Design of Participatory Ergonomics to Promote Occupational Safety and Health Culture in Mechanical Engineering Workshops

Hasianna Nopina Situmorang[1], Yoakim Simamora[2], Manihar Situmorang[3], Banu Nursanni[4], Lisa Melvi Ginting[5]

{hasiannanopina@unimed.ac.id[1], yoakimsimamora@unimed.ac.id[2], msitumorang@unimed.ac.id[3]}

Department of Mechanical Engineering Education, Universitas Negeri Medan, Medan, North Sumatera, Indonesia[1,4,5], Department of Electrical Engineering Education, Universitas Negeri Medan, Medan, North Sumatera, Indonesia[2], Department of Chemistry, Universitas Negeri Medan, Medan, North Sumatera, Indonesia[3]

Abstract. The active involvement of workers in creating ergonomic conditions that are appropriate to the conditions of their work environment needs to be supported in improving health, safety and productivity in the workplace. This research aims to develop a participatory ergonomics design to promote occupational safety and health culture that is appropriate to the work environment of Mechanical Engineering workshop. Research procedures include analyzing ergonomics needs for machinery workshops, and developing, standardizing, testing participatory ergonomics tools. Participatory ergonomics tools have been successfully designed, standardized and tested to promote a safety culture. Several aspects of ergonomics that are of concern to workers include a focus on safety, comfort, ease of use, productivity/performance, and aesthetics related to work in a machinery workshop environment. The implementation of the participatory ergonomics system has an impact on creating harmony between workers and their work in order to increase productivity and reduce risks in the work environment.

Keywords: Mechanical engineering workshop, Occupational safety and health, Participatory ergonomics, Work productivity, Zero accident.

1 Introduction

Participatory ergonomics (PE) is the main key in creating Occupational Safety and Health (OSH) in the work environment [1,2]. The active involvement of workers in paying attention to, organizing and choosing the best conditions for their work environment will have an impact on worker productivity. Ergonomic conditions that are appropriate to the conditions of the work environment will have an impact on the atmosphere of the work environment so that creating a pleasant work atmosphere that supports work activities will have an impact on

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worker productivity [3,4]. Thus, creating ergonomic conditions through participatory ergonomics that are adaptive to the type of work and working environment conditions needs to be supported in improving health, safety and productivity in the workplace. Participatory ergonomics focuses on actively involving workers in selecting and determining the best working environment conditions for workers. This participatory ergonomics can be done by asking for their opinions regarding the work environment in a holistic manner, giving workers the opportunity to propose ergonomic designs according to work problems, and implementing selected ergonomics in overcoming the ergonomic problems they face to improve safety and health in the workplace [5]. Several aspects that need to be focused on in designing participatory ergonomics include the involvement of workers in identifying hazards, developing appropriate solutions according to the characteristics of their work and work environment, and implementing changes to obtain the best ergonomic conditions to support activities in the workplace [6]. Thus, good organizational support is needed in designing participatory ergonomics, providing clear and measurable roles and tasks in creating an ergonomic atmosphere in the work environment, and workers' commitment to maintaining, maintaining and making continuous improvements related to ergonomics to optimize workers' potential in achieving safety and health in the workplace.

One of the work environments that needs attention regarding ergonomics is the Mechanical Engineering workshop [7,8]. The Mechanical Engineering Workshop is a place for student learning and practicums for undergraduate and vocational programs. The Mechanical Engineering Workshop is a collection of machining equipment and supporting equipment used in engineering learning activities involving machines. Academic activities in the Mechanical Engineering workshop relate to fabrication and manufacturing processes by processing materials using equipment and work machines that have OSH risks [9,10]. Apart from material and machine aspects, human aspects such as wrong work positions and lack of accuracy when working and work environment aspects such as lack of lighting and messy work desks are the causes of work accidents and work-related diseases [11].

Several sources of danger or potential causes of accidents in machining workshops include the condition and use of equipment/machines in the practical process, awkward and uncomfortable work postures, metal materials, metal chips resulting from the machining process, ash and dust, as well as poor lighting conditions, noise and vibration levels due to the use of machines. Good ergonomic conditions are very necessary to avoid potential dangers associated with work in a machinery workshop environment. Work accidents can cause work-related musculoskeletal disorders (WMSDs) [12], where there are complaints or pain in parts of the body, especially muscles, skeleton, tendons, joints, nerves, and other soft tissues of the body [13]. Improvements to work systems, such as redesigning work stations, designing tools, and improving work methods are alternative ways to reduce work accidents and work-related diseases, even though these methods are calculated to increase production costs or often the workforce does not pay attention to this need and refuses changes to work methods [14]. The involvement and commitment of human resources from various levels is needed to create a safety culture and achieve zero accident, that is, a work environment free from accidents. This research aims to develop the design of participatory ergonomics tools to promote a culture of occupational safety and health that is appropriate to the work environment of a Mechanical Engineering workshop.

2 Research methods

2.1 Research Locations and Research Objects

The research was carried out at the Faculty of Engineering, Universitas Negeri Medan, in the 2024/2025 academic year involving a population of lecturers, staff and students. The research sample was determined purposively according to the research objectives, namely those who work and study at the Mechanical Engineering Workshop, Department of Mechanical Engineering Education. Participation of lecturers and technicians, namely those who are willing to be research samples.

2.2 Research Ethics

The research was carried out following the research code of ethics established by the University. An explanation of the respondent's participation as a source of research data was first given, including research implementation techniques, participation, the nature of confidentiality of research data, and the rights possessed by the respondent and continued with asking for their consent by filling in and signing an informed consent form. Respondents are given the freedom to withdraw at any time as research samples as they wish.

2.3 Research Procedures

Research is devoted to developing participatory ergonomics to prevent work accidents in machining workshops. The research stages include analyzing the ergonomics needs of the machining workshop, developing participatory ergonomics tools that are appropriate for the machining workshop, standardizing the participatory ergonomics tools, and implementing the ergonomics tools as a small-scale trial before implementing them widely for academics in the mechanical engineering environment, as shown in Figure 1.

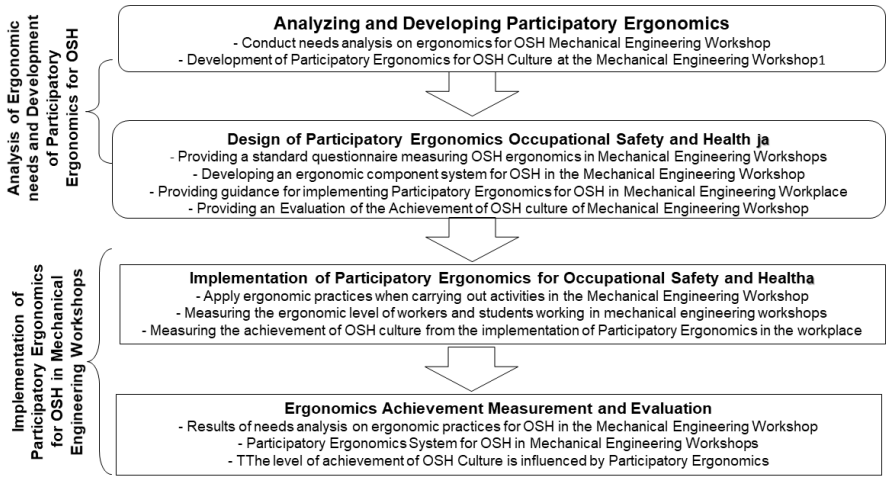

Fig. 1. Stages of development and implementation of participatory ergonomics in a mechanical engineering workshop to promote a culture of occupational safety and health.

A needs analysis for ergonomics was carried out through a survey to identify deficiencies or problems related to occupational safety and health in mechanical engineering workshops. Activities include identifying the availability of ergonomics aspects such as safety, comfort, ease of use, productivity/performance, and aesthetics, so as to create harmony between humans and their work. Needs analysis was carried out using a survey sheet for respondents to ask for their opinions and experiences regarding ergonomics needs in mechanical engineering workshops.

The development of participatory ergonomics was carried out through modification of the participatory ergonomics system by adapting it to the needs of the Mechanical Engineering workshop based on the results of the needs analysis. Participatory ergonomics was developed following the criteria set by the Occupational Safety and Health Administration (OSHA).

The implementation of participatory ergonomics was carried out in the Vocational Study Program which took part in OSH lectures using one experimental class to treat the implementation of participatory ergonomics and one class as a control for comparison. Both groups of students (experimental and control classes) used the same workshop facilities that were available on campus at the time of conducting the research. The results of the implementation of participatory ergonomics are evaluated to see ergonomic experiences during learning, work practices and activities in mechanical engineering workshops as an illustration of the achievement of occupational safety and health culture.

2.4 Data Collection and Evaluation of Occupational Safety and Health Culture

The research was carried out at the Faculty of Engineering, Universitas Negeri Medan, in the 2024/2025 academic year involving a population of lecturers, staff and students. The research

sample was determined purposively according to the research objectives, namely those who work and study at the Mechanical Engineering Workshop, Department of Mechanical Engineering Education. Participation of lecturers and technicians, namely those who are willing to be research samples.

3 Results

3.1 Analysis of Ergonomic Needs for Mechanical Engineering

An analysis of the need for adaptive ergonomics to work in mechanical engineering workshops has been carried out. Survey results related to creating harmony between workers and the characteristics of machining work in a mechanical engineering workshop environment have been identified. Respondents gave responses of Not Appropriate (M=2.57±0.56) for all aspects regarding ergonomic needs that need to be improved in the work environment including safety, comfort, ease of use, productivity or performance and aesthetics which are summarized in Table 1.

Table 1. Respondents' opinions regarding the need for facilities and availability of occupational safety and health in the mechanical engineering workshop environment.

No	Ergonomic components	Respondents opinion (M±Sdv)*		Necessity Conclusion
		Current condition	Actual conditions	
1	Occupational safety and health conditions	4.00±2.16	Not complete	Needs improvement
2	Comfortable working environment conditions	2.43±0.79	Need regulations	Needs improvement
3	Ease and availability of access to the use of safety devices	2.29±0.49	Not standard	Needs improvement
4	Support for complete facilities on work productivity (performance)	2.71±049	Needs to be completed	Very urgent
5	Aesthetic conditions and work space arrangements	2.71±0.49	Needs arrangement	Arrangement
	Average	2.57±0.56		

*Likert scale: (4) Very Appropriate; (3) Appropriate; (2) Not Appropriate; and (1) Very Inappropriate

3.2 Machining Workshop Ergonomics Participatory Toolkit

Participatory ergonomics tools for preventing work accidents in machining workshops have been developed following the ergonomic requirements for workers and types of machining work in mechanical engineering workshops. The components of participatory ergonomics, a brief description of participatory ergonomics tools and communication media for workers are shown in Table 2.

Table 2. Main components of adaptive participatory ergonomics for workers and types of machining work in mechanical engineering workshops.

No	Participatory ergonomics component	Brief description of participatory ergonomics	Promotional media & Information
1	Employee Engagement	Workers are actively involved in designing participatory ergonomics, consulted in identifying ergonomic problems, developing solutions for changes in the work environment, improving the work environment, and creating safer, healthier and more productive workplace ergonomics.	Announcements and Leaflets
2	Goals and Objectives of participatory ergonomics	The goals and objectives of participatory ergonomics are to create safety, comfort, ease of use, productivity/performance, and aesthetics. Goals are defined in a specific, measurable, achievable, relevant and implementation time frame.	Handbook of participatory ergonomics
3	Management Support	Leadership support and commitment in management includes providing resources, financial support, and setting a time for realization. Adequate resource and expert support for the successful achievement of a safe and healthy ergonomics program.	Short, medium, and long term policies
4	Training and Education	Providing workers with the necessary knowledge about ergonomic principles and participatory ergonomics processes so that workers have ergonomic knowledge to create occupational safety and health in the Mechanical Engineering workshop environment.	Announcements and Pocket Book
5	Problem Identification and Solution Development	Workers are at the heart of participatory ergonomics to identify ergonomic hazards in their specific work environments. Workers are involved in developing and evaluating ergonomic conditions and providing solutions to problems related to ergonomic conditions in the work environment that can be accepted by all workers.	Checklist Form and Filling List
6	Implementation and Evaluation	The implementation of participatory ergonomics is focused on creating safety, comfort, ease of use, productivity/performance, and aesthetics by involving implementing solutions and always monitoring their effectiveness. Implementation success is measured using predetermined key performance indicators, and shows the impact on safety, productivity and worker performance.	Handbook of participatory ergonomics
7	Cooperation and Collaboration	Forming a special ergonomics team in the Mechanical Engineering workshop environment with clear roles and responsibilities in solving worker and workplace problems, and facilitating the creation of safer, healthier and more productive workplace ergonomics.	Leadership policy
8	Continuous Improvement	Implementation of participatory ergonomics is an ongoing process that requires regular evaluation and adjustment according to work environment conditions and ensures sustainable success. Improvement results are communicated openly and feedback obtained is provided to all stakeholders.	Participatory ergonomic implementation evaluation book

3.3 Implementation of Participatory Ergonomics for Occupational Safety and Health

Implementation of participatory ergonomics for occupational safety and health in machinery workshops has been carried out through structuring, arranging, placing and fulfilling facilities that can improve workshop ergonomics. By arranging workshop components by adapting to workshop needs to achieve safety goals in order to create a safe and healthy environment for all workers. Through the implementation of participatory ergonomics, workers and workshop managers have a commitment to play a role according to their functions and duties in creating appropriate ergonomics for mechanical engineering workshops. Respondents have provided their responses to the ergonomic components arranged in the mechanical engineering workshop environment as summarized in Table 3.

Table 3. Respondents' opinions regarding the facilities and availability of occupational safety and health in the mechanical engineering workshop environment.

No	Ergonomic components	Number of Questions	Brief description of the need for OSH in the workshop	Respondent assessment (M±Sdv)*
1	Personal Protective Equipment (PPE)	4	Selection, provision and fulfillment of appropriate PPE to protect workers from various hazards in the workshop including: overalls or aprons, safety glasses, gloves, hearing protectors and respirators	3.71±0.49
2	Machine Safety	4	Regular inspection and maintenance of equipment, availability of tools and equipment for moving equipment components, regular training of operators, guidance in heavy equipment protection, equipment maintenance, and handling coolants and lubricants.	3.57±0.53
3	Housekeeping and Aesthetics	4	Organizing and keeping the work space clean, equipment stored properly, keeping environments such as hallways clean, floors free from spills, instructions and reminders to prevent slips, trips and falls.	3.43±0.53
4	Hazard Control	5	Identifying and controlling hazards includes procedures for storing flammable materials, controlling noise levels, providing local exhaust ventilation, guidelines for lifting vehicles, working under vehicles, and refueling.	3.43±0.53
5	Training and Supervision for Emergency Preparedness	4	Training, simulations and workshops in the care and use of fire extinguishers, first aid kits, evacuation procedures, safety procedures, correct use of equipment, emergency protocols and emergency exit instructions.	3.29±0.49
6	Ventilation and Lighting	4	Provision of adequate ventilation to remove smoke and dust, appropriate and sufficient lighting to ensure visibility.	3.57±0.52
	Total/Average	25		3.50±0.52

4 Discussion

The design of participatory ergonomics to promote a culture of occupational safety and health in the Mechanical Engineering workshop has been developed based on an analysis of the real needs of workers. Respondents have given a very good, and relatively urgent assessment of the need for the importance of participatory ergonomics for machinery-related work environments [15]. Workers have also provided an objective assessment of the ergonomic components they are experiencing when working in a workshop environment, including identifying the availability of ergonomic aspects such as safety, comfort, ease of use, productivity or performance, and aesthetics, so as to create harmony between humans and their work [16].

The development of participatory ergonomics has been carried out for the needs of workers in mechanical engineering workshops. Several aspects of ergonomics that are of concern to workers include a focus on safety, comfort, ease of use, productivity/performance, and aesthetics related to work in a workshop environment [17]. The results of data analysis provide good scores in almost all aspects, indicating that the participatory ergonomics approach is very reliable in achieving occupational safety and health in the mechanical engineering environment.

In general, the ergonomic structure in participatory ergonomics design is developed including employee involvement in determining participatory ergonomics, goals and objectives of participatory ergonomics that can be achieved, management support to achieve an ergonomic atmosphere in the work environment, training and education to provide a common perception for workers regarding mechanical engineering ergonomics, strategies for identifying problems and developing solutions in overcoming problems faced in the work environment, implementation and evaluation of participatory ergonomics, related cooperation and collaboration. participatory ergonomics, and continuous improvement for the successful achievement of a safe and healthy ergonomics program [18,19]. The application of the participatory ergonomics approach has succeeded in changing the work system of workers in the Mechanical Engineering workshop environment. The application of the participatory ergonomics system has an impact on creating harmony between people and their work in order to increase productivity and reduce risks to safety and health in the work environment.

5 Conclusion

The research results show that the application of the participatory ergonomics approach has succeeded in changing the work system of workers in the Mechanical Engineering workshop environment. Several aspects of ergonomics that are of concern to workers include a focus on safety, comfort, ease of use, productivity/performance, and aesthetics related to work in a workshop environment. The application of the participatory ergonomics system has an impact on creating harmony between people and their work in order to increase productivity and reduce risks to safety and health in the work environment. The results of data analysis provide good scores in almost all aspects, indicating that the participatory ergonomics approach is very reliable in achieving occupational safety and health in the mechanical engineering environment. This study is still in the refinement stage as a step to obtain a valid participatory

ergonomics design to be implemented on a wider scale to create appropriate ergonomic conditions for workers according to the type of machining work in the Mechanical Engineering Workshop environment.

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