Usability Evaluation of Web-Based RBG Innovation Paradigm (RIP) Framework to Improve the Industrial Processes

Gole S.[a], Gnanavel S.S.[b], Venakatesh B.[c]
Indian Institute of Technology, Madras, India
[a]gole.sai@gmail.com
[b]ssgnanavel@gmail.com
[c]chanakya@iitm.ac.in

Abstract: The need of organized sector in manufacturing industries is widely understood and is implemented at varied amount at different production lines. Our study depicts web-based/online implementation of the framework to relate different ergonomic methods of evaluation for improvising activities and managing the operations for the manufacturing industries. The framework developed is implemented on online interface designed for maximum user utility by structured parameters and outline. It gives analysis and solutions for existing plant; to improve the setups and on-floor human resource (labor) organization along with rigorous ergonomic investigation and cost analysis. The smooth and easy database will encourage the industries to take up the surveys efficiently, without spending much¬¬¬ of their resources and to give instant results. The online/web based framework will help in higher amount of data collection than the traditional way including trivial calculations and offline data. Availability of databases across different industries will help in developing and optimizing the algorithms.

1 Introduction

In today's competitive industrial world, it is difficult to eliminate manual work in manufacturing industries due to cheap labor and cost of technology adoption. People are reported to have fatigue and there is increase in work related injuries. The need of organized sector in manufacturing industries is widely understood and is implemented at varied amount at different production lines. RBG Innovation Paradigm (RIP) was developed to bring process innovation in the organization considering lean tools along with, human and organizational factors [1, 2]. Our study depicts web-based/online implementation of the framework to relate different ergonomic methods of evaluation for improvising activities and managing the operations of the manufacturing industries and evaluating usability.

There are different assessment and benchmarking methods used in literature which are used currently for partial assessment. One of the majorly used tools for lean management is Value Stream Mapping also known as Material and Information Flow Mapping is used for analyzing the current systems and designing the new systems for flow if information or material required. Some other lean tools work with pre-defined targets such as elimination waste, quality improvement, reduction of process time and reduction of total cost [3,4]. These tools are successful in productivity improvement but lack in involvement of human factors to obtain sustained productivity improvement. On the other hand, there are many ergonomic assessment tools available for various tasks in different industries such as RULA

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and REBA which are cater to posture analysis. Initially, these tools de-signed to be suitable for textile confectionary industry with hand/arm-intensive work (RULA) [5] and for caregiver industry (REBA) [6], such as in hospitals where more dynamic full-body works (such as lifting/ transferring patients and pushing heavy carts) are predominant. Other available ergonomics methods may be extra specific (such as NIOSH lifting equation)[7] or even broader (e.g. Key Indicator Method) in order to target work task- or environment-related factors as well as the physical loading [8].

Some studies show the impact of using lean production systems on worker productivity [10, 11]. It is estimated that there is need of framework to combine the lean manufacturing practices with the ergonomics analysis of tasks [12, 13]. Our study combines use of one of such method RBG In-novation Paradigm (RIP) and restructuring this framework for web-based implementation. This study is used to check the effectiveness of implementing the web based approach and provide better solutions/suggestions for manufacturing platform.

2 Methodology

The RBG Innovation Paradigm (RIP) [1, 2] is studied and reorganized for web-based step by step implementation. The RIP is re-formulated into 7-step structure for effective implementation and data collection for different parameters for assessment of industrial processes. The web implementation of RIP framework is depicted in flowchart below (Fig 1).

2.1 RIP implementation

The seven step approach followed for RIP implementation consists of structured webpages for data collection. The web implementation is done with an adaptive format to take account the previous response and change the next page according it. The user manual is provided to the users for having initial understanding of the type of reading needed from the manufacturing unit. Also, the necessary responses are made compulsory to follow the mentioned adaptive technique [Fig. 2].The data collected is stored locally on web-server for further processing and results were mailed to the users. The evaluation of this web assessment is done after each form to have a feedback for the user experience.

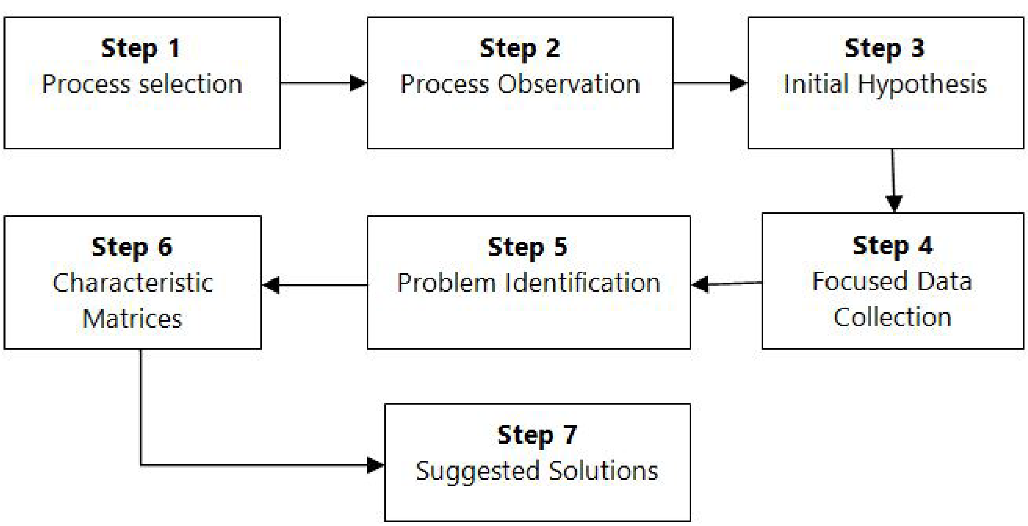

Fig. 1: RIP – Methodology and web-implementation steps

2.1.1 RIP Step 1: Process Selection

The first step in structured data collection is formulated to get maximum basic information about the process. The initial necessary parameters are recorded in this step. The operations layer corresponding to process is selected from machining, fabrication, assembly, packaging, maintenance, tooling, quality check etc. The basic process information of selected operation layer which includes number of workstations, number of operator involved and number of tasks involved in the processes were collected.

According to this information, the next web-pages for data collection are adjusted parametrically for different inputs. For example, if the user inputs the number of tasks = 6, this will be recorded for further steps of assessment and as per this input the questions and web-pages are generated.

2.1.2 RIP Step 2: Process Observation

According to inputs from Step 1, this step is designed to input workstation and task specific data. Layout specific information involves location data for each workstation and the number of workers operating on the same. The task specific information is collected for each task consisting input about type of task such as lifting, carrying, pushing, pulling, climbing, machine specific changing, and machine specific fitting.

The next input is number of workstations involved in particular task. There is a provision to accept data of various possibilities as one worker can work on multiple workstations and one or more workers can do multiple tasks in single workstation. There can be multiple tasks performed in single workstation and added respectively, for e.g. Task 1 – lifting the workpiece at workstation 1; Task2 – carrying the workpiece from workstation1- to workstation

2. These inputs help to create effective process mapping and study the task extensively. The next input is operator to task mapping. The module is created in such a way that only one operator is considered for particular task, when more than one operator is involved, it has to be considered individually. The task specific inputs such as set-up time, run time, unloading time etc. are collected. The task assessment parameters for RULA and REBA are collected to calculate the RULA and REBA score for next step. Operator specific inputs for delays in task and quality production are collected.

All this data is collected for every task. The web-interface is designed interactive and takes account of previous inputs to generate the next web-page.

2.1.3 RIP Step 3: Initial Hypothesis

The initial hypothesis is drawn from the data collected from the Step 2. The tasks with high risk and workstations with lower productivity are selected for more focused data collection. The limits are set for selection of tasks with risk and corresponding workstations. The major parameters for selecting the task for further assessment is by RULA and REBA score. If the score depicts the high risk for the task or if the operator is performing more than one task with medium risk, the task is considered for further inspection. The workstation (and corresponding operators) with more than 5% quality defects and On time delivery (OTD) index less than 90% are considered for further investigation.

The identified tasks and workstations are investigated in details in further steps. This information is separately provided to user in the form of initial assessment results for carrying the next web-based steps.

2.1.4 RIP Step 4: Focused Data Collection

In this step, the task and workstation interaction is studied in more details. '3P Analysis' (Posture, Perception and Process) is performed for each identified tasks. Posture analysis involves the inputs for Job Strain Index (JSI) and NIOSH Lifting Index. Perception includes the interpreting the data for RBG Risk Scale (RBGRS) [9] and RBG Pain Score (RBGPS). The P-map and A-maps are generated in process. The P map shows process mapping of man and material flow with layout details. The A-map shows adjacent process mapping of man and material flow with layout when two or more workstations gets interlinked to perform the job. The detailed study of workstation is performed by '3M-Analysis' (Man, Method, Machine). It included the machine operating conditions such as temperature, sound intensity and exposure to chemical hazards. The understandings of accidental history and safety measures are taken into account. Also, the nature of interaction of operator and machine as well as material is studied.

2.1.5 RIP Step 5: Problem Identification

This step is intermediate identification of problems before the analysis and solutions to the same. This includes the use of data collected in previous steps.
Tasks with ergonomic risk are identified considering RULA, REBA, JIS, NIOSH, RBGRS, RBGPS, LI and the type of risk is also identified. Tasks with operational inefficiency are identified considering 3P-Analysis and dif-ferent data inputs from process observation. Workstations with poor quality production are identified with operator mapping and corresponding causes. Layout inefficiency and work environment related issues are identified using 3M-Analysis.

2.1.6 RIP Step 6: Characteristic Matrix

Characteristic matrix evaluation consists of three matrices. First characteristic is operator skill benchmarking by parameters such as OTD Index, quality defects, productivity index. Second characteristic is process scope assessment. This involves the historical data about changes in working environment and work-stations and different tools/frameworks followed at the work-place. Third characteristic is worker-management liability.
This web-based assessment is followed by work-plan for major modules to change and major concerns in all the verticals viz. Workstation, Task, Operators and de-risk plan for the same.

2.1.7 RIP Step 7: Suggested Solutions

This includes the solutions for all the verticals discussed. The solutions are provided in the following forms

a) Layout Changes- Analysis
b) Task Improvements - Analysis
c) Cost reductions - Analysis
d) Worker training
e) Lean practices to follow

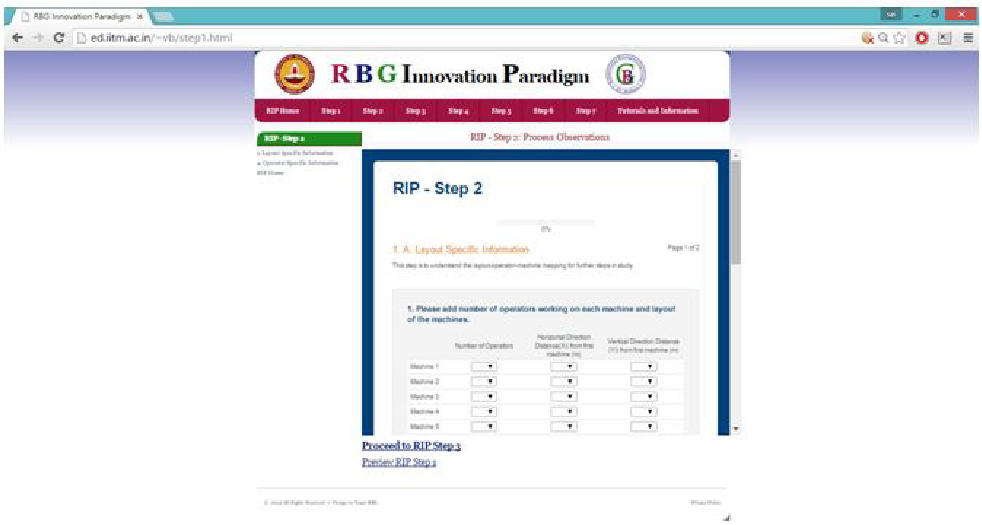

Figure 2: Additional features to collect effective data

3 Analysis and discussions

The analysis of the web-page implemented with RIP framework as explained in methodology is carried out by user analysis for 16 users. The users were from different manufacturing industries and processes were unique and independent. The assessment was divided into two parts RIP-Part-A consisting of the first three steps and RIP-Part-B consisting next three steps and the sug-gested solutions. The survey questionnaire was designed to understand the utility of the RIP survey.

75% of the users rated above 8 for the RIP web-based platform. 81.25% of the users were satisfied with the web-implementation of RIP (rated greater than 8 out of 10)and 81.25% users felt it easy to use than any other possible manual method of interpretation.93.75% of the users felt that the assessment interface is pleasant and 81.25% users were satisfied with overall assessment format.

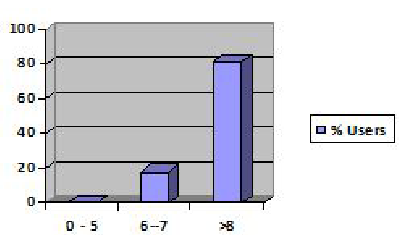

Figure 3: User evaluation for format

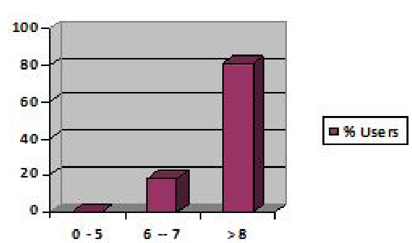

Figure 4: User evaluation for interface comfortability

The evaluation suggests that the web implementation of RIP in restructured format can be used by industry for assessment purpose. The user involvement can be enhanced more by adding the features and providing the feedback about the same, time to time for continuous assessment.

The instant web-based implementation of RIP is expected to give instant evaluation results based on criterion set for analysis. Also, the overall of assessment of processes including ergonomic bottlenecks at various stages are highlighted. The collective online framework is modified to be applicable for all kind of manufacturing industries regardless of type of manufacturing industry.

The user evaluation was designed to understand the changes from user for effectiveness. The discussed changes by the users will be implemented and the interface will be optimizes. The user experience will be improved by more intensive data collection using more intensive methods for evaluation.

4 Conclusion

The smooth and easy online database of parameters will encourage the industries to take up the surveys efficiently without spending much of their resources such as labour, time and cost on inspection. These tools were developed to give instant results. The online/ web based framework will help in collecting large amount of data than the traditional way including trivial calculations and offline data. Availability of the databases across different industries will help in developing and optimizing the algorithms. Database collected will also be used for finding and improving the user utility by statistical methodology. The customizability of framework can be extended further to other service industries and other industries other than manufacturing. The usability analysis done so far is for user experience evaluation for the RIP and it can be further improved by implementing more researched ways for feedback.

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