A CLUSTERING BASED MATRIX FOR SELECTING APPROPRIATE QUALITY TOOLS AND TECHNIQUES IN INDUSTRIAL REVOLUTION 4.0

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DECLARATION

I declare that this thesis entitled "A Clustering Based Matrix for Selecting Appropriate Quality Tools and Techniques in Industrial Revolution 4.0" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	……..
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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Technology Management.

Signature	:	……..
Supervisor Name	:	……
Date	:	……..

DEDICATION

This thesis is specially dedicated to:

To my beloved mother and father; my family, supervisors, lecturers, as well as my best friends Hafizzudin, Franky, Najatul Haya, Zety, Nazmi, Aisha, Laili, Azfar and Yusri Farhan.

Thank you for the love, guidance, understanding and support.

ABSTRACT

The purpose of this research was to explore a systematic pattern for selecting quality tools and techniques in industrial revolution 4.0 particularly in smart manufacturing context. This study asked, “What are the appropriate tools and techniques concerning circumstances of quality dimensions and smart manufacturing?” To answer this question, this research developed a diagnostic matrix by developing the outcome matrix for selecting appropriate quality tools and techniques. This matrix is intended to help non-expert users and industrial practitioner to select appropriate sets of quality tools and techniques for solving different quality problems. By conducting an analysis, the researcher uncovered homogeneous patterns of enough quality case studies, which ultimately provided the basis for selecting appropriate groups of quality tools and techniques in different circumstances. Multiple case study and in-depth literature review were employed as the research design approach. Two key data collection methods (qualitative methods) were used: Firstly, primary data from face-to-face interview with Toyo Memory Technology and Intel Malaysia and secondly, secondary data from previous study. Accordingly, this review on the previous study allows the researcher to establish the theoretical framework. This review coupled with the case study analysis led to the identification on the real implementation of quality tools and techniques in the industries. Thus, the researcher gained the information on how the industries select the quality tools and techniques to manage quality performance in the organization and the researcher examined the association and prevalence of different quality tools and techniques and the quality dimensions in context of smart manufacturing component. The study developed the clustering-based matrix of quality tools and techniques for smart manufacturing. After developing and verifying the developed matrix, the researcher discussed their strengths and limitations as well as their roles for selecting the appropriate quality tools and techniques in the context of smart manufacturing industries. The finding of this study is a clustering-based matrix for selecting appropriate quality tools and techniques in smart manufacturing that has been successfully developed. The proposed matrix applies quality management dimensions and smart manufacturing component to facilitate waste elimination, defect reduction and improving productivity in smart manufacturing that can be used as a basis for many future investigations in the field of quality management and industrial revolution 4.0.

ABSTRAK

Tujuan kajian ini adalah untuk mengenal pasti cara pemilihan alat dan teknik kualiti secara sistematik dalam revolusi industri 4.0 terutamanya dalam konteks pembuatan pintar. Persoalan bagi kajian ini adalah, "Apakah alat-alat dan teknik-teknik kualiti yang sesuai dengan keadaan dimensi kualiti dan pembuatan pintar?" Untuk menjawab soalan ini, kajian ini membangunkan satu matrik untuk memilih alat dan teknik kualiti yang sesuai. Matrik ini bertujuan untuk membantu pengguna yang tidak mahir dan pengamal industri untuk memilih set alat dan teknik yang sesuai bagi menyelesaikan masalah kualiti yang berbeza. Daripada analisis yang dijalankan, penyelidik menemui corak homogen dalam kes kajian ini, yang pada akhirnya membangunkan matrik bagi memilih kumpulan alat dan teknik yang sesuai dalam keadaan yang berbeza. Kajian kes berganda dan kajian literatur yang mendalam digunakan sebagai pendekatan reka bentuk penyelidikan. Dua kaedah pengumpulan data utama iaitu (kaedah kualitatif) telah digunakan: Pertama, data prima dari temubual secara bersemuka dengan Toyo Memory Technology dan Intel Malaysia dan kedua, data sekunder diperoleh dari kajian-kajian lepas. Oleh itu, dengan merujuk pada kajian lepas ia membolehkan penyelidik membangunkan konsep kerangka kerja. Tambahan pula, analisis kajian kes telah membawa penyelidik kepada pengenalan mengenai pelaksanaan yang sebenar bagi pemilihan alat dan teknik kualiti yang diguna pakai dalam industri. Oleh itu, penyelidik memperoleh maklumat tentang bagaimana industri memilih alat dan teknik kualiti bagi mengatasi masalah kualiti dalam organisasi dan penyelidik juga mengkaji kesan serta kekuatan alat dan teknik kualiti yang berbeza dari segi dimensi kualiti dalam konteks komponen pembuatan pintar. Kajian ini membangunkan matriks yang berasaskan alat dan teknik kualiti bagi kluster industri pembuatan pintar. Selepas membangunkan matriks bagi tujuan memilih alat dan teknik kualiti yang sesuai, penyelidik membincangkan kekuatan dan batasan matriks serta peranan bagi memilih alat dan teknik kualiti yang sesuai dalam konteks industri perkilangan pintar. Hasil kajian ini adalah penghasilan kluster-matrik yang berjaya dibangunkan untuk memilih alat dan teknik kualiti yang sesuai dalam industri pembuatan pintar. Matriks yang dibangunkan menggunakan dimensi pengurusan kualiti dan komponen pembuatan pintar untuk memudahkan penghapusan sisa, pengurangan kerosakan dan meningkatkan produktiviti dalam pembuatan pintar yang boleh digunakan sebagai asas bagi lebih banyak penyelidikan pada masa hadapan dalam bidang pengurusan kualiti dan revolusi industri 4.0.

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AIP	-	Annual Improvement Plan
B2B	-	Business to business
CPO	-	Chief Production Officer
CQA	-	Chief Quality Assurance
DFSS	-	Design for Six Sigma
DMAIC	-	Define, Measure, Analysis, Improve and Control
DoE	-	Design of Experiments
FMEA	-	Failure Mode and Effects Analysis
IoT	-	Internet of Things
IR 4.0	-	Industrial Revolution 4.0
ISO	-	International Organisation for Standardisation
MQNW	-	Materials Quality Network
MTS	-	Module Target Specifications
QC	-	Quality Control
QM	-	Quality Management
QOS	-	Quality Operating System
SBR	-	Supplier Business Review
SPC	-	Statistical Process Control
SSQA	-	Supplier Standardized Quality Assessment
TMT	-	Toyo-Memory Technology

LIST OF PUBLICATIONS

Journal

1. Isa, S., Hamid, S. R., and Chew, B. C., 2020. A Study of Quality Tools and Techniques in the context of Industrial Revolution 4.0 in Malaysia. What's new? *Quality-Access to Success Journal Calitatea, 21(174),* pp.88-96.

2. Hamid, S. R., Isa, S., and Altun, A., 2019. Quality Management Evolution from the Past to Present: Challenges for Tomorrow. *Organizacija*, *52*(3).

3. Muzaimi, H., Hamid, S. R., Isa, S., and Chew, B. C., 2019. Integrated Management System: The Converging of Key Quality Standards into Single Standard. *International Journal of Human and Technology Interaction (IJHaTI)*, *3*(1), pp.75-82.

CHAPTER 1

INTRODUCTION

1.1 Research introduction

World are facing a tremendous 4th industrial revolution in manufacturing and production control, being dominated by the penetration of internet technologies into smart manufacturing environments and a paradigm shift from hierarchic production management to self-organization and self-optimization on the manufacturing floor, also the changes in quality control will be revolutionary (Gluck., Wolf, 2014). With the evolvement of Industrial Revolution it is important to have a good through quality management where is a source that become the competitive advantage and leadership that carry the values in the organization and successfully not neglecting the technology and the capabilities of the organization have to analyse and operationalize that data towards optimizing and benefiting the organization, (Davenport et al., 2012; McAfee & Brynjolfsson, 2012; Constantiou & Kallinikos, 2015; Henke et al., 2016).

Hence, this research aimed to identify the appropriate quality tools and techniques used for quality improvement in Industrial Revolution 4.0. This chapter begins with the background of the research, problem definition, research questions and objective, significance of the research, the scope of the research, then lead to the summary.

1.2 Research background

The world now is at the beginning of the fourth industrial revolution. The most commonly used terms to describe this development, which is rapidly changing the industrial landscape, are Industry 4.0, smart manufacturing, the Internet of Things, cyber-physical system and digital transformation. The Industry 4.0 concept encompasses the digitalization of the horizontal and vertical value chain, innovation in products and service and the creation of new business models.

The phenomenon of Industry 4.0 was first mentioned in 2011 in Germany as a proposal for the development of a new concept of German economic policy based on high-tech strategies (Mosconi, 2015). The concept has launched the fourth technological revolution, which is based on the concepts and technologies that include cyber-physical systems, the Internet of things, and the Internet of services (Feld, et al., 2014; Ning & Liu, 2015), based on perpetual communication via Internet that allows a continuous interaction and exchange of information not only between humans (C2C) and human and machine (C2M) but also between the machines themselves (M2M; Cooper & James, 2009).

From the global insight report in (World Economic Forum, 2016) has stated that the world today on the cusp of a Fourth Industrial Revolution. Developments in previously disjointed fields such as artificial intelligence and machine learning, robotics, nanotechnology, 3D printing and genetics and biotechnology are all building on and amplifying one another. The changes will affect the skill sets required in both old and new development in most industries and transform how people work, leading to new management and regulatory challenges. Given the rapid pace of change, business model disruptions are resulting in a near simultaneous impact on employment and need for new skill sets, requiring an urgent and concerted effort for adjustment for achieve greater quality in product.

The advanced technical features suggest that the Industry 4.0 exhibits an attractive and promising production paradigm. It has a significant contribution to the quality improvement system as well as product which can cope with the global challenges. For example, the customized products can be produced effectively, efficiently, and profitably. The penetration of internet technologies into manufacturing environments and a paradigm shift from hierarchic production management to self-organization and self-optimization on the manufacturing floor, also the changes in quality control will be revolutionary (Gluck, Wolf, 2014).

Accordingly, measure of modern quality management aiming for sustainable success does not only mean to avoid the delivery of defective products to the customer but seek to establish maximum efficiency in the performance of all process of the company. With such optimized procedures, products of high quality can be provided with minimum effort of time and costs (Werner & Weckenmann, 2012). For all those quality improvements to be happen, the implementation of smart manufacturing is needed. Smart Manufacturing can improve quality management through improving productivity in production process as well as manufacturing planning (Wang & Wang, 2016).

The Digitization of Manufacturing or Smart Manufacturing, in which connected networks of humans and robots interact and work together with information shared and analyzed, supported by big data and cloud computing along entire industrial value chains (Wee, et al., 2015). The impact of Smart Manufacturing to be flexible and efficient in production becomes possible (Drath & Horch, 2014; Pfeiffer & Suphan, 2015; Li et al., 2015; Hermann, Pentek & Otto, 2016; Long, Zeiler & Bertsche, 2016). Smart manufacturing increases cost and time efficiency and improves product quality, associated with the enabling technologies, methods, and tools (Albers et al., 2016). As a result, Smart Manufacturing will accelerate manufacturer to achieve unprecedented levels of operational efficiencies and

growth in productivity (Drath & Horch, 2014; Hermann, Pentek & Otto, 2016; Thames & Schaefer, 2016).

The emerging of information technologies, such as IoT, big data, and cloud computing together with artificial intelligence technologies, it is believed the Smart Manufacturing of Industrial Revolution 4.0 can be implemented. The Smart manufacturing can communicate with each other under quality management system to reconfigure themselves for flexible production of multiple types of products with high quality improvement. Smart manufacturing has the potential advantage in bringing stronger integration of top floor and shop floor and thus more intelligence and flexibility to production. An additional, Smart manufacturing will allow manufacturer to improve quality system through using data from production, service, and quality control which will lead to quality improvement of both product and process.

Several studies have been conducted to verify the priority and importance of different tools and techniques for quality improvement. For instance, a study by Tari and Sabater (2004) found that the most frequent tools and techniques used within 106 ISO- certified firms in Spain are audits, graphs, SPC, and flow charts, respectively. On the other hand, the least used tools and techniques in the firms studied were the basic tools. Another study by Drew and Healy (2006) of Irish organizations discovered that the most and widely used quality tools were customer surveys, followed by competitive benchmarking.

In the study by Fotopoulos and Psomas (2009), it was found that two thirds of the organizations used easy to understand quality tools, which included check sheets, flow charts, and data collection, while the remaining tools and techniques had very limited implementation. Also, a study conducted with Swedish quality professionals by Lagrosen and Lagrosen (2005) revealed that the application of all quality tools and techniques was generally limited, expect for flowcharts, which were used extensively. Although quality

tools and techniques were used significantly more often in larger organizations (Fotopoulos & Psomas, 2009), they could be implemented in all organizations, regardless of size or type (Basu & Wright, 2012).

Yet, the study about quality management in Smart Manufacturing is not well addressed, which adequate that Industrial Revolution 4.0 not spread widely. Previous studies carried out by authors such as Gluck, Wolf, (2014); Mosconi, (2015) in the areas of quality management and Industrial Revolution 4.0 seem lack to see how current quality tools and techniques need to change, improvise inlign with development of Industrial Revolution 4.0 particularly in the area of smart manufacturing.

1.3 Problem statement

According to the Khaitan and McCalley (2016) Industry 4.0 will influence business model significantly due to the evolution from information communication and technology (ICT) factories to the Smart Factories. Due to this major change within the whole business environment, new business processes must be identified and implemented in order to increase productivity. Therefore, the quality management area must be revise and improvise to analyse the new situation in the company considering the industrial revolution.

Kagermann et al. (2013) also seconded that, quality is a crucial part of the concept of a Smart Factory and therefore crucial for the implementation of Industry 4.0. They are discussing many opportunities that Industry 4.0 will bring in the future regarding the business environment as well as production quality itself. This will happen within the focus improving quality on individual customers' requirements, flexibility, processing time optimization, resource productivity and efficiency.

To identify these implications and to see their implementation within a company it could be interesting to have a look into classical quality management tools and techniques