

Literature Review: Macroergonomics in the Industry of Transportation

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Abstract: Literature study is a series of writings in the context of the application of macro ergonomics in the transportation industry, which is viewed from the point of view of users and companies that produce vehicles. This writing aims to find out the optimization of work system design in its sociotechnical system and then bring it to the design of individual work, human-machine, and human-software to ensure a fully working system that runs well. The literature study was made by analyzing journals on the application of macro ergonomics in the transportation industry which were obtained from international journals indexed by Scopus (www.scopus.com) and Google Scholar (www.scholar.google.co.id). The results of the implementation of macro ergonomics in the transportation industry are proven to be able to produce positive trends. Macroergonomics based on the results of the study was found to not require large costs, and even reduce costs, especially in industries that produce transportation by involving all socio-technical elements so that good solution are produced.

Keywords: Macroergonomics, transportation industry, sociotechnical

1. INTRODUCTION

Every country is closely related to the industry. This is because the foreign exchange of a country, both developed and developing countries, is quite dependent on the industry. Saudi Arabia, for example, relies on the largest foreign exchange for the energy sector, namely oil and gas, China relies on the energy and manufacturing sectors, and Thailand relies on the tourism industry. From the various sources of foreign exchange, all countries need a transportation system that supports the balance of other industries. For example, the results of oil and gas products are used as a transportation fuel to facilitate public services or tourism uses transportation. A country needs to have a high level of accessibility of its transportation infrastructure (Banister & Berechman, 2001). Transportation is a discussion with a fairly broad scope, starting from assembly, design, to user convenience. The stage of making a transportation fleet is accompanied by ergonomics studies that consider user comfort. From the aspect of transportation service providers, including land, sea, and air transportation, it is very well considered as possible considering the competition is quite tight, which encourages each country to improve and improve its facilities to achieve the highest level of consumer satisfaction. Consumer satisfaction is one of the factors that will lead to a desire to use the service repeatedly.

Improving transportation services, especially in infrastructure, is quite important. Generally, the solution to the transportation improvement problem is carried out using a micro-ergonomics approach. However, along with the development of technology and science, and consumer desires, the solution for each problem requires improvement efforts using a macro ergonomic approach. Literature on ergonomics, in general, has been found

in various studies up to sub-disciplines of ergonomics, such as micro-and macro-ergonomics. Macroergonomics evolved as a subdiscipline of ergonomics in the 1980s to meet the changing technological, social, and value systems that emerged during the 1970s (Hendrick, H. W., 2007). The rapid development of science and technology has triggered the industrial revolution 4.0. This makes ergonomics experts always develop methodologies, tools, and curricula on macro ergonomics in their education.

Macroergonomics is the study of work systems where the work system consists of two or more people who work together (i.e. personnel sub-systems), interacting with technology (i.e. technology sub-systems) in an organizational system characterized by an internal environment (both physical and social). and culture) which then integrates principles and perspectives from industry, work, and organizational psychology (Kleiner, BM, 2006).

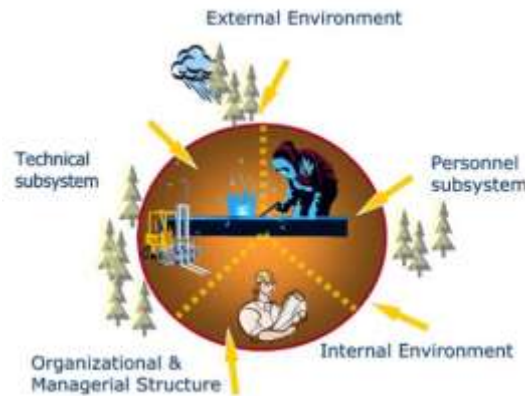


Figure 1. Illustration of the basic model of a working system (Kleiner, B. M., 2006)

Macroergonomics in its role aims to optimize the design of work systems in terms of the characteristics of their socio-technical systems which then brings the overall design characteristics of work systems to the design of individual jobs and human-machine and human software to ensure that the work system fully runs well (Hendrick, HW, & Kleiner, BM, 2002). Macroergonomics is often used when an organization or stakeholder is unable to solve a chronic problem, such as cost overruns by implementing micro ergonomics or other intervention strategies. The application to perform macro ergonomics without micro ergonomics rarely occurs because at first many thought that the micro approach could solve the problem.

Generally, ergonomics use a microreduction approach to technology research and design which is usually related to the human interface with technology. The macro approach places the many contributions of macro ergonomics in the context of human, technological, operational, and contextual variability where various outcomes can be produced from certain combinations of key factors (Peacock, B., Ping, C. Y., & Hedge, A., 2016). Hendrick, HW (2007) made a report recap with the context of macro ergonomics applications, including large-scale accident analysis, aviation safety, community ergonomics, hazard management, TQM, application of kansei to work systems, large-scale organizational changes (several companies), regional planning and community development, technology transfer, and training system development all of which are used to illustrate macro ergonomic applications and approaches.

In Stanton, N. A., & Salmon, P. M. (2011), it is explained that there are about forty papers with the main topic of applying ergonomics related to transportation or vehicles within three years. Some of these topics include road, air, and rail transportation. In recent decades, the transportation industry, particularly air transport, has experienced significant development due to increasing global connectivity and accelerating growth of most economies, especially high-income countries in the tourism industry. Given this phenomenon, the role of air transport cannot be overstated as the demand for air transport has grown in line with the increasing relevance of the tourism sector. This increase in demand also has a positive impact on the transportation preferences of tourists visiting from very long distances where many of them are often frustrated with the costs and inconvenience of transportation (Adedoyin, F. F. et al., 2020). The travel and tourism industry is considered the second largest industry in the world (Wikiversity, 2016). Air transport is currently being upgraded in terms of service quality and price gradually by taking advantage of innovations in aircraft technology and marketing

schemes, as well as information and communication technology (UKessays, 2018).

2. RESEARCH METHOD

The results of the literature review related to macro ergonomics describe several studies that are closely related to the transportation industry. The results obtained were re-analyzed, namely, the problems reviewed in the journals taken as well as detailed summaries related to how the application of macro ergonomics can act as the best solution in solving these problems.

Broadly speaking, 10 steps in the MEAD process are very useful for analyzing the work system process systematically developed by Brian Kleiner. The ten phases of MEAD analysis and design can be customized for specific applications. The framework promotes the participation of users involved in each phase. This framework is scalable considering its use that it can be applied to a network of systems or single systems. The framework has 10 phases as presented in Table 1 below.

Table 1. Main Stages and Tasks in the Macroergonomic Analysis and Design Framework (MEAD) (Hendrick, HW, 2007)

<i>Phase</i>	<i>Major Tasks</i>
<i>1. Scanning analysis</i>	<i>1.1 Perform mission, vision, principles analysis</i> <i>1.2 Perform a system scan</i> <i>1.3 Perform an environmental scan</i> <i>1.4 Develop organizational design dimensions</i>
<i>2. System type and performance analysis</i>	<i>2.1 Define production/industry system type</i> <i>2.2 Define performance expectations</i> <i>2.3 Prescribe organizational design dimensions</i> <i>2.4 Define system function allocation requirements</i>
<i>3. Technical work process analysis</i>	<i>3.1 Identify unit operations</i> <i>3.2 Flowchart the process</i>
<i>4. Variance data collection</i>	<i>4.1 Collect variance data</i> <i>4.2 Differentiate between input and throughput variances</i>
<i>5. Variance matrix analysis</i>	<i>5.1 Identify relationships among variances</i> <i>5.2 Identify key variances</i>
<i>6. Variance control and role analysis</i>	<i>6.1 Construct key variance control table</i> <i>6.2 Construct role network</i> <i>6.3 Evaluate effectiveness</i> <i>6.4 Prescribe organizational design dimensions</i>
<i>7. Organizational, joint, and function design</i>	<i>7.1 Perform function allocation</i> <i>7.2 Prescribe technological changes</i> <i>7.3 Prescribe personnel interventions if appropriate</i> <i>7.4 Prescribe final organizational design recommendations</i>
<i>8. Responsibility perception analysis</i>	<i>8.1 Evaluate role and responsibility perceptions</i> <i>8.2 Provide training recommendations</i>
<i>9. Support system and interface design</i>	<i>9.1 Design/redesign support subsystems</i> <i>9.2 Design/redesign interfaces and functions</i> <i>9.3 Design/redesign internal physical environment</i>
<i>10. Implement, iterate, and improve</i>	<i>10.1 Implement</i> <i>10.2 Perform evaluations</i> <i>10.3 Iterate</i>

The method used in this research is in the form of analysis and evaluation of journals to then conclude, which

is related to the application of macro ergonomics in the transportation industry. Journals are obtained by searching for scientific articles in the form of international journals that review macro ergonomics related to transportation. Analysis of scientific articles in international journals was selected based on elimination indexed by Scopus (www.scopus.com) and registered with Google Scholar (<https://scholar.google.co.id/>). The purpose of the basic application is to improve the quality of the literature study journal that will be made. All articles obtained will be recorded as much as possible concerning transportation macro ergonomics covering the land, sea, and air sectors.

Building a literature study requires the linkage of knowledge and the ability to relate knowledge to what has been focused on previous research. This is very complex considering the increase in knowledge that is growing rapidly where a lot of research is produced even in a short period. This challenge also creates difficulties to keep up with the latest research as well as the cutting edge/latest. A literature review is a more relevant research method because it can broadly describe the research being aimed at systematically (Snyder Hannah, 2019). By integrating many findings empirically, the literature review can answer research questions well and accurately.

3. DISCUSSION

The results obtained from searching international journals found several criteria that were included in the macro ergonomics radar in the transportation industry sector. In terms of the application of macro ergonomics in the transportation sector, governments such as Singapore, seek to address transportation challenges with a highly managed approach where this effort is different from several other Southeast Asian countries, especially Vietnam, whose approach is more Darwin (Bin and Ching 2013).

The special edition journal by Stanton, N. A., & Salmon, P. M. (2011) gives a message to the entire transportation industry and places more emphasis on safety where the work system in transportation is very complex so it needs gradual improvement and development. This is related to ergonomics which evaluates human actions or behavior during activities. Drivers or users have the potential to experience disturbances, which can come from vehicle systems, information systems on transportation, infrastructure, or from the environment through which the transportation is passing. The development of a system on a vehicle will occur and must be followed by user knowledge. Therefore, it is necessary to have a macro ergonomic approach to be further applied to help improve safety in transportation.

The study conducted in the journal entitled "*Creating safer routing for urban freight transportation*" by Prasolenko, O. et. al, (2019) is about the impact of traffic conditions on truck drivers associated with heart rate results. The driver's response to heavy traffic factors, obstacles to the way the car, the choice of the desired road direction, and the parking of the truck were investigated in this study. As a result, a macro ergonomic approach needs to be applied by considering the factors that become research variables and then used in developing safe traffic routes in urban goods transportation conditions, including taking into account the human factor.

In the journal "*Minimizing the maximal ergonomic burden in intra-hospital patient transportation*" by von Elmbach, AF, Scholl, A., & Walter, R. (2019), it is studied about patient transportation involving three parties, including hospital managers, patients, and porters who carry patients. It stated that managers should ensure an efficient transportation system with adequate porters to perform physical lifts so that surgical delays on patients are avoided. The ergonomics approach has been applied to the last group where physical work was found to be at risk for occupational diseases and injuries.

The old journal "*Passengers Management and Guidance at Railway Station*" by H. Oda (1986) examines human-machine systems with rail services. The train is one of the transportations with the most users in Japan, both nationally and privately managed trains. The highest users of trains are during the morning and evening rush hours. At that time, the use of more sophisticated machines created problems regarding the use of automatic ticket machines and automatic gates. The resulting staff reduction made instructions on how to use the machine unavailable. In addition, the number of parents continues to grow so that problem solving is carried out using an ergonomic approach such as providing user manual instructions that can be seen and heard.

"An Ergonomic Study on the UP-Diliman Jeepney Driver's Workspace and Driving Conditions" a research journal by Coz, M. C., Flores, P. J., Hernandez, K. L., & Portus, A. J. (2015) examines public transportation in the Philippines. Public transport drivers work an average of 10 hours per day with uncomfortable postures. Research is more focused on discomfort at work to be further evaluated and linked to the workspace and driver anthropometry. The ergonomics study approach resulted in the finding that drivers have the potential to be exposed to health-hazardous diseases with seats that impede mobility. The ergonomics approach is used to solve problems in macro ergonomics. Problem-solving is done by redesigning the vehicle dimensions by collecting the average measurements.

"Human Factors and Ergonomics in transportation control systems" by Dobson (2015) examines the evolution of control systems in rail transport. Modern transportation must be followed by an updated control system that makes operational performance better for the common good, including safety. The integration of the human factor in the design of work systems, equipment, environments, and tasks to support users is critical to ensure that operators react efficiently and safely. Through the application of Human Factors and Ergonomics, the possibility of human error can be significantly reduced if the transit control system is designed to be intuitive and effective through an iterative user-centered design lifecycle.

"Macro ergonomics approach to analyze the quality of public bike-sharing transportation services" by Sudiarno, A., & Aldhama, S. A. (2020) examines the public transportation system, namely the bicycle initiated by MIGO E-bike. A macro ergonomics approach is adopted to evaluate service quality by referring to the socio-technical system aspect in macro ergonomics theory. In this study, the strategic model of the relationship between management and customers was modified by adding the concept of the Green Ergonomic Model (GEM) to evaluate product service functionality. The concept of macro ergonomics is used to identify the main dimensions, criteria, indicators, and customer expectations of MIGO E-bike. The macro ergonomic approach allows companies to predict user characteristics and public interest in using public transportation modes.

The study entitled *"A sociotechnical systems approach to enhance safety climate in the trucking industry: Development of a methodology"* was conducted by Murphy, et.al, (2018) by applying a macro ergonomic approach to the trucking industry where the approach was applied to workers for safety in a socio-technical system. Utilizing a macro ergonomic approach to designing work systems can help identify aspects of the human-organization-technology interface that influence workers' perceptions of safety, both positively and negatively. It aims to develop a methodology that extends the safety climate beyond just a numerical rating by using a macro ergonomic framework to examine the entire system more comprehensively. This research emphasizes more on companies that produce trucks and not truck users. Similar is the case with the research conducted by Murphy, et.al, (2019) which applies a socio-technical system in the truck industry which is associated with the behavior of long-distance drivers to improve worker safety.

"The Mobility in Belo Horizonte Through the Macroergonomics and Service Design" is a study conducted by Botelho et.al., (2018) and examines the application of ergonomics in urban transportation. The background of the analysis of the capital city's transportation system under the perspective of macro ergonomics and service design (organization and its physical/psychological impact on the population) is because the application of macro ergonomics does not solve the problems caused by the unintegrated global system of urban mobility. Thus, the macro ergonomic approach is one of the efforts that can be done.

Neville Moray urges the discipline of ergonomics to address the global problems facing humanity and consider how ergonomics can help find some solutions. The challenge for ergonomics is to derive the value structures that move us beyond a view of technology-organization-worker fit and take a multidisciplinary approach that deals with the social and biological sciences by considering the cross-cultural factors that determine how different societies can operate. each function (Thatcher, A, et.al., (2018). The macro ergonomic approach is therefore believed to be able to solve existing problems because the macro ergonomics approach is a complex approach where the design approach must be human-centered. This approach is a work approach that is humane and integrates the sociotechnical characteristics of the organization into the design of an effective work system structure. In its application, this approach involves considering three main sociotechnical system elements that interact and influence the optimal functioning of the work system, including technology subsystems; personnel subsystem; and the relevant external environment, or part of the external environment permeating the organization on which it depends for its survival and success.

4. CONCLUSION

Problems that occur in the transportation industry are generally solved by an ergonomic approach. Most problems can be handled through a micro ergonomic approach. However, some problems that fail to be solved using a micro approach will be addressed by a macro ergonomic approach. It is rare for a macro ergonomics approach to be carried out directly because companies that have problems generally believe that solutions can be handled only by micro ergonomics. Unfortunately, the reality found is that macro ergonomics is the right solution in solving almost every industrial problem. Macroergonomics does not require large costs and can even reduce costs, especially in industries that produce transportation and involve all sociotechnical elements to produce good solutions.

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