during the appointed working hours. This study aims to identify the condition of each component of the company's work system and propose improvements to the condition of the components of the company's work system. The method used in work system improvement is Path Analysis (path analysis). By using Path Analysis (path analysis) obtained Relationship Between X1 (social environment) and Y (work system) that is equal to 0.885 This shows a very strong relationship. The Relationship Between X2 (Work Conditions) and Y (work system) of 0.743 indicates a very strong relationship. The relationship between X3 (individual characteristics) and Y (working system) that is equal to 0.689 shows a very strong relationship. The relationship between X4 (organizational conditions) and Y (work system) that is equal to 0.927 shows a very strong relationship. Relationship Between X5 (Equipment and Technology) and Y (work system) that is equal to 0.379 this shows weak relationship. The relationship between X6 (physical environment) and Y (work system) is equal to 0.638 and this shows as a strong relationship. Based on the results of research relationships between components then the improvement of work system components are components of the physical environment and organizational conditions.
1. INTRODUCTION
The term of ergonomics is derived from the Latin word *ergon* (work) and *nomos* (natural law) and can also be defined as the study of human aspects in its work environment reviewed in anatomy, physiology, psychology, engineering, management and design (1). Macroergonomics is a study that optimizes the organization and design of the work system by considering human, technological and environmental variables as well as the interaction between these variables (2). Macroergonomics aims to improve social design, techniques, work productivity and avoid unbalanced workloads (3). Workload is how much worker capacity is limited and takes time to complete the task or job (4). Unbalanced workloads cause the workers unable to work optimally due to an ergonomic work environment (5).

Unbalanced workloads may cause workers’ health problems resulting in large numbers of workers not finished specified working hours. Working system improvement can be done with macroergonomic approach to prevent unbalanced workload (6). A good working system is affected by the external environment (7). Under adverse of working environment conditions will affect the work system of workers to work optimally (8). And there is no perfect working concept but can be done by improving the existing work system with a better work system (9). The improvement of the work system provides the benefit of any macroergonomic components such as: social conditions, worker conditions, individual characteristics, organizational conditions, equipment and technology and the physical environment (10).

The improvement of working system of macroergonomic component is one of the study that need attention to increase work productivity so that give positive impact to company (11). But not apart from the company doing exercises on workers to improve their skills in accordance with company’s standard operating procedure (12).

2. RESEARCH METHODOLOGY

2.1. TYPES OF RESEARCH
This type of research is correlation or correlation research is a type of research that aims to determine the relationship and level of relationship between two or more variables without any attempt to influence the variable so that there is no manipulation of variables.

2.2. RESEARCH OBJECTS
The object of this research observed is the company’s working system

2.3. RESEARCH INSTRUMENT
The research instruments used in this study are open questionnaires and closed questionnaires

2.4. PROBLEM SOLVING METHODOLOGY
The methodology used to solve the problem consists of:
1. Identify the condition of each component of the work system
2. Conduct an assessment of the effect of the work system components
3. Provide proposed improvements to the conditions of the working system components
3. RESULT AND DISCUSSIONS

3.1. DATA COLLECTION

In this study, the primary data collected were obtained from the questionnaire. Respondents who became the object of this research is the operator of production work which amounted to 20 people.

3.2. QUESTIONNAIRE VALIDATION TEST

To test the instrument validity of the question, first count the correlation value between the parts of the instrument as a whole by correlating the score of each question item with the total score which is the total number of question items.

| Number of Respondents | Question 1 |
|-----------------------|------------|
|                       | X  | Y  | X^2 | Y^2 | XY  |
| 1                     | 4  | 153| 16  | 23409| 612 |
| 2                     | 1  | 65 | 1   | 4225 | 65  |
| 3                     | 4  | 149| 16  | 22201| 596 |
| 4                     | 3  | 146| 9   | 21316| 438 |
| 5                     | 3  | 135| 9   | 18225| 405 |
| 6                     | 5  | 130| 25  | 16900| 650 |
| 7                     | 2  | 69 | 4   | 4761 | 138 |
| 8                     | 5  | 133| 25  | 17689| 665 |
| 9                     | 5  | 142| 25  | 20164| 710 |
| 10                    | 5  | 137| 25  | 18769| 685 |
| 11                    | 3  | 135| 9   | 18225| 405 |
| 12                    | 5  | 138| 25  | 19044| 690 |
| 13                    | 3  | 138| 9   | 19044| 414 |
| 14                    | 3  | 138| 9   | 19044| 414 |
| 15                    | 4  | 144| 16  | 20736| 576 |
| 16                    | 3  | 138| 9   | 19044| 414 |
| 17                    | 5  | 131| 25  | 17161| 655 |
| 18                    | 4  | 137| 16  | 18769| 548 |
| 19                    | 2  | 76 | 4   | 5776 | 152 |
| 20                    | 5  | 141| 25  | 19881| 705 |
| Total                 | 74 | 2575| 302 | 344383 | 9937 |
3.3. PATH ANALYSIS

The research variables to be tested are:
1. Independent variables which are the condition of every component of work system which cover:
   - Social Environment (X1)
   - Work (X2)
   - Individual Characteristics (X3)
   - Organization Condition (X4)
   - Equipment and Technology (X5)
   - Physical Environment (X6)

2. Dependent Variables (Endogen / Effect) ie work system (Variable Y)

While the causal link between the variables described above in a path diagram (Path Diagram) below:

![Path Diagram](image.png)

**Figure 1.** X1, X2, X3, X4, X5, X6, and Y Line Chart

3.4. CALCULATION OF CORRELATION AND REGRESSION ANALYSIS

Correlation and regression analysis of the variable score recapitulation data done with the calculation of microsoft excel software and obtained the following results:
Table 2. Correlation inter-variable

|     | X1     | X2          | X3   | X4   | X5         | X6          | Y    |
|-----|--------|-------------|------|------|------------|-------------|------|
| X1  | 1      |             |      |      |            |             |      |
| X2  | 0.642892 | 1           |      |      |            |             |      |
| X3  | 0.807004 | 0.608786    | 1    |      |            |             |      |
| X4  | 0.861718 | 0.748569    | 0.789772 | 1    |            |             |      |
| X5  | 0.502653 | 0.306971    | 0.448867 | 0.384213 | 1          |             |      |
| X6  | 0.547243 | 0.709572    | 0.432965 | 0.623143 | 0.588588   | 1          |      |
| Y   | 0.884925 | 0.742821    | 0.688743 | 0.926958 | 0.379076   | 0.637734   | 1    |

3.5. Line Coefficient Calculation

Based on the results of regression and correlation calculation above, it can be obtained that:

\[ R^2_{yx1x2x3x4x5x6} = 0.859 \]

\[ r_{ij} \] = partial correlation values between variables i and j are obtained from the correlation table

\[ \rho_{ij} \] = the path coefficient between variables i and j is obtained from the regression table

\[ \rho_y \varepsilon_y = \sqrt{1 - R^2} \]
\[ \rho_y \varepsilon_y = \sqrt{1 - 0.859} \]
\[ \rho_y \varepsilon_y = 0.3755 \]

And the equality becomes

\[ Y = \rho_{y1}x_1 + \rho_{y2}x_2 + \rho_{y3}x_3 + \rho_{y4}x_4 + \rho_{y5}x_5 + \rho_{y6}x_6 + \rho_y \varepsilon \]

\[ Y = -0.198x_1 + 0.267x_2 + 0.228x_3 + 0.296x_4 + 0.138x_5 + 0.394x_6 + 0.375 \]

Then it can be illustrated the following path diagram

![Figure 2. Final line Diagram](image-url)
From the above path diagram can be determined the contribution or influence of each independent variable (working system components) to the dependent variable (work system) as follows:

| Table 3. Intercomponent Correlation Results |
|---------------------------------------------|
| X1-X2=0.642  | X2-X1=0.642  | X3-X1=0.861  | X4-X1=0.861  | X5-X1=0.502  | X6-X1=0.547  |
| X1-X3=0.807  | X2-X3=0.608  | X3-X2=0.608  | X4-X2=0.748  | X5-X2=0.306  | X6-X2=0.709  |
| X1-X4=0.861  | X2-X4=0.748  | X3-X4=0.789  | X4-X3=0.789  | X5-X3=0.448  | X6-X3=0.432  |
| X1-X5=0.502  | X2-X5=0.306  | X3-X5=0.448  | X4-X5=0.384  | X5-X4=0.384  | X6-X4=0.623  |
| X1-X6=0.547  | X2-X6=0.709  | X3-X6=0.432  | X4-X6=0.623  | X5-X6=0.588  | X6-X5=0.588  |

In the table above can be seen that the correlation between components as follows:

a. The relationship between the social environment with the work conditions (Task) is shown by the value of r12 that is 0.642 and this can be interpreted as a strong relationship.
b. Relationship between X2 (Working Conditions) and X3 (individual characteristics) The relationship between job conditions and individual characteristic conditions is indicated by a value of r23 of 0.608 and this can be interpreted as a strong relationship.
c. Relationship between X3 (individual characteristics) and X4 (organizational conditions) The relationship between individual characteristics and organizational conditions is indicated by a r34 value of 0.789 and this can be interpreted as a very strong relationship.
d. Relationship between X4 (organizational conditions) and X5 (Equipment and Technology) The relationship between the condition of the organization with the condition of equipment and technology is shown with the value of r45 which is 0.384 and this can be interpreted as a weak relationship.
e. Relationship between X5 (Equipment and Technology) and X6 (physical environment) The relationship between the condition of equipment and technology with the physical environment is indicated by the value of r56 of 0.588 and this can be interpreted as a strong relationship. The cause of physical environment components need improvement is the noise of the company's production machines of 95 db.

3.6. Proposed Working System Improvement

Based on the identified work system of the physical environment components of the working area, the following improvements can be proposed:

1. Noise from the company's production machines is anticipated by making dampers on production machines. Noise generated by crude palm oil production machinery of 95 db.
2. Provide personal protective equipment for operators to avoid hazards or accidents. PPE is proposed to be used to prevent inter-work accidents lain :
   - Ear Plug
     Use to protect the ears from the noise caused by the factory machinery. This will reduce the noise by 5 db.
   - Safety helmet
     Useful for protecting the head from a collision of iron-iron plant construction and hot temperatures on the production floor.
   - Gloves
     Useful for absorbing sweat and avoiding hand damage (calluses) caused by workpieces such as scop and chemicals such as alum / aluminum sulphate
   - Eyeglasses
     Useful for protecting eyes from dust on the production floor, and chemicals such as alum / aluminum sulphate
   - Safety shoes
     Useful to protect the feet from sharp palm shells and avoid work accidents due to slippery floor.
- Masks
  Useful to avoid inhalation of chemicals such as alum / aluminum sulfate and dust on the production floor.

  To improve the work system, then the efforts that can be done by the leadership of the company related to the condition of the company's organization are:
  1. Formulate standards, criteria and strategies to adjust the workload to be truly in accordance with the capabilities and resources available so that the division of labor is balanced.
  2. Reinforce the roles and responsibilities of each person to avoid crowded or overlapping. This can be done formally (standard agreement) or non-formal (note based on the development of circumstances).
  3. Giving the opportunity to participate in the decision-making process. People will feel responsible when involved in the decision-making process. Feeling responsible is a positive part of the psyche.
  4. Establish a competency-based performance management: reward those who achieve and reprimand those who violate and encourage those left behind. Let us not be indifferent to the achievers, indifferent to the violent and indifferent to the left.
  5. Maintain decisions and actions (implementation) to fit the values adopted by the organization

4. CONCLUSION

  Based on the results of data processing and analysis has been done, some things that can be concluded, among others:
  1. Effect of condition of all components of work system of PT. Jabal Perkasa is very significant simultaneously that is equal to 0.859. Components of the working system that is the condition of organization, work, physical environment, social environment, equipment and machine technology and individual characteristics greatly affect the company's work system.
  2. Assessment of the influence of work system components i.e. Relationship X1 (Working Environment) X3 (Individual Condition) X4 (organizational condition) X5 (Equipment and Technology) X6 (physical environment) with Y (work system) greatly affect the company's work system.
  3. Improvements to the components of the physical environment and components of the organization's conditions.

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