Clasification of ergonomics levels for research

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Abstract. Ergonomics is useful to create a conducive system among people, work facilities, and work environment, so that the task demands are not underloaded or overload. Task demands far greater than the human ability or capacity can cause the impact of overstress, accidents, fatigue, injury, illness, pain and others. Ergonomics studies and intervention can create the system which can be classified into three types, namely macro ergonomics, mesoergonomics and micro ergonomics. This paper will distinguish boundaries among the three types as there are no definite boundaries. The method of study is by focusing on a pre-existing concept in the literature review. The purpose to understand and to classify according to specific variables. A table was constructed to differentiate them. Macro ergonomics was found to be more to broad such as production system as a work organization. Micro ergonomics approach is aimed at a specific process. Mesoergonomics is in-between and encompasses relationships between individuals and organizations and sociotechnical systems.

1. Introduction
Ergonomics is a vast field of science where there are several usage ratings. According to Nurmianto (1996), ergonomics is a study of the system in which humans, work facilities, and the environment interact with the main purpose of adjusting the working atmosphere with human beings. However, Tarwaka and Sudiajeng (2004) defined ergonomics as the performance or the ability of a human depends on the comparison between the size of the work demands on the large ability of the worker, when:

- task demands exceeding the workers’ ability or capacity can cause overstress, accidents, fatigue, injury, illness, pain and others
- task demands much lower than the workers’ ability will result in under-stress and boredom
- balanced task demand will enable a comfortable condition, safe and productive

Therefore, ergonomics is balancing the task demands and work capacity. The two factors must be balanced to achieve high work performance. Poor balance between task demands and work capacity will adversely affect the work system or the worker. One of the negative impacts caused is fatigue. Fatigue will not only affect workers physically and mentally but also decreases productivity levels. Low workers' productivity will harm the company economically and will affect the workers’ welfare.

In the current study, ergonomics is divided into three types, namely micro ergonomics, meso ergonomics, and macro ergonomics (Karsh et al, 2014). Until now there are two ergonomic design approach that is micro ergonomic and macro ergonomics approach.
1.1. Macro Ergonomics
Macro ergonomics is the activity of analysing work postures, estimating productivity, designing work tools. Macro ergonomics has several studies including the structural dimensions of the work system. Macro ergonomics is more broadly ergonomic and needs to be implemented through integration into a larger environment (corporate organization) known as macro ergonomics, which places the production system as a work organization. In subsequent developments, the work system design approach is associated with organizational structure, human and organizational interaction and motivational aspects of the work. This approach is known as Macro Ergonomic.
In industrial systems, this approach is also called Organizational Design (OD) and is used in the design of organizational structures and relationships among components of such structures. Hendrick (2002) said there are three sequential generation of ergonomic development which focused on:
- designing specific tasks, working groups, human-machinery relationships, including displays, workplace settings, the physical environment of work. It is directed at anthropometry and human physical characteristics and their implications in product design.
- cognitive factors reflected in the design of the system. The emphasized development model is user-system interface technology. The ergonomic development basis started to touch many problems of technology systems. This approach is called the human factor engineering or cognitive ergonomics.
- focusing on Organizational Ergonomics, such as macro system design, work system optimization in relation to organizational behaviour and organizational psychology. The emphasized development model is organization machine interface technology. Assessment of the organization was from top to bottom using the sociotechnical system approach.

1.2. Micro Ergonomics
Ergonomics can be regarded as ergonomics in small scope or traditional ergonomics. Activities analysing work or worker posture, estimating productivity, designing work tools, work physiology, work biomechanics, physical environment, anthropometry, percentiles, standard time and others, these are scientific within the scope of micro ergonomics. Thus, micro ergonomics is an ergonomic approach to a process aimed specifically at a specific process.
In the early development of ergonomics, the ergonomic is more focused on the design of work systems that emphasize on the relevance of the suitability of human capabilities with work /tasks that must be completed. Such an approach is characteristic of micro ergonomics.
The current development of science sees that ergonomic assessment is not only necessary and micro-analysed.

1.3. Meso Ergonomics
Meso ergonomics is in-between micro and macro ergonomics. However, the boundaries are unknown. Meso ergonomics encompasses relationships between individuals and organizations and sociotechnical systems. In designing the work system, the main factor to be considered as the centre of attention is the human factor. The approach in industrial design is Human Integrated Design, that utilises all information about human beings covering its advantages and disadvantages and being integrated as the basis for a system design.

2. Methodology
Review of relevant literatures is the main approach used. Literatures pertaining to macro, meso and micro-ergonomics were being searched mostly using Science Direct, Scopus and Web of Science websites. The literatures were classified accordingly and reviewed.
Concept analysis method was used during the reviewing work. Conceptual research deals with abstract or theoretical thinking. This research is commonly used to develop new concepts or to reinterpret a theory or thought. The ergonomic level analysis focuses on existing concept that it is
looking at the searched materials on how the three level of ergonomics was understood, described, explained and being implemented in the field. The concept analysis method has three functions. Firstly, to closely relates a concept /theory based on referred literatures and theory. A theory is then established. Secondly, to build a model which can help in structuring the problem, identifying relevant factors, and then providing connections. This effort simplifies the proper mapping of the problem’s framework. A well mapped conceptual model provides a correct representation of the phenomenon being studied. Thirdly, to connect the mapped framework to the newly established theory system found in the first function.

3. Results
In this study the authors theoretically classified the levels of ergonomic studies into macro, meso and micro ergonomics. This is established based on the reviewing work. The next step done was developing an easy to understand concept framework. The concept framework consists of the following concept items being classified into the three level of ergonomic studies:

- the level implement site
- decision making output
- users organisational level
- type of applications
- size of involvement
- scope of workspace
- area of work
- tools

The materials from the literature review are extracted and mapped according to concept items. The next stage was to connect the classified items with the three level of ergonomics studies. The table 1 shows the connection between the three level of ergonomic studies with the mapped items.

| Ergonomic | The level Implement Site | Decision Making Output | Users Organisational Level | Type of Applications | Size of Involvement | Scope of Workspace | Area of work | Tools |
|-----------|--------------------------|------------------------|---------------------------|---------------------|-------------------|------------------|-------------|-------|
| Macro     | Organisation             | Decision making        | Top management            | Decision making     | Organisation      | Environment      | - Organisational - Work System Design |
| Meso      | Multilevel: Organisation-Group-Individual | Decision making | Middle | System creation | Group/Department | Individual - Socio technical system | Group-work - Man-machine - Human-software | - Man-Machine - Man-job - Man-software |
At organizational system level, macro ergonomic is implemented in a very broad system compared to the meso ergonomic and micro ergonomic level. At meso ergonomic level, the size of the population is between the micro and macro levels, such as community or organization. The decision making output generated in each ergonomic level also have significant differences where by decisions at a macro level centred on decision making or organizational policy that is very influential on the future or direction of the organization. At meso level the decision output criticality is lesser than those of macro, as it operates at work group level only. The decision output in micro ergonomics are generated to include improvements in working methods, work design, working procedures and so forth.

The users of ergonomics studies and intervention also differ when based on organization levels. At the macro level, the studies’ users are mainly the top management, while at the users at meso level are middle management. At the micro ergonomics decision responsibility is for implementing at operational level.

On ergonomic applications, macro ergonomics is more towards decision making. Decision making at the meso level is more towards work group / system creation, while at the micro level, it is mainly applied to activities of individual, such as to identify the level of fatigue, musculoskeletal problems and so forth.

Number of people involvement in implementing at each level are also different. At the macro level, in it involve the whole organization. At the meso level group or work groups are engagement, while at the micro level the main involvement is the individual. Pertaining workspace scope, macro level study can encompass organization, society, company and even country. The scope at meso level covers the individual and the socio-technique, while the micro level only covers work station.

Macro ergonomics level covers largest area of work with boundaries covering the environment, social relations, and organizational level. Meso level area of work is limiting to systems in human work, human-machine and human-software. Micro level includes only work flow.

Tools at the macro level are organizational and work system design. Tools used at the meso level are man-machine, man-task, and human- software. While tools at the micro level includes work maps, SMED, kaizen and so forth.

4. Discussion
Ergonomics studies are classified into three levels which are macro ergonomics, meso ergonomics and micro ergonomics. Macro ergonomics is the activity of analysing work postures, estimating productivity, designing work tools and macro ergonomics have several studies including the structural dimensions of the work system. Macro ergonomics is more to the broad ergonomics that places the production system as a work organization.

Meso ergonomics encompasses relationships between individuals and organizations and sociotechnical systems. However, the meso level may also refer to an analysis that is specifically designed to reveal the relationship between the micro and macro levels. It is sometimes referred to as a mid-range, especially in sociology. While at the level of micro ergonomics includes a system that is smaller than the level of ergonomic meso that is on the scope of work stations.

Micro Ergonomics can be regarded as ergonomics in small scope or traditional ergonomics. The micro ergonomics level of the smallest unit of analysis in the social sciences is the individual in their social environment. At the micro level, also referred to as the local level, the study population is usually an individual in their social environment or a small group of individuals in a social context.
The developed conceptual model for ergonomic studies level should enable researchers to show how to look at the phenomena that are at the forefront of their research. The theoretical concepts can provide perspective or a way to see empirical phenomena. The conceptual model is built at least on a theoretical understanding or a hypothesis. Without theoretical input, it is impossible to build a framework of studies that focus on an occurring reality. The hypothesis can assist researchers on identifying a problem, tell the direction of research work and items to be researched.

5. Conclusion
There are some limitations in ergonomics research or intervention work. The limitations are dependent on the type and level of ergonomic. This paper distinguished the boundaries among level of ergonomics research works based on certain type of concept. This knowledge facilitates the researchers in ergonomic studies in understanding the concept of ergonomic level. Thus, making it easier to focus within the science level of ergonomics. There are several key differences among the three level ergonomics studies. For example, macroergonomics covers the environment or social relations and the scope of the organization. The boundaries and studies of macro ergonomics are very broad compared to the meso and micro ergonomics levels. Meso ergonomic includes the sociotechnical system, which is a combination of social and technical systems of a job, such as human-work, human-machine, and human-software. Studies in meso level ergonomic is limited to the boundary between macro level and micro level. Micro ergonomics studies are more directed to the tools used such as workflow, kaizen, smed and others. It is more specific and focused on individuality and more traditional ergonomics.

6. References
[1] Ayubkhon Radjiyev, Hai Qiu, Shu pinh Xiong and Kyung Hyun Nam 1992 Ergonomics and Sustainable Development in The Past Two Decades: Research trends and how ergonomics can contribute to sustainable development (Elsevier)
[2] Christina Oberg, Stephan C Henneberg and Stefanos Mouzas 2012 Organizational inscriptions of network pictures: A meso-level analysis (Elsevier)
[3] Donald C Cole and Richard P Wels 2003 Methodological issues in evaluating workplace interventions to reduce work-related musculoskeletal disorders through mechanical exposure reduction (Sjweh)
[4] Hendrick H W and Kleiner M B 2002 Macroergonomics theory methods and applications
[5] Iridiastadi H 2014 Ergonomi Suatu Penganantar (Bandung: PT. Remaja Rosdakarta)
[6] Karsh B, Waterson P and Holden R 2014 Crossing the levels in systems ergonomics: A framework to support ‘mesoergonomic’ inquiry Applied Ergonomics pp45-54
[7] Mark A Huselid and Brian E Becker 1997 The Impact of High Performance Work System Implementation Effectiveness, and Alignment with Strategy on Shareholder Wealth (Rutgers University)
[8] Melroy E D'Souza Joel S Greenstein 2003 Methods in a manufacturing organization: a context-based approach to the development of a computer-supported collaborative work system (Elsevier)
[9] Mike F, Patrick W and Colin M 2015 Macro and Micro Ergonomic Outcomes in Healthcare: Unravelling the Relationship between Patient Handling Performance and Safety Climate (Loughborough Design School: Loughborough University)
[10] N Jaffar, A H Abdul-Tharim, I F Mohd-Kamar and N S Lop 2011 A Literature Review of Ergonomics Risk Factors in Construction Industry (Elsevier)
[11] Nurmianto E 1979 Ergonomi Dasar dan Aplikasinya (Surabaya: Institut Sepuluh Nopember)
[12] Steven A 2004 Making Work System Principles Visible and Usable in System Analysis and Design (AISeL)
[13] Sue H 2000 Embedding ergonomics in hospital culture: top-down and bottom-up strategies (Elsevier)
[14] Sutalaksana I Z 2006 Teknik Perancangan Sistem Kerja (Bandung: ITB)
[15] Triana I 2009 Pengertian Ergonomi Makro at: https://ikhetriana.wordpress.com/2009/02/04/pengertian-ergonomi-makro/  
[16] Wignjosoebroto S 2008 Ergonomi Studi Gerak dan Waktu (Surabaya: GunaWidya)  
[17] Zjohan B and Sidney W A D 2010 Bridging the Macro and the Micro by Considering the Meso: Reflections on the Fractal Nature of Resilience Ecology and Society