



Roadmap to Implement Industry 5.0 and the Impact of This Approach on TQM

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Abstract. The fifth Industrial Revolution (Industry 5.0) encompasses the transition from a digital-driven to a sustainable, human-centric, and resilient industry. Industry 5.0 recognize and value the role of workers in the production system. Therefore, it sets the health and safety of employees as a priority. Workers will be empowered and aided by robots and advanced technologies in order to improve work processes and work areas, hence improving companies' productivity and efficiency. However, the shift from Industry 4.0 to Industry 5.0 will depend on how employees will embrace the new vision and on how prepared they are to work alongside machines, especially since advanced technologies have developed the fear of loss of jobs among employees. In this context, we propose a roadmap to implement the industry 5.0 vision and build interest among workers for change by merging two concepts ADKAR and Quality Circles. Furthermore, we discussed the impact of industry 5.0 on Total Quality Management.

Keywords: Industry 5.0 · Human-centric manufacturing · Empowerment · Total Quality management

1 Introduction

The fourth industrial revolution often referred to as Industry 4.0, had its origins at the Hannover Fair in 2011. It describes the digital transformation of the manufacturing system and it is based on several technologies to support this transition [1, 2]. These technologies include artificial intelligence, Cyber-Physical Systems, additive manufacturing, the Internet of Things, and robotics. Industry 4.0 aims to create a highly integrated value chain to improve industrial productivity, efficiency, and competitiveness [3]. However, despite the benefits that Industry 4.0 brought to the manufacturing sector, an important element of the industrial scene was missing. Industry 4.0 has focused more heavily on the automation approach, while the human workforce was sorely neglected.

Recently, several researchers have brought the issue of the value of human operators in the manufacturing process to the forefront. In the light of the increasing complexity of the manufacturing industry [4], industrial companies are starting to place greater emphasis on the importance of human workers in the production system.

The changing customer demand and mass personalization have reshaped the manufacturing sector [5]. The salient features of modern production systems are shorter life

cycles of products and technologies, shorter lead times, and intense competition [6]. To fulfill these requirements, the human workforce remains indispensable, the creativity, intuition, critical thinking, and cognitive skills of humans are important in the production line [7]. Besides leveraging the industry 4.0 technologies, industrial companies need to invest in their employees.

In this context, The European Commission has defined “Industry 5.0” as a human-centric, sustainable, and resilient industry [8]. Industry 5.0 is about revaluing the human’s role in the manufacturing system. This new concept considers technologies as tools provided to workers to support them in their daily activities to create a safer, healthier, and more efficient work environment. One of the main objectives of Industry 5.0 is to promote efficient human-machine collaboration [9]. Cobots (collaborative robots) will assist the workers on their tasks taking into account the conditions of the surrounding environment and the worker’s intention [10], as this allows technology to be adapted to human needs.

The shift from technology-driven to a human-centric approach is not as simple as it seems. Industry 4.0 has solidified among workers the idea that new technologies and automation are a threat to the workforce [11]. Automation has destroyed many jobs and decreased the participation of operators in added value, which has led to decreased job satisfaction and job burnout among a number of employees [12].

2 Related Works

The human-centric approach has been discussed from different perspectives by some researchers. Pinzone et al. [13] stressed the importance of the touch of human in modern production systems and investigated the impact of industry 4.0 technologies on the health and job performance of workers. Mattsson et al. [14] provided a study on ways used by companies to empower their employees in order to handle the complexity of the production system. Empowering is about adapting the workplace to the needs of the worker and supporting him to improve his competencies. The work [15] proposed a human-in-the-loop model, which is an artificial intelligence architecture based on a human-centric approach. Rowlands et al. [16] assumed that focusing only on technologies is not enough to reach expected results, so in order to get the full benefit of industry 4.0, they suggested the transition to a quality 4.0-driven strategy.

Romero et al. [17] introduced the operator of the future “operator 4.0”. They presented a typology in which workers are reintegrated back into the production process. The role of operator 4.0 is vital, he is empowered, skilled, and has decision-making power. Operator 4.0 will be supported by robots and smart tools when needed. They determined a framework with eight characteristics: Super-Strength Operator, Augmented Operator, Virtual Operator, Healthy Operator, Smarter Operator, Collaborative Operator; Social Operator; and Analytical Operator. Kaasinen et al. [5] presented their vision of Operator 4.0 and they interviewed 44 workers to analyze their expectations related to the worker of future, thus they concluded that operators should be involved in the process of developing technical solutions.

3 Roadmap for Human-Centric Approach Implementation

In Industry 5.0 scenario, cobot and advanced technologies will provide assistance to the worker in order to improve safety and health. Thus, industrial companies could make the most of the skills and creativity of their employees. From a worker's point of view, advanced technologies and robots could be seen as threats of losing their jobs and as result, maybe they would not be interested in adopting these technologies [5]. To manage this resistance to change and to avoid the misconception that advanced technologies are competitors to workers, the first step is to build worker trust in digital tools. In this context, we propose a roadmap to implement the process of bringing back operators to the production line alongside machines, by merging two tools: ADKAR and quality circles.

3.1 Quality Circle

A quality circle (QC) is a tool to improve quality. It consists of a group of workers who often share the same workplace, they regularly meet in order to determine, discuss and solve issues negatively affecting their working environment [18]. Quality circle involves the following steps:

1. Identification of related work-related problems.
2. Selection of problem.
3. Analyzing the problem.
4. Develop solutions.
5. Communicate the findings to the top management.
6. Implement approved solutions.

3.2 ADKAR

ADKAR is an acronym for a change management model [19]; it enables gradual implementation of the desired change through five sequential phases:

- a. Awareness of the need for change.
- b. Desire to make the change.
- c. Knowledge of how to change.
- d. Ability to implement the change
- e. Reinforcement until this change takes root.

3.3 Proposed Framework

Figure 1 depicts the steps involved in the proposed framework and the importance of each step.

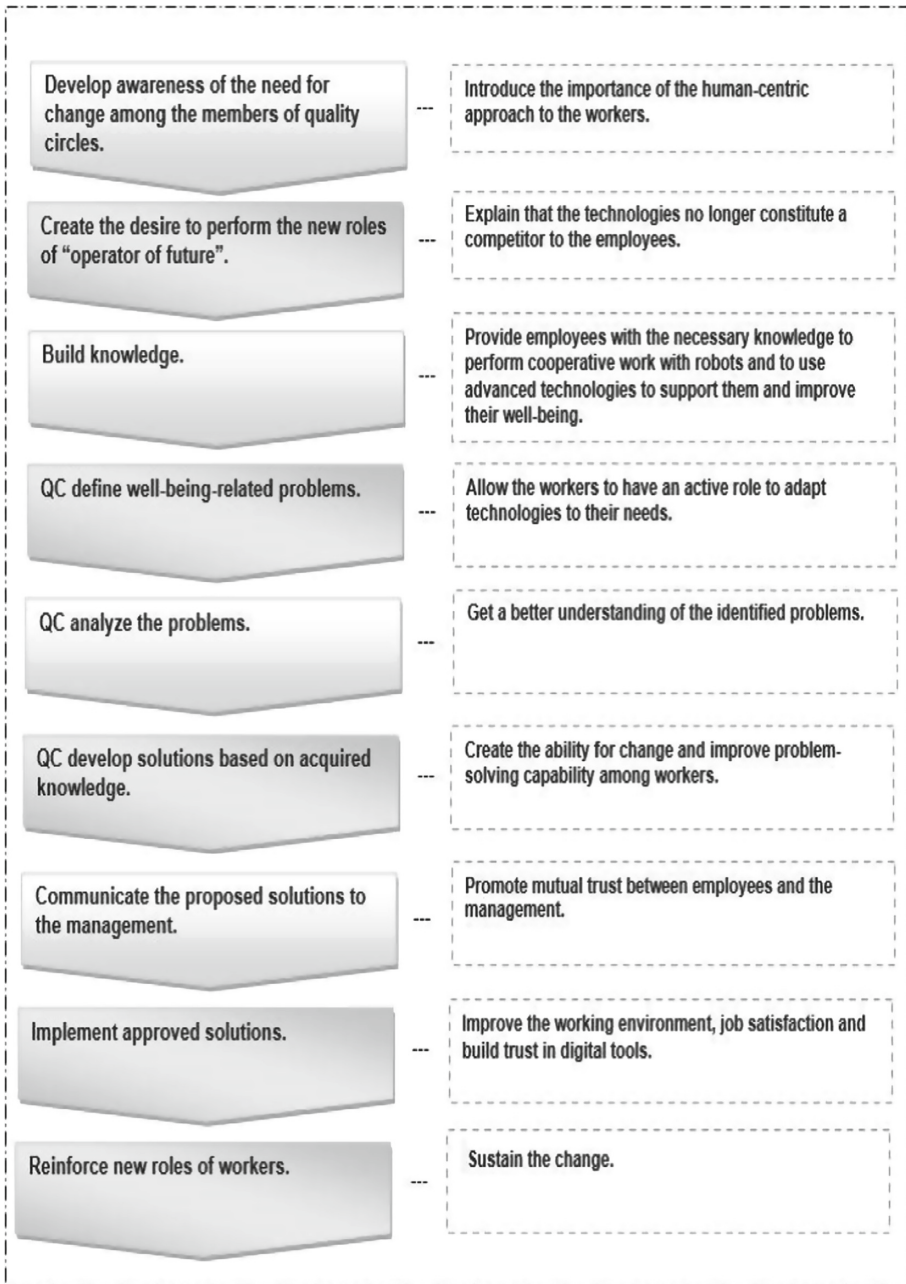


Fig. 1. Steps of proposed framework and importance of each step

As an example, we consider a quality circle consisting of 7 members with a line executive as a facilitator. The facilitator communicates with all levels of management and provides training to QC members. This QC aims to reduce ergonomic risk factors. The latter represents working conditions such as repetition, work stress, extreme heat, and vibration. Generally, all situations that can cause injuries or lead to musculoskeletal disorders (MSDs).

The proposed framework is used in this case to build and maintain worker trust in monitoring technologies, because, for example, wearing health monitoring devices such as wearable sensors could be considered uncomfortable. Furthermore, these devices may create psychological pressure or risk of privacy invasion [8].

The following steps are adopted to make use of the proposed framework:

- Develop awareness of the need for monitoring technologies.
- Highlight the benefits of monitoring technologies: these technologies will aid in ensuring workers' safety, and keeping a close eye on workers' health and the conditions of the surrounding environment.
- Provide the members of QC with the necessary knowledge to adopt and take full advantage of monitoring technologies, by delivering training and facilitating access to information.
- QC members define ergonomic risk factors in their workplace.
- QC members analyze the identified risks.
- QC members develop solutions using monitoring technologies based on their needs. The wearable sensors will generate real-time alerts (e.g., high-stress levels, extreme temperature, toxic gases...), and so the worker takes the necessary measures to handle the situation.
- The facilitator communicates the proposed solutions to the management.
- Implementation of the approved solutions by the management.
- Reinforcement of role of Healthy Operator.

This framework enables members of quality circles to embrace their new roles in the production system and participate to adapt technologies to their needs. And therefore, the proposed framework will improve participative management. Since the members work in the same functional area, it would be easier to implement the change among a group who have almost the same concerns and face similar problems. Non-members also benefit from applying this framework, they help in implementing the solutions proposed by quality circle members. so, they will show interest and enthusiasm to work alongside robots and use digital tools to participate in the development of their work environment.

4 Impact of Industry 5.0 on Total Quality Management

Total Quality Management (TQM) is a management quality approach. It was first introduced by the quality guru "Deming". TQM is an approach that gives companies a competitive edge and improves their profits, by ensuring a better quality of products and services that satisfy customers and meet their expectations [20].

TQM consists of seven key principles:

1) customer focus, 2) leadership, 3) engagement of people, 4) process approach, 5) improvement, 6) evidence-based decision making, 7) relationship management.

The human-centric approach of Industry 5.0 may serve to implement and promote the TQM principles listed above, especially customer focus, engagement of people, and improvement, as explained in Table 1.

Table 1. Impact of industry 5.0 on TQM principals

TQM principal	Industry 5.0 contributions
Customer focus	Industry 5.0 has a clear focus on mass customization and it will enable employees to devote more time and energy to tasks that require creativity and critical thinking skills, in order to adapt to the changing customer demands
Engagement of people	Industry 5.0 will empower its workers with cobots and advanced technologies. The human role will be more valuable. Operators will have a say in the production line, and empowerment of workers is positively related to job involvement
Improvement	The synergy between humans and machines, and the focus on creativity will enable to develop new products and services and manage the challenge of complexity

5 Conclusion

The main concern of Industry 4.0 is to automate manufacturing and leverage new technologies. To remedy this situation, Industry 5.0 adopts a human-centric approach to bring back workers to the center of the production line. In this paper, we proposed a roadmap to implement this vision and build trust in digital tools to get rid of any technology anxiety that was associated with industry 4.0. As a result, workers will be more involved in their jobs and companies could reap the benefits of the human-centric approach. Furthermore, we presented the impact of Industry 5.0 on TQM and how Industry 5.0 can serve to promote TQM principles.

Since Industry 5.0 is a new concept, more discussions need to be held to explore this approach from a different point of view. We are planning in the future to implement this framework in various cases, furthermore, we are planning to explore the relation between the state of a worker's health and job assignment.

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