DIGITALIZATION OF OPERATOR SKILL COMPETENCY BY DEVELOPMENT OF INFORMATION SYSTEM

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DECLARATION

I hereby declare that I have conducted, completed the research work and written the dissertation entitled "Digitalization of operator skill competency by development of information system". I also declare that it has not been previously submitted for the award of any degree or diploma or other similar title of this for any other examining body or University.

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Table of Contents

LIST OF TABLES

LIST OF FIGURES

ABSTRAK

Mara ke era Industri 4.0, sistem perlu ditubuhkan untuk tujuan komunikasi di sesebuah kilang. Setakat peringkat semasa, hakikat bahawa penglibatan tenaga manusia dalam proses pembuatan adalah suatu keperluan tidak dapat dinafikan. Oleh itu, bakat manusia harus diuruskan secara sistematik untuk meningkatkan kecekapan. Kertas kerja ini melibatkan kajian kes yang dijalankan di sebuah syarikat industri kesihatan. Ia hanya melibatkan pekerja-pekerja bahagian pembuatan. Objektif kajian kes ini adalah untuk membangunkann satu rangka kerja yang sistematik untuk digitalisasikan kemahiran pekerja-pekerja bahagian pembuatan dengan membangunkan sistem pengurusan pangkalan data. Ia juga penting untuk memudahkan perancangan kapasiti dengan menggunakan sistem pengurusan pangkalan data yang dibangunkan sebagai 'alat pencarian'. Ia melibatkan skim pembangunan yang komprehensif tentang satu sistem pangkalan data relasional. Sistem pangkalan data relasional ini mencatatkan tahap kemahiran pekerja bahagian pembuatan untuk peringkat pengeluaran yang berbeza. Khususnya, aliran pengeluaran, langkah-langkah dan pengkategorian kemahiran telah ditakrifkan secara formal dan dikaitkan. Penyambungan antara input maklumat serta persembahan hasil telah dibina dengan menyesuaikan keperluan syarikat dalam membuat keputusan. Temuan utama kertas ini ialah penggunaan sistem pengurusan pangkalan data yang telah dibangunkan untuk menodalkan kemahiran pekerja bahagian pembuatan dan melaksanakan perancangan kapasiti. Oleh kerana tenaga manusia dalam pengeluaran sangat ketara dalam syarikat yang berasaskan pembuatan, perancangan yang sistematik akan mengoptimumkan operasi sesebuah kilang. Sumbangan praktikal kepada syarikat adalah sistem pengurusan pangkalan data ini boleh digunakan terus oleh kakitangan yang berkaitan dalam perancangan kapasiti pekerja bahagian pembuatan. Batasan sistem pengurusan pangkalan data ini adalah beberapa kaedah penyampaian maklumat yang dikehendaki tidak dapat dicapai. Oleh kerana sistem pengurusan pangkalan data ini terhad kepada pekerja bahagian pembuatan, kemahiran setiap pekerja dari syarikat itu boleh dipertimbangkan pada masa akan datang untuk menambahbaikkan lagi sistem pengurusan pangkalan data ini.

ABSTRACT

Advancing into Industry 4.0, system is set up for the communication in the shop floor of the manufacturing industry. At current stage, the fact that involvement of human power in the production environment is a must could not be denied. That is why the talent of the human power shall be managed systematically to increase the efficiency. This paper involves a case study conducted in a company of the healthcare industry. It only includes operators from the shop floor. The objective of this case study is to develop a systematic framework to digitalize operator skill competency by developing a database management system. It is also significant to facilitate capacity planning by using the database management system developed as a 'searching tool'. Apart from that, acquiring insights into operator competency through data mining tool shall not be neglected. This paper involves a comprehensive development scheme of a relational database to structurally store operator skill levels for different production stages. Specifically, the production flow, steps and categorization of skills were formally defined and linked. Interfaces were constructed for input of information as well as result presentation, fitting to the needs of the company in decision-making. The main finding of this paper is utilization of the developed database management system to digitalize the operator skill competency and perform capacity planning. As human power in the production are considerably notable in a manufacturing-based company, the systematic planning of operator appointment would optimize the operation of the shop floor. The practical contribution to the company is that the database management system is readily used by related personnel in capacity planning of the operators. The limitation of this database management system is some desired presentation method of information cannot be achieved. As this database management system is limited to the shop floor operators, the competency of every worker from the company could be included in the future to further improve this database management system.

CHAPTER 1 INTRODUCTION

Overview:

This chapter outlines the background of the research. The objectives to be achieved at the end of this research was set. The scope of research was stated clearly to avoid confusion which might cause the focus of the research to be deviated.

1.1 Research background

Database management system has been widely used in the manufacturing industry to manage the enormous data flow in a company. Databases in manufacturing industry are broken down into three components, which are supply chain database, production item database and inventories database.

Industry 4.0 is about the expansion in digitization of the entire value chain and the resulting interconnection of people, objects and system through real time data exchange (Hecklau et al., 2016). A digital factory utilizes sophisticated digital technology for interactions in manufacturing processes. Digital factory facilitates the integrated planning, implementation, control and ongoing improvement of all significant manufacturing processes and resources relating to the product (Silva et al., 2015). The digitalization of worker portfolio tends to keep the competency records of the operators in database management system which is more favorable.

Capacity planning is considered as one of the important elements in the shop floor for a manufacturing-based company. The operational system on the shop floor will directly affect the company profitably. Without a database to store the information, when the shop floor issues such as lack of operators during peak season arise, the management would have to manually look for suitable operators with right skill set to aid the manufacturing process. This involves an often painstaking process of inquiry on the shop floor.

1.2 Objectives

1. To develop a systematic framework to digitalize operator skill competency.
2. To digitalize operator skill competency by developing a database system.
3. To facilitate capacity planning by using the database system developed as a ‘searching tool’.
4. To acquire insights into operator competency through data mining tool.

1.3 Scope of research

This study is limited to digitalization of operator skill competency using the production lines of a company in the healthcare industry as the case study. The production floor of the company comprised of production lines, packaging station and central station. However, this study is focus on the operator from the production lines only. Only three out of the fifteen production lines in the company were understudied due to limited time given for the project. The proposed database management system covers on how the operators can be switched within the production lines when they are in short supply.

1.4 Organization of thesis

There is a total of six chapters in this paper. The first chapter introduces the background of the research in this paper. The objectives to be achieved and the scope of research was stated clearly. The second chapter presented the summary on previous research on assessment, modelling and recording on worker competency, and information system developed related to labor. The next chapter is about the research methodology to build a database management system in which the research approaches were proposed and explained. After that, a section on how a case study had been conducted in the company was written in detail. Discussion was done on the case study to analyze the performance of the database management system developed. Conclusion and future work that could be done on this research were presented in the last part of this paper.

Summary:

In advancing towards industry 4.0, capacity planning could be done with the aid of digitalized tool which is a database management system. A database management system would be developed for the company in which the case study of this research paper is conducted. The work only includes operators within the production lines from the shop floor of the company. The next chapter would be reviewing researches related to labor competency and information system done by other researches in recent years.

CHAPTER 2 LITERATURE REVIEW

Overview:

This chapter outlines the summary on research that has been done previously. Different frameworks used to assess, process and display the competencies of workers were mentioned. The application of various information system to study the labor information were listed down in detail.

2.1 Introduction to shop floor labor management

A shop floor is referred to the area in a manufacturing site in which the process of converting raw material into finished goods is carried out manually, through the automated system or both. The shop floor staff includes shop floor manager, supervisor, foremen, workers, and operatives. The shop floor labor, in this study, is referring to the operators. Shop floor operators are important company resource as they are the drivers for changing processes that creates value in the production area (Hertle et al., 2015). The global future trends encourage a human-centered production environment. Hence, shop floor's operators need to be proficient and prudent in making decision as administrative work is diminishing (Hannola et al., 2018).

Shop floor labor management is an activity that manages and directs efforts of production line's operators towards the achievement of goals effectively and efficiently. The objective of shop floor labor management is to ensure that the operators are capable to accomplish their errands on time so that the products can be delivered to the customer as scheduled (Martignago et al., 2017). Another objective of shop floor labor management is to arrange and assign work content to the operators appropriately while managing their skills. The types of shop floor labor management are performance management, career management and the management of labor development (Pankaj.chourey, 2012). Performance management stresses on the appraisal aspects and performance improvement of the workers. Career management deals with the advancement in career of workers. Career development plan is introduced so that the workers are allowed to gain various experiences to move up in the organization. Development is crucial for a worker in order to improve their skills and so performs excellently. The most traditional development is by providing training to the workers. Some examples of shop floor labor management includes Taylor's Concept Scientific Management which focuses on the efficiency (Holm et al., 2016). The shop floor workers are seen as machines and strict guidance is needed to achieve high productivity. Method Time Management (MTM) analyses task focusing and evaluating improvement to work smarter. This concept has big impact on productivity, competitiveness and shop floor environment. While Management concept in Toyota Production System together with Total Quality Management stresses on customer needs, quality and flexibility. The concept lead to an increased motivation to work with continuous improvement and waste elimination.

2.2 Skill competency and computer integrated manufacturing

Skill competency is known as the underlying characteristic of a person that could be a motive, trait, skill, aspect of one's self-image, social role, or a body of knowledge which he or she uses (Zaim et al., 2013). Competencies are also specified as a mean of 'being able to perform a work role to a defined standard with reference to real working environments'. Cachay et al. (2012) further expands competency to include the capability of workers to implement new techniques to reflect the need of being versatile and adaptable in production floor. Competencies are becoming progressively significant when one needs to cope with more challenging tasks as cater to the gradually breakthrough in technologies. In accordance to the emergence of Industry 4.0, future competencies were categorized into personal competencies, social or interpersonal competencies, action-related competencies and domain-related competencies (Simic et al., 2019). The labors' skill competency is important to be explicit for several reasons. First of all, it is to make sure that the right people are identified and placed in the right role (John Osteen B, 2013). When the right people are assigned to the right task given, the productivity can be maximized and the quality of product can be guaranteed. When they are doing the task that they have experienced with, error could be minimized. Next, an employee potential is explored and would be developed and utilized to the fullest extent. Employee's satisfaction due to their accomplishment can be achieved and provides the impetus for them to further improve. Apart from that, the skill competencies can be investigated in term of its alignment to the strategies, business performances and goals of a company. According to the survey done to identify competencies needed in production industry, professional knowledge and technical skills were most needed. Communication, self-reliance, reliability, sharing knowledge and experiences, and teamwork were among the essential competencies as well (Gudanowska et al., 2018).

John Osteen B (2013) underlines five criteria to be considered in labor skill competency, namely knowledge, skill, aptitude and attitude of the labor. Knowledge relates to the information and understanding required to fulfill the responsibility as a shop floor labor. Skill is the acquired ability or experience needed to fulfill the responsibility. Manual work is skill-based and it is essential in the shop floor, that is the reason why skill is the key to determine the precision and quality of the final product. Aptitude is known as the normal ability that prepares a person to fulfill responsibilities. It reflects the performance of worker and training can be provided for improvement purpose. Attitude regards what behavior is needed to fulfill the responsibility. According to Zaim et al. (2013), attitude has effect onto a person's experiences and personality combined with job related factors.

Competency is seen as a cluster of related knowledge, skills and attitudes that influences the role and responsibility of a worker and it is correlating with the performance of the workers. Özçelik et al. (2006) proposed the modeling method of ranking competencies based on managerial levels. In this case, three categories are used. First, are the core competencies common for all employees. Second are leadership or managerial competencies required for managerial positions and third are functional competencies specific to a job role or profession.

Alternatively Zaim et al. (2013) modeled competencies by developing generic versus organization-specific competencies. Generic competencies are a cluster of competencies identified within the context of a specific job which is common to all individuals occupying that specific job whereas, organization-specific competencies are specific to the job in the particular organization. Generic competencies could be further breakdown into trait-based or behavior-based. Apart from that, skill matrix is a framework used to assess the competency of labor. The matrix appraises the skills of an employee on a scale range based on various aspects such as process knowledge, method knowledge, management skills, business knowledge and tool skills (Pydala Bhasha, 2014). The employees are then being allocated to related department based on the skills they possess.

Hertle et al. (2016) divided their research model into four phases to record competencies. The first phase defines requirements for a method to record shop floor management competencies. The second phase designs the target state regarding roles and competencies. The last two are the application and the evaluation phases. The application phase records the competency level of the shop floor roles based on observations and interviews. The final phase evaluates the competency model based on the requirements. A competency model used to assess and develop employee's competencies in the manufacturing industries in order to meet future challenges is brought by (Hecklau et al., 2016). The three steps in developing the model are identification of emerging challenges, derivation and categorization of core competencies and visualization of identified core competencies. The model allows company to run the competence gap analysis for required competencies in Industry 4.0. The existing competence gap will be revealed after the competencies of employee is evaluated. The most critical gap could be identified, and we can see that whether the employee is ready for his job in industry 4.0.

Competence iceberg model as shown in Figure 1 divides competencies into two parts: knowledge and skills locate at upside water surface while the other such as viewpoint of value, self-image, character or personality, self-force or social motivation and so on is below the surface (Manxhari et al., 2017).

Figure 1: Competence iceberg model

Bagaeva et al. (2018) discussed the theoretical and methodological aspects of the personnel assessment based on competence approach which combines several models. Companies nowadays are facing intense competition and hence it is necessary to hire and retain skillful employee. The application of this assessment system acts as a basis in decision making of the management to promotion, training and dismissal of employee. The scope of competency model includes assessment, recruitment, motivation, adaptation, education and development and staff reserve. This competency model serves as the standard to assess the quality of employee's work. Competency model with more competencies might complicates the incorporation of the model to the organization practice.

Information systems are interrelated components working together to collect, process, store, and disseminate information to support decision making, coordination, control, analysis, and visualization in an organization (Kenneth C.Laudon, 2012). The ultimate goal of information system is to take data and turn them into information, and finally organizational knowledge (Dave Bourgeois, n.d.). Information system is also crucial for optimization and cost saving as electronic information can be easily transferred. According to (Mesaric, 2003), an information system could have established the basis of monitoring and IS manager networking so that their activities are meeting the objectives of top management.

Several applications of information system are given. Implementation of human resource information system for banking and finance sectors in India was brought by Mohapatra (2009) to align business goals with stakeholders' objectives. Automation of business processes related to employee by means of advent technology had improved the business performance and effectively managed large talent pools. The framework of implementation includes data re-engineering in which present database is ported to the new database of the HRIS. The rest of implementation are considered as administrative aspects which composed of disclosure of implementation goals, stakeholder's involvement, status review by senior management, implementation project plan and project organizational structure.

Waters et al. (2013) reported that the introduction of Kenya Health Workforce Information System (KHWIS) to monitor and address health workforce issues like health worker shortages, skill mix imbalances, and malpractices in distribution. The system facilitated deployment of the right health workers (qualifications, skills mix) in the right place (deployment location) at the right time (availability). Key features of KHWIS are components for capturing data on pre-service education, training, registration and re-licensing, in-service specialties and upgrades, continuing professional development (CPD), human resources management, nursing deployment, and the ability to link nursing regulation data with nursing deployment data. KHWIS has a series of databases to track the nursing deployment. Deployment data from the provinces were interlinked with the Ministry of Medical Services (MOMS) via satellite internet connection and moved to fiber-optic connection. The system was accessed within a Local Area Network (LAN) for each board while provincial coordinators are allowed to access using a CITRIX connection. As overspill effects, KHWIS brought positive policy changes on human resources planning, health management, and the provision of workforce information.

Ríos-Aguilar et al. (2015) presented an information system for mobile presence control of local and remote workforce through reactive and behavior-based monitoring. The system is built with open source software and composed of two components. The first component is a mobile web application for worker to clock in and submit remarks. The second component is the control panel web application allowing real time queries regarding worker clock in processes, including georeferenced information in maps and individual historical analysis.

The impact of human resource information system (HRIS) usage in industrial and banking sector was studied by KAYGUSUZ et al. (2016). The HRIS consists of three subsystems namely HR planning and recruitment subsystem, wages and benefits management subsystem, and training subsystem. The first subsystem stores labor requirements and current labor information. Employee's salary history, payroll practice, health and insurance information, performance payments and sales commissions can be found at the second subsystem. The training subsystem composed of employee appraisal, special skills, talents and competencies in order to track career development. The result of the research shows that there is a positive relationship between HRIS rate and organizational efficiency, personal performance, and HRIS-oriented personal performance in the organization. Mesaric (2003) introduced the new information system of higher education (ISHE) which comprised of a few of modules. However, results from the study show that the success of ISHE is guaranteed only if the stakeholders are aware of the reasons why the system fails.

Parinsi et al. (2018) described Labor Market Information system (LMIS) which specifically linked vocational schools (SMK) graduates and industries to help the industries to find labors or graduates that matched with the company requirement at real time. The components that made up LMIS are divided into user interface for user, company and government. For users, there is system for registration of job seeker(students) with their curriculum vitae and a search engine that matches the job with industries demanding specific skills from the employees. The system will send the student's data to the company private email once the student applied for that particular job. While for company, the registration of company profile which is saved in database on server, a system showing the list of employees available for specific positions and response of the employees. For government, they can see the reports on number of companies, workers, vacancies and acceptance of applicants. The statistical value of visitors for the system is available too.

Smart HR 4.0 is introduced to effectively manage employees as part of Industry 4.0 (Sivathanu et al., 2018). Implementation of SHR 4.0 requires a flat hierarchy-based agile organization structure. The case study of SHR 4.0 shows that the company utilize the analytic methodology of SHR 4.0 to identify employee which is at the risk of attrition. A score would then evaluated based on different aspects of the employee which shows the intent of leaving the company. The aspects include role maturity, company experience, location, attendance at event, manager ratings, promotion status and so on. Attrition rate of the company was decreased by one percent resulting from utilizing the model for one year. Implementation of this model able to benefits a company by developing a leaner HR department. It also able to attract and retain new-age talent. However, the challenge of implementing this model is to overcome the existing organizational structure and to select new set of technological tools.

Summary:

The frameworks used to model competencies are ranking competencies based on managerial level, develop generic versus organization specific competency and competence iceberg model. Skill matrix, three-step model and personnel assessment system are used to assess competencies. Four phase method is used in recording the competencies. The information system used to study labor information are Human Resource Information System (HRIS) for finance and banking, Kenya Health Workforce Information System (KHWIS), information system mobile presence control of workforce, Human Resource Information System (HRIS) in industrial and banking, Information System for Higher Education (ISHE), Labor Market Information System (LMIS) and Smart HR 4.0. Research methodology is to be discussed in the next chapter. Sequential steps in developing the database management system of operator skill competency were proposed.

CHAPTER 3 RESEARCH METHODOLOGY

Overview:

This chapter includes the research methodology of this paper. The steps in developing a database management system of operator skill competency were proposed and discussed. This section also shows that why certain procedures were adopted. Inappropriate methodology might lead to research failure and inaccuracy of results.

3.1 Methodology

The research methodology is divided into a number of sequential steps as depicted in Figure 1.

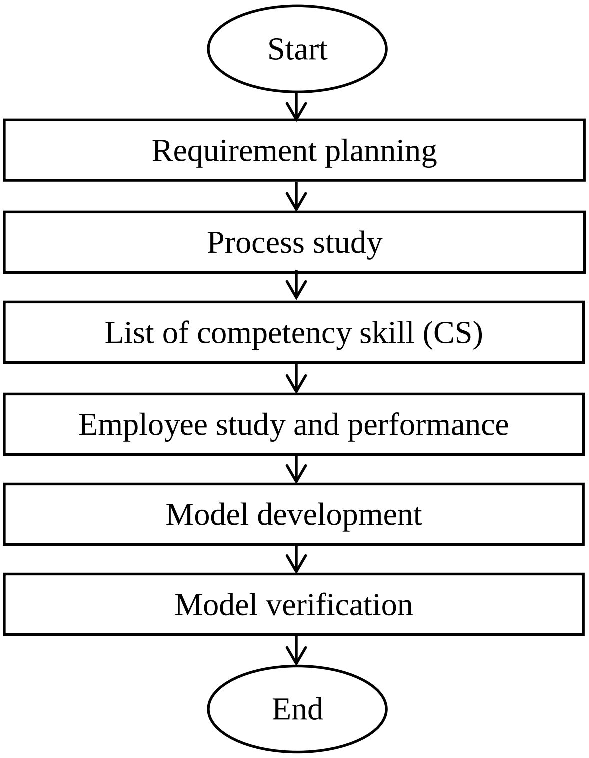

Figure 2: Flow chart of developing a database management system of operator skill competency.

3.1.1 Requirement planning

The database management system would be used to serve a number of functions in the production. Company personnel of various levels that are aware of the production process such as senior production executive, process engineers and project manager shall be interviewed by having a meeting all together to obtain the list of requirements. The interview needs to be ended by achieving consensus about the requirement list among the personnel mentioned previously. The areas to be studied has to be identified. The types of products and the operations involved should be determined. The personal details regarding operators has to be obtained and the competency of operators from each production lines needs to be evaluated.

3.1.2 Process study

The level of skill and techniques about the manufacturing processes of different types of products are collected. Product families are identified. Of production lines used to produce a product family, the key and common processes are identified. Similarity indices are built after studying the processes and consulting to relevant shop floor personnel. The final list of processes is developed.

3.1.3 List of competency skills (CS)

The skills required to perform a particular process are identified. They are remarked with either critical or non-critical by the senior production executives.

3.1.4 Employee study and performance appraisal

The operators usually have certain skills out of the complete set of skills that is needed to manufacture an article. It is based on the observation from the line executive and line supervisor to decide the operators to work on certain processes. The operators are assessed based on their performance at different frequency depending on their job level. The appraisal is to be done by the line's supervisor to record the operator's level of competency.

3.1.5 Model development

The data collected need to be stored in an organized manner by distributing them to different tables. The data could be manipulated to be displayed in desired format. The result of manipulated data would then be performed by generating report. Graphs can be plotted for related personnel to catch a glimpse of useful information. For example, they can provide training or job rotation based on the achievement of the operators aligned with the baseline set by the company.

3.1.6 Model verification

Model verification serves to maintain the integrity of database. Review the database and trace error at the potential part which is targeted to have the high possibility of presence of errors. This could be done by 'find duplicates' function and hence unwanted data can be removed to make sure the database would function well.

Summary:

The research approaches proposed are requirement planning for the database management system, study on manufacturing process, listing of competency skill, evaluation on performance appraisal of the operator, development and verification of the database management system. A case study conducted according to the research methodology proposed was being described in the next chapter.

CHAPTER 4 CASE STUDY

Overview:

The case study was conducted in B.braun Medical Industries Penang. The Manufacturing Execution System (MES) project of the company impacts most on the operators from shop floor. This project aims to digitalize the flow of information for transforming raw materials into finished goods which is currently paper based in the shop floor. 2D drawings and work schedules are the main medium to convey the information. In the future, the shop floor would be paperless, and being replaced with gadgets for information delivery. Part of the project which is digitalization of operator skill competency is focused in this paper. Only three out of fifteen production lines were studied due to shortage of time and the complicated process.

4.1 Company background

B. Braun Corporation was originated in 1839 and started its business operations in Asia with the first production facility in Penang in 1972. It is one of the world's largest medical technology companies which develops high quality product systems and services that are both evolving and progressive, thus it has constantly growing product portfolio. The company intended to apply MES and planned to commence the application of system first at BMI Penang before having it at the headquarter in Germany. The expected time to launch and test the system is five years. The company is currently executing the initial stage of the project, on which the data collection is in progress to build the system. The digitalization of operator skill competency is first introduced, and it is part of the MES system to be developed by the team member of MES project. The lack of existing database management system that includes and integrates information of shop floor's operator highlights the significance of this project. The information stated are skills possessed by each operator, their performance rating, and the articles that could be handled by each operator with certain skills they have. Development of the database management system helps to do capacity planning and evaluation of relative knowledge capital growth in the Aesculap plant.

4.2 Organizational structure in the shop floor

Operators of each production line are managed by their supervisor. While the line executive is the one who administers operators and supervisor of the production line associated with them. All of them are crucial to make sure that the shop floor is operating well. There are 15 supervisors and approximately 750 operators in the shop floor.

4.3 Methodology

The database management system for the company was developed based on the research methodology proposed at the previous section. The details of each step were elaborated individually.

4.3.1 Requirement planning

The main use of database management system is to ease the capacity planning process within a number of production lines in the shop floor. Information such as skills, operator's performance rating, article numbers were recorded and linked. Article number is the specific code assigned to different types of product in the company. The performance of operator was evaluated monthly by the line's supervisor and the rating was recorded.

4.3.2 Process study

The production area is divided into three main modules that carry out every process to manufacture the products. The three modules mentioned are adjusting, grinding and inspecting respectively. Although the manufacturing processes of articles from different production lines are sometimes similar, certain articles are categorized as 'special' and it can only be manufactured by a specific production line itself. The sets of production processes of these special articles are totally different from the atraumata(basic) articles even though the naming of processes for both type of articles is exactly the same as stated in the routing. These processes are handled by the line's supervisor and much precision and technical skills are needed to manufacture the articles.

4.3.3 List competency skill (CS)

Core competency skill is the techniques an operator ought to have in manufacturing the company's products. A list of competency skills that represents the operations was generated and recorded in the routing. The skills listed in the routing are in the form of sequence in producing the articles. The routing for articles with similar shape and dimension might be similar. The skills include belt grinding, adjusting, break edge, bending, brushing, finishing, riveting and surface checking.

4.3.4 CS categorization and standardization

The first step in standardization of skill was categorizing articles into respective types, based on product families such as atraumata (basic article), special, clip and screw. Then, the standardization of skill by engineers collaborating with line executive and senior production executive for a single production line was performed. The description of every operation in a single line was being extracted from the routing and the repeated descriptions are removed. Operation which requires same skill and technique was grouped together under a skill set. Standardization between lines (e.g. Line 2, Line 3 and Line 4) was then performed based on the standardization of each single line and the finalized set of skills was assigned to specific skill matrix (eg.SM001). The standardization carries the meaning that operations grouped under a skill matrix can be performed by operators from Line 2, 3 and 4 responsible for that specific operation for every article that required the operations involved in these three lines. The result of standardization was then verified by senior production executive by going through the skill matrix with every article.

4.3.5 Performance appraisal

Performance of operator is rated by score, which are 25, 50, 75 and 100. Score twenty-five means that the operator is lack of skills and a two to three weeks training is needed for the operator, while for fifty score, the operator can perform moderately. An operator can perform well without needing guidance if they are rated by score of seventy-five. The highest score which is one hundred indicates that the operator had fully mastered certain skill and they can be assigned to guide other operators. Operators are assessed by the line executive for their performance in terms of speed and quality. The frequency for the evaluation for new operator is weekly while permanent operator is being assessed monthly.

4.4 Model development

The operator skill competency database management system is established by using Microsoft Access. Data required to build the database are stored in different tables and linked together by the relationship function in access. Forms, queries and reports based on various criterion are generated as the main tool to be used by the related personnel of the company. They could have a quick look on the information they want in doing operator capacity planning. Loss of time and resource in planning could be avoided by using the database management system as a searching tool. The tables were normalized to eliminate data redundancy in order to build a functional database management system. When repeated fields were found in a single table, a new table was created by keeping only one field. After that, separate tables were built for the sets of values that apply to multiple records found in the new table created previously. These tables were then linked together.

4.4.1 Table

Seven tables were created in this database management system.

1. Table of employee records. It is categorized into personal details (name, age, gender, address, IC number), contact details (phone number), employment details (employee ID, employment date, working experience in company) and job details (job level, line).
2. Table of characters of line. The type of product manufactured by each production line is known.
3. Table of list of articles. Articles are the different types of products produced. Each article has their unique article number and number of production line associated. The articles are being categorized into atraumata or special article and the job level needed to manufacture the different type of articles are also stated in this table.
4. Table of operations of each article. The complete set of skills required to make each article are stated.
5. Table of performance rating. This table contains employee ID, skill content, skill matrix, matrix ID, rating and line. The evaluation on the performance of operator for different kind of skills are being illustrated.
6. Table of rating of scale. This table describes the four level of scoring scale and each score is indicated by color scale.
7. Table of skill descriptions. This table has the information of skill matrix, description, applicability of skill and the criticality of the skill.

4.4.2 Relationship

The tables were linked to one another to develop the database management system as depicted in Figure 2. The employee records table was linked to performance rating table by one-to-many relationship to show the rating on each skill that the operator possesses. The performance rating table was further linked to rating scale table that stores the score indicator in the form of image to enhance the visibility of the forms and queries which is to be explained in next session. The table description of skills was linked to both performance rating table and operations for each article table. The table characters of line was also linked with list of articles table and employee records table. The list of articles table linked with the operations for each article table to show the article category whenever needed in the documentations.

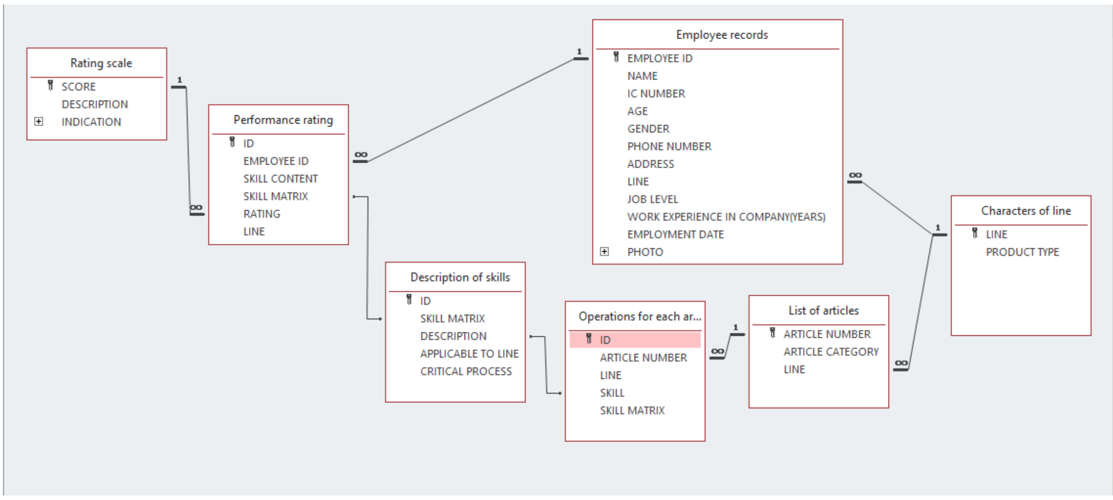

Figure 3: Relationships between tables.

4.4.3 Form

Two forms were created in this database management system, which are employee records form and performance rating form. These forms would be used to edit or add new data to the database management system. Even though this could be done in table, but it is preferable to manage the data in form as the user can always have a clearer and nicely arranged view. If user is to view the data in table, he or she might not be able to see the full information. In this case, new employee records could be added to the database management system and also update the operator skill competency using forms. An overview of the employee record form and performance rating form is shown in Figure 3 and Figure 4 respectively.

Figure 4: Employee Records form.

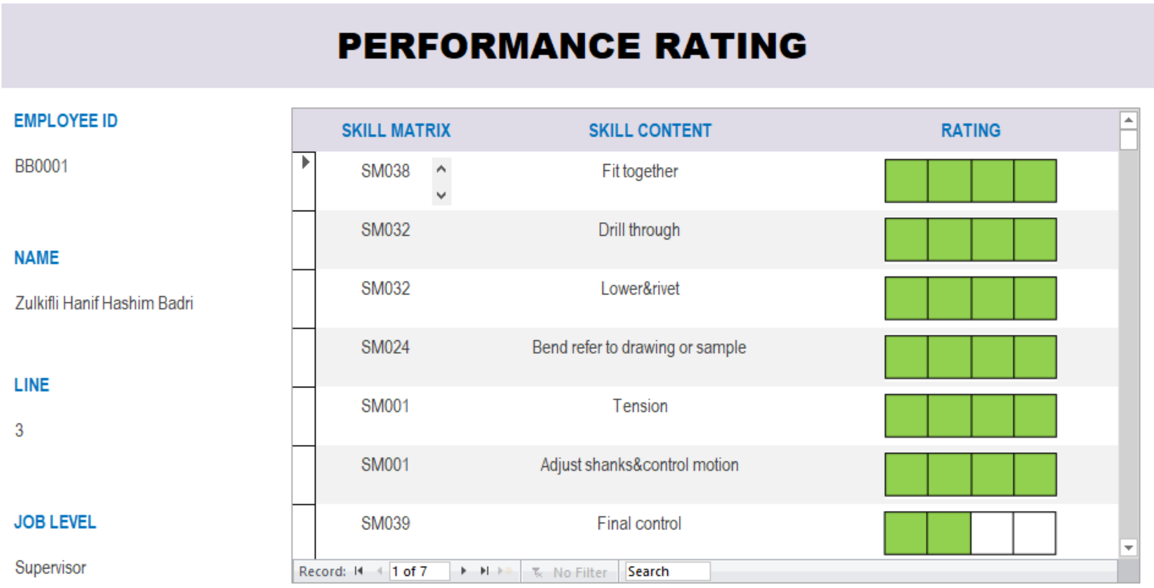

Figure 5: Performance rating form.

4.4.4 Query

Two queries were created, namely Article_Skill_Employee query and employee rating query, as shown in Figure 5 and Figure 6 respectively. From the former query, the user can know that to which articles the operators are entitled to work on and vice versa. This could be done by the filtering function provided. Based on the employee rating query, the user can have a quick look on the list of operators which can do certain process without needing to scroll across each performance rating form of employees.

ARTICLE NUI	fyp_List of a	SKILL	SKILL MATRI	EMPLOYEE II	NAME	Employee re
BD995R	2	Adjust shanks&control motion	SM001	BB0001	Zulkifli Hanif Hashim Bac	3
BD995R	2	Adjust shanks&control motion	SM001	BB0003	Mohd Hiswan Zulkifli Da	3
BD995R	2	Adjust shanks&control motion	SM001	BB0004	Ibrahim Dahaman	3
BD995R	2	Adjust shanks&control motion	SM001	BB0007	Saini Jaafar	3
BD995R	2	Adjust shanks&control motion	SM001	BB0008	Abd Fattah Ishak	3
BD995R	2	Adjust shanks&control motion	SM001	BB0009	Zainal Ariff Ghazali	3
BD995R	2	Adjust shanks&control motion	SM001	BB0010	Mohd Wira Ramli	3
BD995R	2	Adjust shanks&control motion	SM001	BB0011	Elias Aqmal Hisham Elias	3
BD995R	2	Adjust shanks&control motion	SM001	BB0012	Ahmat Ikhram Ahmat Ma	3
BD995R	2	Adjust shanks&control motion	SM001	BB0030	Hasrul Nizam B Hassim	3
BD995R	2	Adjust shanks&control motion	SM001	BB0031	Shah Rulnizam B Senit	3
BD995R	2	Adjust shanks&control motion	SM001	BB0032	Aliff Aqmar B Adnan	3
BD995R	2	Adjust shanks&control motion	SM001	BB0036	Mohd Nazir Mustapa	3
BD995R	2	Adjust shanks&control motion	SM001	BB0042	Azahar Bin Hussain	2
BD995R	2	Adjust shanks&control motion	SM001	BB0043	Zakaria Bin Hashim	2
BD995R	2	Adjust shanks&control motion	SM001	BB0047	Nornizam Bin Nordin	2
BD995R	2	Adjust shanks&control motion	SM001	BB0050	Mohd. Syazwan Jalani	2
BD995R	2	Adjust shanks&control motion	SM001	BB0081	Zahiruddin	2
BD995R	2	Adjust shanks&control motion	SM001	BB0082	Rosli	2
BD995R	2	Adjust shanks&control motion	SM001	BB0087	Abdullah	4
BD995R	2	Adjust shanks&control motion	SM001	BB0088	Putera	4
BD995R	2	Adjust shanks&control motion	SM001	BB0089	Adi	4
BD995R	2	Adjust shanks&control motion	SM001	BB0090	Lukman	4
BD995R	2	Adjust shanks&control motion	SM001	BB0091	Kifli	4

Figure 6: Query of Article_Skill_Employee.

EMPLOYEE II	NAME	SKILL MATRI	SKILL CONTENT	RATING
BB0001	Zulkifli Hanif Hashim Badri	SM038	Fit together	100
BB0001	Zulkifli Hanif Hashim Badri	SM032	Drill through	100
BB0001	Zulkifli Hanif Hashim Badri	SM032	Lower&rivet	100
BB0001	Zulkifli Hanif Hashim Badri	SM024	Bend refer to drawing or sa	100
BB0001	Zulkifli Hanif Hashim Badri	SM001	Tension	100
BB0001	Zulkifli Hanif Hashim Badri	SM001	Adjust shanks&control moti	100
BB0001	Zulkifli Hanif Hashim Badri	SM039	Final control	50
BB0002	Amyrul Che Ros	SM038	Fit together	75
BB0002	Amyrul Che Ros	SM032	Drill through	50
BB0002	Amyrul Che Ros	SM032	Lower&rivet	50
BB0003	Mohd Hiswan Zulkifli Das	SM038	Fit together	75
BB0003	Mohd Hiswan Zulkifli Das	SM032	Drill through	50
BB0003	Mohd Hiswan Zulkifli Das	SM001	Tension	75
BB0003	Mohd Hiswan Zulkifli Das	SM001	Adjust shanks&control moti	75
BB0004	Ibrahim Dahaman	SM038	Fit together	75
BB0004	Ibrahim Dahaman	SM032	Drill through	50
BB0004	Ibrahim Dahaman	SM001	Tension	50
BB0004	Ibrahim Dahaman	SM001	Adjust shanks&control moti	50
BB0005	Mohd Nazir Safie	SM038	Fit together	50
BB0005	Mohd Nazir Safie	SM032	Drill through	75

Figure 7: Query of performance rating.

4.4.5 Report

Some reports were generated from the database management system. Report provides the user a proper view and understanding on the information listed. Some examples of report created were shown in Figure 7, Figure 8 and Figure 9 accordingly.

Description of skills				
ID	SKILL MATRIX	DESCRIPTION	APPLICABLE TO LINE	CRITICAL PROCESS
1	SM001	Adjust shanks&control motion	2	NO
2	SM001	Adjust shanks&control motion	3	NO
3	SM001	Adjust shanks&control motion	4	NO
4	SM001	Adjust form&tension	2	NO
5	SM001	Adjust form&tension	3	NO
6	SM001	Adjust form&tension	4	NO
7	SM001	Adjust after harden	2	NO
8	SM001	Adjust after harden	3	NO
9	SM001	Adjust after harden	4	NO
10	SM001	Tension	2	YES
11	SM001	Tension	3	YES
12	SM001	Tension	4	YES
13	SM001	Break edge jaw and tensioning	2	NO

Figure 8: Report of description of Skill.

Operations for each article			
ARTICLE NUMBER	LINE	SKILL MATRIX	SKILL
BD995R	**2**		
		SM001	Adjust shanks&control motion
		SM003	Belt grind complete ring
		SM003	Belt grind internal ring
		SM004	Belt grind fine shank
		SM004	Belt grind shank
		SM008	Belt grind jaw
		SM013	Belt grind boxlock
		SM013	Belt grind rivet&polish boxlock
		SM017	Belt grind fine
		SM020	Break edge jaw
		SM024	Bend refer to drawing or sample
		SM025	Brush ratchet and ring
		SM027	Completion
		SM029	Oil,clean
		SM032	Drill through

Figure 9: Report of operations for each article.

List of Articles			
ARTICLE NUMBER	LINE	ARTICLE CATEGORY	PRODUCT TYPE
BD995R	2	ATRAUMATA	Cold forge forcep
BH114R	2	SPECIAL	Cold forge forcep
BH118R	2	SPECIAL	Cold forge forcep
BH134R	2	ATRAUMATA	Cold forge forcep
BH135R	2	ATRAUMATA	Cold forge forcep
BH198R	2	ATRAUMATA	Cold forge forcep
BH215R	2	ATRAUMATA	Cold forge forcep
BH216R	2	ATRAUMATA	Cold forge forcep
BJ002R	2	ATRAUMATA	Cold forge forcep
BM270R	2	ATRAUMATA	Cold forge forcep
MD569	2	ATRAUMATA	Cold forge forcep
BF120R	3	SPECIAL	Warm forge clamp
BF121R	3	SPECIAL	Warm forge clamp

Figure 10: Report of list of articles.

4.4.6 Analysis of graph generated

Some graphs were extracted from the database management system by using Microsoft Excel and imported to Microsoft Access. Figure 10 shows the scatter plot of operators' working experiences versus rating. Scatter plot of operator's working experience versus their job level in the company is depicted in Figure 11. A pareto diagram of operators' skills was presented in Figure 12 and it tells us about the number of operators who can work on certain operations. Figure 13 represents the scatter plot of working experiences versus critical process while Figure 14 shows the pie chart of critical and non-critical process. In Figure 15, pie chart of percentage of operator for types of article is depicted. It reveals the percentage of operator capable of handling the manufacturing process of different types of article with dissimilar difficulty level. Apart from that, Table 1,3,4,6 and 7 shows the pivot tables that record used to get the data interpreted in the following paragraphs. Meanwhile, Table 2 tells us the description of indicators used in Figure 11. Table 5 shows the description of indicators used in Figure 14 and Table 6.

Figure 11: Scatter plot of working experiences versus rating.

Table 1: Pivot table of frequency for working experience with respect to rating.

Count of EMPLOYEE ID	Column Labels																			
Row Labels	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**18**	**19**	**20**	**21**	**23**	**26**	**30**	**Grand Total**
25	2			6	5				1					1						15
50	33	9	20	19	10	7	2	1				4	5	1	3			1		115
75	46	9	18	51	28	15	3	1	1	3	3				2	5			3	188
100	26	2	1	39	14	3		1	5		1			13	6	9	4	6		130
Grand Total	**107**	**20**	**39**	**115**	**57**	**25**	**5**	**3**	**7**	**3**	**4**	**4**	**5**	**15**	**11**	**14**	**4**	**7**	**3**	**448**

The operators shall achieve rating of 75 or 100 after working for at least 5 years. According to the scatter plot, 70.98% of the operators are capable to achieve this.

Figure 12: Scatter plot of working experiences versus job level.

Table 2: Description of indicator used in figure 9.

Indicator	Job Level
1	Supervisor
2	Jumper
3	Ordinary performer
4	New worker

Table 3: Pivot table of frequency for working experience with respect to job level.

Count of EMPLOYEE ID	Column Labels														
Row Labels	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**18**	**19**	**20**	**21**	**23**	**26**	**30**	**Grand Total**
Ordinary perfomer	6	1	1	1		1		1		1				1	13
Supervisor					1	1	1		2	1	1	1	1		9
Grand Total	**6**	**1**	**1**	**1**	**1**	**2**	**1**	**1**	**2**	**2**	**1**	**1**	**1**	**1**	**22**

After working for at least 10 years, the operators should be at the position of supervisor. However, only 40.91% of operators can achieve this. Higher job level is held by operators with higher working experience.

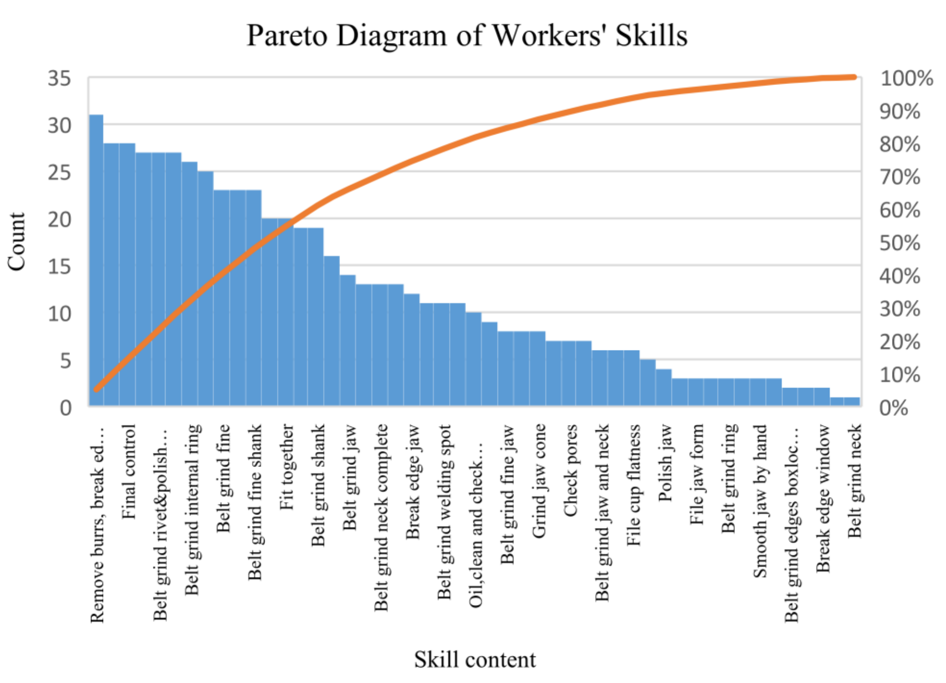

Figure 13: Pareto diagram of workers' skills.

Table 4: Pivot table of count for skills possessed by workers.

Count of EMPLOYEE ID	Column Labels						
Row Labels	Adjust shanks&control motion	Belt grind rivet&polish boxlock	Brush ratchet and ring	Completion	Final control	Remove burrs, break edge boxlock&slant edges	Grand Total
25	1	1				1	3
50	9	11	2	3	6	2	33
75	10	9	20	14	15	16	84
100	7	6	5	11	7	12	48
Grand Total	**27**	**27**	**27**	**28**	**28**	**31**	**168**

The higher count represents the skills possessed by most workers which is easier and can be done by almost everyone. The skills include remove burrs, completion, final control, adjust shanks and control motion, and so on. Remove burrs has the highest overall percentage which recorded 5.17%, followed by 4.67% by completion and final control, and 4.50% by adjust shanks and control motion, belt grind rivet and polish boxlock and brush ratchet and ring.

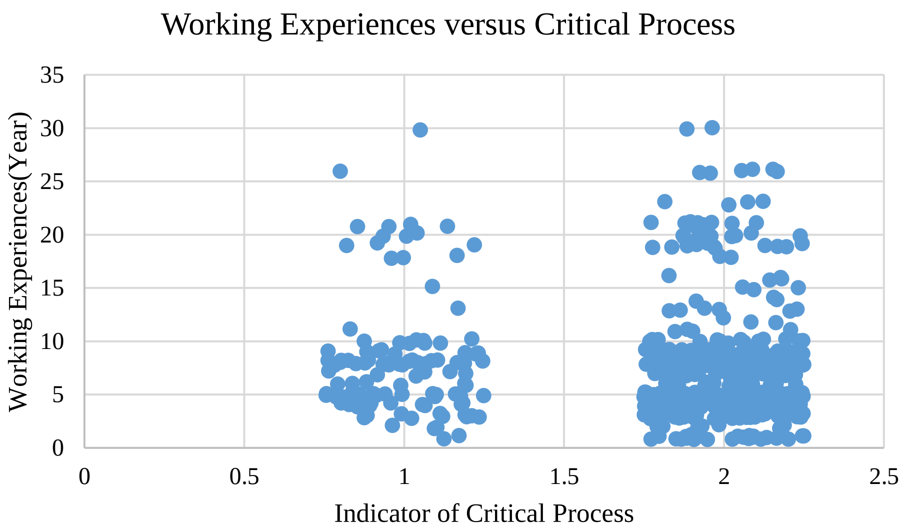

Figure 14: Scatter plot of working experiences versus critical process.