Ergonomics in Mining: Participatory Approach in Indonesian Tin Mining

R Priyoko Prayitnoadi¹, Glyn Lawson², Brendan Ryan² and Setia Hermawati²

¹Jurusan Teknik Mesin, Fakultas Teknik, Universitas Bangka Belitung, Bangka 33172, Indonesia
²Human Factors Research Group, University of Nottingham Nottingham NG7 1RD, United Kingdom

E-mail: priyokoprayitnoadi@gmail.com

Abstract. This paper presents the investigation of the acceptability and suitability of Participatory Ergonomics (PE) interventions within tin mining companies. The study was conducted by scenario-based-design (SBD) method and questionnaire with participants from small medium enterprises (SMEs) tin companies. Five companies and fifteen participants were involved in this study. The acceptance of participatory ergonomics through SBD study revealed positive in Indonesian tin mining companies. The study shows that support from occupational safety and health (OSH) authorities are needed in order to strengthen workers’ knowledge in ergonomics and good safety practices and to allow them to implement ergonomics through training and the participatory approach. The results of this study may contribute towards the implementation of PE. As a consequence of improved implementation, tin mining accidents may be reduced.

1. Introduction
Tin mining in Indonesia has been operating for more than 300 years. Located in Bangka Belitung islands, tin mining is continue to produce around 90% of Indonesia’s tin and fulfills 30% of the world’s tin requirements [1,2]. Indonesia is the world’s second-largest tin exporter after China [3]. Since 2000, Bangka and Belitung Island became new province and through the regional autonomy, illegal miners have emerged developed as local government has the ability to issue permission where central government has not [4]. Tin mining activity can be done by small scale miners and even by individuals who do not have experience and knowledge of mining best practices. Consequences to illegal mining practice with unsafe devices, lack of knowledge about the tin mining exploitation process and limited funds result in dangerous incidents, accidents and even fatalities. This could be the reason why the number of occupational accidents in the mining industry sector is relatively high when compared to other industry sectors [5].

One of the approaches to support ergonomics intervention is participatory ergonomics (PE). Wilson et.al [6] defined participatory ergonomics as ‘the involvement of people in planning and controlling a significant amount of their own work activities, with sufficient knowledge and power to influence both processes and outcomes in order to achieve desirable goal’. The implementation of PE has been applying in many fields and industries such as in military, manufacturing, production and processing plants, service industries, construction and transportation [7,8].
In review of ergonomics applications in industrially developing countries (IDCs), Hermawati et al. [9] posited the view that a participatory approach is needed as a bottom-up approach in implementing ergonomics at workplace. They also suggested that by ‘having an appropriate adaptation and modification of ergonomics tools will definitely be beneficial in the future’. Hermawati et al [9] found that there are few studies addressing the health and safety domain in Indonesia, and the mining sector, which was shown to have the least number of ergonomics application.

So far there has been little research on PE in Indonesia; the research work that has been done has tended to focus on the physical ergonomics rather than organizational ergonomics [9]. To the best of authors’ knowledge, there are no other scientific publications that discuss the implementation of participatory ergonomics (PE) in occupational safety in Indonesian tin mining.

The aims of this research were to investigate the acceptability and suitability of participatory ergonomics interventions within tin mining companies in Indonesian tin mining. The approach for this study i.e. measuring an interaction between people during a discussion was developed during this study. To the extent of authors’ knowledge, this approach had never been applied before. However, this work should be evaluated to review the novel contribution against other works. This paper’s main contribution is on the identification by the actual condition of PE issues, new approach to measure participation, and future research recommendation in addressing identified problems. Although this paper is focus on Indonesian tin mining companies, it is expected that this findings will also be useful for other IDCs where tin mining SMEs is one source of employment.

2. Research Methods

The study used a Scenario-Based-Design (SBD) and Questionnaire methods. Those methods are described as follow.

2.1 Scenario-Based-Design (SBD)

SBD was used to identify claims and trade-offs that may impact PE in the study of participatory ergonomics intervention. It consisted of two problem scenarios, i.e. workers problems in onshore tin mining, and in a tin smelter.

2.1.1 Story in onshore tin mining: the story said that there are six workers at the ‘front’ (the mention of a place where a huge mixed water and sand are collected to be sucked up with suction machine unit). Some workers hose down the land with high-pressure water, whilst some of them are manage the sand. The workers work in a hot, wet, and noisy environment, with no personal protective equipment (PPE). The workers are working 8 hours a day and are paid based on tin result. The participants were asked some questions i.e. why do not they use PPE? What are the consequences of not using PPE? How do you suggest preventing those consequences? Moreover, what kinds of PPE do you think suitable for them?

2.1.2 Story in smelter: where it said that the participants imagined work for a tin smelter small medium enterprise in town. In the plant, there are activities in the workplace as the participants can see in the picture given. It is a very dusty, hot, noisy and dangerous work environment. The participants were asked to discuss within the group to make a list at least three most important things that they could discuss it in more detail in order to identify the consequences and to find the solutions to overcome those problems. Moreover, the group would discuss about any experience in similar problems in their workplace, explain what their experienced and what they could do to solve these problems.

These two scenarios were given to a group consisting of owner, manager, and worker (n = 15). The groups (n = 5) were tasked to discuss safety issues through those problem scenarios and it recorded by video recorder.

SBD was used to measure participation and to find ergonomics issues through SBD discussions. To measure participation, the author collected data from videos and calculated the duration each participant’s spoke. The data was translated into a line chart, which is shown the relationship between
time and duration. This line chart allows the author to analyze how much time each participant contributes in a discussion in terms of time durations and time intervals. Another chart, a pie chart, was made to display a total duration of each participant in percentage. Meanwhile, to find ergonomics issues, the author transcribed and translated the audio from the video and it grouped for each question in the scenarios to analyze through content analysis.

2.2 Questionnaire

Questionnaire was used to identify how participants found PE process, i.e. did you get a chance to contribute in problem solving?, and how likely success of further PE if it applicable, i.e. do you think this type of participatory approach would be suitable way to improve your work? The questionnaire, which consisted of twelve questions, was given to the participants after finished their scenario-based-design (SBD) study. Questionnaire responses were translated into English and content analysis was used to analyze collected data by roles categories. Tabulations of content analysis were made and managed according to the questions. The summary of study has been made for each participant category.

3. Results

3.1 Participatory Measurement

A Microsoft Excel database of intermittent voice duration was formed during participatory analysis. The data was translated into a line chart, which is shown the relationship between time and duration. This line chart was analyzed how much time each participant contributes in a discussion in terms of time durations and time intervals. Another chart, a pie chart, was made to display a total duration of each participant.

The acceptance of participatory ergonomics through SBD study revealed positive in Indonesian tin mining companies. Based on participatory measurement, it shows that across all companies, owner contributed 35%, manager and worker contributed 38% and 27% respectively (See Figure 1).

![Figure 1. Participation analysis on all companies](image)

Nevertheless, the participatory distribution for each role in every company is varying. For example, company 1 and 2 were found that managers have greater contribution in discussion. Company 3 indicates that owner has dominant in discussion with more than 50% talk time. Worker has slightly more than manager does in company 5. Meanwhile, company 4 showed a good balance of talk time, where there are small spreads among the roles, i.e. owner is 26%, manager 36% and worker is 38% (Figure 2)
3.2 Ergonomics Issues

Generally, participants were expressing the same arguments from the question about using personal protective equipment (PPE) during work, i.e. lack of knowledge and attitude of workers in use of PPE. This situation happens due to external and internal factors. External factors are mostly come from company such as less information about safety regulations including no adequate training provided, inappropriate of PPE, and lack of daily safety supervision whilst internal factor is a problem of human cultural such as sense of ‘unnecessary’ of using PPE, and take for granted a wrongdoings.

Since ergonomics is important to fitting workplace conditions and job demands to the capabilities of the working population, ergonomist or industrial experts must work together with non-experts to improve human-machine working relationship and working safety. This means that participatory ergonomics approach for disseminating ergonomics information is needed.

3.3 Participatory Issues

Most of participants expressed that PE approach is better than the existing approach. Most of owners said this approach is new and involving negotiation among roles. Some managers argued this approach is more practical and through team working. Indeed, PE intervention approach will be an effective and efficient way to implement, but it will not work if participants are reluctant. Opportunities to say something, share knowledge and team based solution are the reasons why this approach is more effective and efficient way. Moreover, this type of participatory approach would be a suitable way because it involves all levels, increasing safety awareness and self-responsibility.

The barriers in implementing PE in Indonesian tin mining are concluded as communication among roles, which is hard to do. Specific communication problems are misunderstanding about the work place problem, and disagreeing or forcing arguments that could happen.

These barriers could bring this approach into a long-term solution become slower. In fact, long-term solution needs dissemination of PE to improve understanding, improving quality of communication among roles, and making easier to accept new information/approaches.

4. Discussion

The acceptance of PE through scenario based design (SBD) study revealed positive in Indonesian tin mining companies. Based on participatory analysis, it shows that owner contribute 35%, manager and
worker are contribute 38% and 27% respectively. Nevertheless, the participatory distribution for each role in every company is varying.

Although almost all workers admitted that they contribute in solving problem, this finding confirmed the idea that there are workers who reluctant to talk and only work as boss asked them. In contrast, Owner in one company showed only 1% contribution. This is inconsistent with the questionnaire result that all owners have chances to contribute in problem solving. It is presumably that the owner reluctant or fears to say something and it is likely that ‘management see participation as threat to their right to manage rather than as an aid’ [10]. Moreover, they said that group or individual resistances are said to be one of the reasons why workforce hesitate to get involved and the workforce feel lack, sufficient motivations, time and energy. They also said that ‘they might defer too much either to management or to technical experts’.

All participants were happy with the group’s chosen solutions in SBD discussion. Owner said that solution solved through group with different roles and the consensus was taken. Manager, in this case, said that this could improve occupational safety awareness since it involves floor workers. Meanwhile, worker was happy because they had opportunities to say something that bosses should know the workplace problems directly and formally. Besides, this makes ‘togetherness’ in working was implemented as Haines & Wilson [10] mentioned that ‘work teams participating together to identify problems and implement improvements’. Through all those findings, it can be concluded that participating in solving problem in-group, which consist of all roles in Indonesian tin mining companies, is generally acceptable with the terms that deepening study to investigate problems in implementing PE is conducted to generate a comprehensive suggestions in supporting this acceptance.

5. Conclusion
It is found that despite the floor workers are accept the PE approach to improve occupational safety, the study distinctly prove that support from OSH authorities are needed in order to strengthen workers’ knowledge in ergonomics, good safety practices and allow them implemented ergonomics through training and participatory approach. The findings of this study offered new information on specific barriers to implementation of participatory ergonomics intervention.

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