SEMI-SKILLED WORKER SELECTION IN LABOR-INTENSIVE INDUSTRY

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ABSTRACT

With the increasing global economy, an efficient management on manufacturing resources is considered as a key of organization's success. In labor-intensive manufacturing, human resource highly impacts the entire production performance since such system is driven by workers. This research presented semi-skilled worker selection and grouping in the context of labor-intensive industry with perspectives of academic and manufacturing practice. The important criteria and practical method of worker selection processes, preliminary approach in grouping phase, similarities and differences among five manufacturing case studies of food, textiles/wearing apparel, plastic, and steel products including recruitment outsourcing provider, were discussed. Analytic Hierarchy Process (AHP) was applied as a main research tool of multiple criteria decision making methods to provide weights and priorities of the selection criteria conducted from previous studies and case studies. Five aspects of human-related factors were highlighted: competency, experience, personal characteristics, skill, and operational output. In AHP, ten decision-makers (DMs) from case studies were investigated to provide judgement matrix for the model. As the result, semi-skilled worker selection and grouping approaches in labor-intensive industry were obtained with significant benefits to improve the overall production performance.

KEY WORDS: WORKER SELECTION / SEMI-SKILLED WORKER / LABOR INTENSIVE

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บทคัดย่อ

ในปัจจุบันการแข่งขันกันในภาคอุตสาหกรรมมีความรุนแรงมากขึ้น และส่งผลให้ผู้ประกอบการต่างพัฒนาประสิทธิภาพความสามารถในการผลิตสินค้าตลอดโซ่อุปทาน การบริหารจัดการทรัพยากรการผลิตอย่างเหมาะสมนั้นถือเป็นปัจจัยสำคัญในการเพิ่มขีดความสามารถทางการแข่งขัน โดยเฉพาะอย่างยิ่งในอุตสาหกรรมประเภทใช้แรงงาน ซึ่งขับเคลื่อนด้วยแรงงานคน งานวิจัยนี้นำเสนอการเลือกและการจัดกลุ่มแรงงานกึ่งใช้ฝีมือในอุตสาหกรรมประเภทใช้แรงงาน จากแง่มุมทางวิชาการและเชิงปฏิบัติในอุตสาหกรรมจริง ทั้งนี้ได้ทำการศึกษาข้อมูลที่เกี่ยวข้องประกอบด้วยปัจจัยสำคัญที่พิจารณาในการเลือกแรงงานกึ่งใช้ฝีมือ วิธีการ/กระบวนการในการเลือกและจัดกลุ่มแรงงานกึ่งใช้ฝีมือเบื้องต้น รวมถึงความเหมือนและแตกต่างจำแนกตามประเภทของการผลิต ได้แก่ อาหาร สิ่งทอ/เครื่องนุ่มห่ม พลาสติก และเหล็ก รวมถึงบริษัทจัดหาแรงงาน ที่มีความเชี่ยวชาญในการเลือกแรงงานกึ่งใช้ฝีมือให้กับภาคการผลิต เครื่องมืองานวิจัยหลักที่ใช้ในการวิเคราะห์ข้อมูลคือวิธีการตัดสินใจด้วยกระบวนการลำดับชั้นเชิงวิเคราะห์ หรือ Analytical Hierarchy Process (AHP) โดยการให้น้ำหนักคะแนนเกณฑ์การเลือกแรงงานกึ่งใช้ฝีมือด้วยเมตริกซ์เปรียบเทียบเชิงคู่ จากผู้เชี่ยวชาญจำนวน 10 ท่านในแต่ละกรณีศึกษา ทั้งนี้ประกอบด้วยปัจจัยที่เกี่ยวข้องกับทรัพยากรมนุษย์ทั้งหมด 5 ด้าน ได้แก่ ขีดความสามารถ ประสบการณ์ คุณลักษณะส่วนบุคคล ทักษะการทำงาน และผลผลิต ผลของการศึกษาในด้านของเกณฑ์การเลือกแรงงานกึ่งใช้ฝีมือ รวมถึงกระบวนการเลือกและจัดกลุ่มแรงงานดังกล่าวเบื้องต้น สามารถช่วยเป็นแนวทางในการปรับปรุงกระบวนการจัดการทรัพยากรมนุษย์ในภาคอุตสาหกรรมการผลิตประเภทใช้แรงงาน ซึ่งมีส่วนช่วยผลักดันระบบการผลิตให้มีประสิทธิภาพมากยิ่งขึ้น

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CHAPTER I
INTRODUCTION

1.1 Background and Statement of Problems

With the increasing of global competition, all manufacturing sectors have been forced to not only improve efficiency but also increase productivity gain along its supply chain. An efficient management on manufacturing resources is an important key to be appropriately utilized and to reach the competitive advantages. Since an efficient management of resources has led to increase overall manufacturing performance, in order to scale down overheads which are in term of operating costs, and achieve productivity gain. In manufacturing industries, there are four key resources in the systems: (1) capitals, (2) machines, (3) materials, and (4) labor. These key resources are the main components for all manufacturing systems that facilitate the production system in transforming raw materials into finished products.

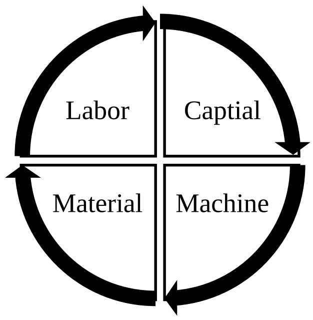


Figure 1.1 Manufacturing resources

Generally, workers are ones of the important resources in the production systems who not only drive the systems as a part but also manage and control the whole system. Consequently, an efficient management on worker resources has a large impact in many companies. In labor-intensive manufacturing environment, labor plays an important role as a major resource besides capitals, machines and materials that operates and controls the entire production system. By its nature, labor intensive represents an industry that requires a substantial involvement of worker especially in the operational level which directly impacts the overall production performance. It also refers to the system that mostly consists of small and inexpensive machines and equipment (Süer and Bera, 1998). Traditionally, the production system of any firms primarily consists of three major elements namely, (1) input, (2) process, and (3) output.

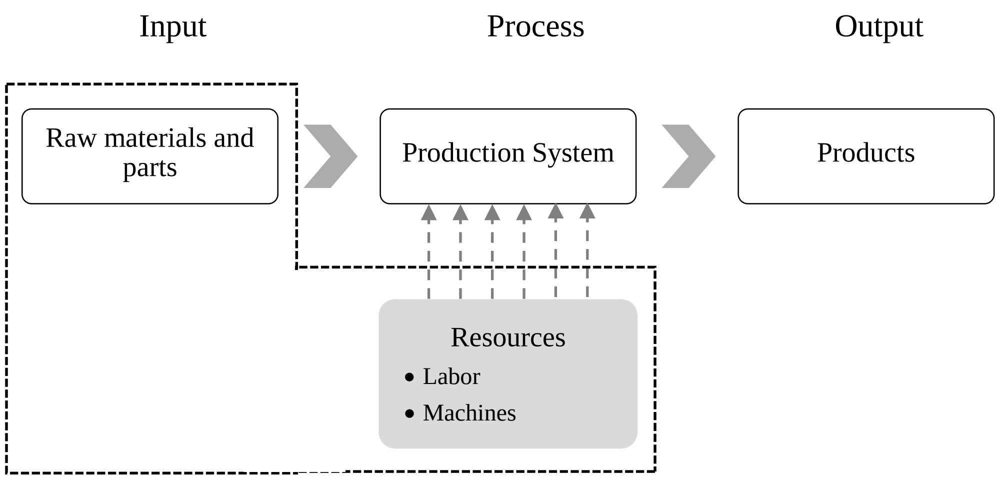


Figure 1.2 Production system

Figure 1.2 presents a general production system which is composed of raw materials and parts as the input element, and includes resources of labor and machines. The input is converted into the output product via the process of the production system. In the managerial viewpoint, differences in labor resource are the critical factors in labor-intensive manufacturing that greatly impact the production capacity, quality and quantity of a finished product, manufacturing lead time, and the overall efficiency of the entire production system.

Regarding to the importance of labor resource in labor-intensive industry, worker's capabilities and skills have become an influencing criteria in an organization since an individual worker has different abilities or skills to perform a specific task. It is commonly agreed that workers with different skill levels have different abilities in terms of operational understanding and response times, this significantly impacts the system performance. A number of the existing literatures stated different levels of worker skills. Winchester *et al*. (2006) classified a worker in the manufacturing into four types; namely highly-skilled, skilled, semi-skilled, and unskilled. The study constructed a new method for identifying groups of workers with similar skills characteristics that considered both academic and vocational qualifications. In labor-intensive manufacturing, worker resources with semi-skilled characteristics play an important role in an organization for recruiting and selecting a worker to operate various tasks in the production system. In term of industrial relations and human resource, a semi-skilled worker primarily refers to a worker that is partly skilled or trained but not sufficiently to perform specialized work. From the manufacturing perspective, this type of worker does not require the advanced training or education and it typically takes a short period to completely learn a semi-skilled task. Moreover, a semi-skilled worker also provides a higher level of flexibility in the production system since an individual worker is able to operate multiple tasks and the environment of job rotation is allowed with respect to the labor-intensive manufacturing. Hence, the semi-skilled worker is only focused in this research.

In order to achieve a successful management on labor resources, the effective methods of evaluation and ranking for workers with diverse competencies are needed to be taken into account, and this is the most challenging goal of all organizations (Güngör *et al*., 2009) for selecting a right worker and place his/her into a right task. However, in the related worker management literature, much of the existing studies has been focused on the final management decision in allocating worker-to-task problem which strongly constructed by the mathematical models, without respect to the real manufacturing practice.

The problems regarding workforce decisions are carried out into different phases; e.g. worker evaluation, selection, allocation and scheduling in Majozi and Zhu (2005). This classification corresponds to Şen and Çınar (2010) which focused on worker evaluation and pre-worker allocation phase. In the pre-worker allocation phase, worker selection and grouping are included. In brief, evaluation refers to the performance measurement of workers (e.g. competency, experience). Selection refers to the question of “who” will be selected? (Nembhard and Bentefouet, 2014), and grouping is concerned with clusters of selected workers who have similar competencies. Worker allocation is concerned with “who works where?”, while worker scheduling is concerned with "who works when?" (Majozi and Zhu, 2005). It is evident that the problems of worker allocation and scheduling have been widely published in today's researches as the final workforce management decisions that strongly focused on mathematical models. Meanwhile the prior activities in worker selection and grouping phases have been neglected in those study areas.

In order to fill the gaps, this research aims to present a methodology of selection and grouping of the semi-skilled worker, with the different perspectives of both academic and real manufacturing practice in the labor-intensive industry. The important worker selection criteria with various skills from previous literatures and manufacturing practice are identified and prioritized using the Analytic Hierarchy Process (AHP) as a multi-criteria decision-making tool (MCDM). A sample of ten labor-intensive experts from each of the manufacturing types categorized by its economic activity (Thailand Standard Industrial Classification; TSIC) is investigated, namely food products, textiles/wearing apparel products, plastics products, and steel products. In worker grouping, the previous literatures are respectively investigated with manufacturing practice in labor-intensive environment, to achieve the effective worker selection and grouping model. The rest of the research is organized as follows: literature review, research methodology, discussion and conclusion, references, and appendices.

1.2 Research Questions

1) What are the important criteria used to select a semi-skilled worker in labor-intensive industry?

2) What is the practical method currently used to select and group a semi-skilled worker in labor-intensive industry?

3) What are the similarities and differences of a semi-skilled worker selection and grouping practices among labor-intensive case studies, include food products, textiles/wearing apparel products, plastic products, and steel product?

1.3 Objective of Study

This research aims to investigate semi-skilled worker selection and grouping in the context of labor-intensive industry with different perspectives of both academic and real manufacturing practice.

1.4 Scope of Study

The scope of this study contains the following elements:

1) In this research, the "*semi-skilled worker*" who is able to operate various tasks in the production line is only focused. This worker type also allows job rotation in the production system.

2) The *labor-intensive manufacturing* is highlighted. Previous studies and manufacturing practice in labor-intensive perspective are primarily investigated. The case studies of labor-intensive firms in this research are classified into four different industry types following TSIC 2009 (Thailand Standard Industrial Classification), includes food products, textiles/wearing apparel products, plastics products, and steel products.

3) The case study of *Recruitment outsourcing provider* is only investigated through the government sector, Department of Employment (Thai Ministry of Labour). As labor specialists, DOE represents the third party that professionally provides worker recruitment service to the manufacturing industry.

4) The *Code of Conduct* regarding to labor regulations is taken into account in the case studies of textiles/wearing apparel and plastic products for AHP qualitative judgement process.

5) The study is limited to worker selection and grouping phases which are examined through the real case studies of labor-intensive industry in Thailand. Accordingly, worker allocation phase and integrated workforce decisions would be a potential extension for the future research.

1.5 Expected Results

The expected results derived from this proposed research, are given in the following.

1) The important criteria used to select semi-skilled worker from previous studies and viewpoints of manufacturing experts from firms of labor-intensive industry classified by TSIC, are identified with the weights of importance and priorities including the selection methods used in the real manufacturing environment.

2) The preliminary grouping approach with distinct groups of semi-skilled workers are examined with respect to previous studies and the manufacturing practice from labor-intensive case studies.

3) Similarities and differences of semi-skilled worker selection practice in each industry type with selected firms of labor-intensive industry are presented.

4) Results obtained from worker grouping approach are able to support decisions regarding to wage raise of the semi-skilled worker, using the overall worker capability values (OWC).

5) The proposed semi-skilled worker selection and grouping in this research are applicable in other manufacturing sectors.

CHAPTER II
LITERATURE REVIEW

In this chapter, the previous studies on workforce management background with research tools in labor-intensive manufacturing and other different manufacturing are investigated. The chapter is carried out into four main sections, given in the following.

2.1 Labor-intensive manufacturing
- 2.1.1 Labor and capital intensive manufacturing
- 2.1.2 Labor-intensive nature and its production system
- 2.1.3 Industrial classification

2.2 Background of workforce management

2.3 Semi-skilled worker
- 2.3.1 Worker skill gaps
- 2.3.2 Definitions of semi-skilled worker and its impact

2.4 Worker selection

2.5 Worker grouping

2.6 Research Tools
- 2.6.1 Analytic hierarchy process (AHP)
- 2.6.2 In-depth interview

2.1 Labor-intensive manufacturing

2.1.1 Labor and capital intensive manufacturing

In the manufacturing environment, it is categorized into two main types following to their business characteristics. The first type is labor-intensive manufacturing and the second type is capital-intensive manufacturing (some relevant literatures use machine-intensive manufacturing). However, the study of this research is focused in labor-intensive manufacturing.

The production operations of any manufacturing are combined with two major inputs as follow.

(1) Labor – refers to a management of workforce which could be full-time, part-time, or temporary.

(2) Capital – refers to plant, machinery, IT system, and vehicle (for example).

Labor-intensive manufacturing is defined as an industry that requires heavy labor investment or a large amount of workforce, to produce goods or service. The degree of labor intensity relies typically in proportion of labor costs required, as compared with the other costs. On the other hand, capital-intensive manufacturing is an industry that requires a high level of capital investment compared to the labor cost. Most of the production processes are likely to be automated, in order to produce goods in a mass scale. Moreover, the background of labor-intensive industry is investigated through the relevant literature. Süer and Bera (1998) categorized the manufacturing cells following to the involvement of work in process, to be labor and machine intensive cells. From their explanations, the manufacturing cells in labor-intensive industry are enclosed with inexpensive machines and equipment which are small and simple. The worker is the major effect of the production output rate from each manufacturing cell. As compared with machine-intensive manufacturing, the operator involvement is greater. While, in machine-intensive cell, the worker involvement is usually limited with small impact to the production output, insteadly the number of machines determines the output of a cell (Süer, 1996).

Similarly, Egilmez *et al*. (2014) described that the production output is heavily depended on worker performance in labor intensive cell. Here are some examples of the labor-intensive manufacturing, apparel industry, jewelry and gems industry, electronic parts and devices industry and sport goods industry. For machine intensive cell, the most critical decision that has a great impact to the manufacturing performance is, machine assignment. On the other hand, workforce allocation is the influential decision since workforce has the strong impact to the manufacturing compared to machinery.

In the labor-intensive manufacturing system, the level of human resources and worker skills play an important role in the production including the worker assignment, which is the major factor and also effect to the productivity (Egilmez and Süer, 2012).

Based on the existing literature, the important characteristics of labor and captial intersive manufacturing are summarized in Table 2.1 as shown below.

Table 2.1 Characteristics of labor and capital intensive manufacturing

	Labor Intensive	**Capital Intensive**
High level of investment	Workforce	Plant, machinery, IT system, vehicle
Operations nature	Manual	Automatic
Scale of production	Small	Large
Production performance largely depends on	Worker skills	Machine capacity
Firms benefit from	Low-cost labor	Low-cost, long-term financing
Examples	• Apparel, Garment • Construction • Mining • Agriculture • Furniture • Food processing • *Steel** • *Plastic**	• Electronic • Car manufacturing • Oil extraction & refining

*Steel and plastic manufacturings could be considered as both Labor Intensive and Capital Intensive regarding to the contexts of their production characteristics.

In Table 2.1, the investment in workforce plays a key factor in labor-intensive manufacturing while plant, machinery, IT system and vehicle are focused investment in capital-intensive manufacturing. According to their different investment natures, the production lines are thus different. In labor-intensive manufacturing, most of the operations in the production line are manually operated by workers. On the other hand, automatic operations are mostly operated in the production line in capital-intensive manufacturing, using machinery as a major resource which is controlled by workers.

Furthermore, the production scales of these manufacturing systems are different. In labor-intensive manufacturing, the production scale is smaller than the capital-intensive manufacturing, which is considered as the large scale of production since the production line performance is highly depended on the machine capacity. While in labor-intensive manufacturing, the worker skills have a great effect in the production line performance.

The entire characteristics of two different manufacturing systems cause the different benefit structures. In labor-intensive manufacturing firms, most of them gain benefit from low-cost labor, which is the main resource. While long-term financial is a major concern in capital-intensive manufacturing firms. In term of costs, the production cost of labor-intensive goods and services are vary since the workers can be added or subtracted depending on the business situations. During the economic downturns, this is one advantage that allows the manufacturers to control the production costs while the capital-intensive industry normally turns on the higher fixed costs.

Regard to the distinct characteristics of industries, they are categorized into two groups, one is manufacturing sector and the other is service sector. The manufacturing sector is only focused in this research. Apparel and garment, construction, mining, agriculture, furniture, and food processing are some examples for labor-intensive manufacturing. For the capital-intensive manufacturing, such as electronic, car manufacturing, oil extraction and refining. Additionaly, it is found that a number of the manufacturings in plastic and steel industries is highly labor-intensive regarding to their operations which require a huge labor involvement. Unni (2012) as a research director with the Measurement & Instrumentation group at Frost & Sullivan said that the trend of steel industry rapidly changes from labor-intensive to capital intensive since it is driven by energy consumption, emissions, standards, and requirements from end markets. However, a number of steel making processes remain labor-intensive characteristics which depends on a specific operation and their final products. On the other hand, a survey of plastic industry studied by Runckel (2006) reveals that the plastic manufacturing tends to be highly labor-intensive regarding to its production that requires a number of labor to operate e.g. the medical equipments

(Schönberger and Hoffstetter, 2016). Accordingly, in order to represent the valid model of semi-skilled worker selection and grouping in labor-intensive industry, various perspectives from food, textiles/wearing apparel, plastic, and steel manufacturings are investigated in this research.

2.1.2 Labor-intensive nature and its production system

In the manufacturing cells of labor-intensive environment, worker involvement and assignment play a central role in the entire production performance. Operations in labor-intensive manufacturing are generally characterized by the presence of light-weight, small, inexpensive machines and equipment where continuous worker attendance and involvement are required (Süer, 1996). On the other hand, labor-intensive describes the proportion in which labor is employed to process an operation when compared with other resources (Ng and Tang, 2010).

Das *et al*. (2006) presented a workforce model in labor-intensive export oriented factories, it revealed that this industry mostly has limited capital investments in production equipment which conforms to the explanation of Süer *et al*. (2009). Hence, the workforce size is a major factor that significantly relates to the factory's fixed cost. Generally, the manufacturing of a single product e.g. handbags and shoes is well represented labor-intensive industry regarding to Das *et al*. (2006). Since these labor-intensive export oriented factories have less concern in product design phase, most of them operate as an outsourced manufacturing facility which provides to a massive customer scale. Apparel, leather products and soft furnishings are given as some example industries with above-mentioned characteristics. Das *et al*. (2006) also found that the factories size may be limited with 100 – 400 permanent workers. Generally, there are two types of worker who work in the labor-intensive production line, (1) permanent worker, and (2) temporary worker. Once the production size of the particular product is determined, the production orders will be released periodically. Both fixed and frequent basis of production orders are issued and the order pattern of their customers varies from two factors which are frequency and volume of the order. The size of customer orders tend not to be large which will be mostly finished within 3 – 4 weeks.

According to the competitive situation nowadays, the labor-intensive export oriented factories have been driven to quickly respond to their customer orders, while continuously maintaining an efficient cost structure. Minimizing the finished goods inventory becomes a major concern, since it directly effects to the inventory cost. In addition, since the cost of hiring and layoff of workers is not that high, these factories tends to prefer the temporary worker to a large pool of permanent workers (Das *et al*., 2006).

The critical success factor (CSFs) of labor-intensive environment was investigated in Ng and Tang (2010) with respect to the context of construction industry. Through their study, the CSFs of labor-intensive sub-contractors have been grouped into three major elements, namely managerial performance, financial performance, and labor-intensive specific factors. From this study, it is evident that managerial performance is one of the most important critical success factor in labor-intensive nature which is guided to an organization improvement.

In this research, the study on selection and grouping of semi-skilled worker is scoped in the context of labor-intensive industry which has the unique characteristics that entirely differ from the capital-intensive industry. From the previous literature, it is found that workforce management plays an important role in achieving the overall production performance improvement in labor-intensive industry since the manufacturing system is mainly operated by human or “worker” as the major resource. Subsequently, this study aims to investigate semi-skilled worker selection and grouping through relevant studies and perspectives from manufacturing practice in the real case study companies.

2.1.3 Industrial classification

Industry sector is one of the most important economic activity in Thailand, it highly benefits the region in many terms such as national income and career employment. The industry also plays a great role in the national development to add value of raw materials and transform into finished product, then launch to the markets. Based on the existing literature, industry has been categorized into different types depending on criteria considered. Generally, the industry can be classified with repect to its scale which includes;

(1) Large scale industry – High invesment industry which consists of skilled-workers, high technology machines, complicated processes and operations such as metals, automotive, machinery manufacturings.

(2) Medium scale industry – Medium investment with lower number of human resource and machines. For example, electronics and textile.

(3) Small scale industry – Low investment and consists of a small number of human resource, i.e. sugar manufacturing.

The classification of industry is also considered from its primary operation, namely;

(1) Extractive industry – Adding more value into the natural resouce, oil palms manufacturing, fishing, operation of forest tree for examples.

(2) Manufacturing industry – Transforming raw materials from the extractive industry into finished products, i.e. paper and garment manufacturings.

(3) Transporting industry – Operations of moving finished products to final customers. For example, train, ship, and air transportations.

(4) Service industry – All service business, i.e. hotels, tourisms, and infrastructures.

For the industry classification that considered its materials used, is carried out into 3 groups;

(1) Primary industry – The natural resource or agriculture is directly used to produce the products for further manufacturing, i.e. minning.

(2) Secondary industry – Manufacturing of finished products using the product from primary industry, transforming iron into machines for example.

(3) Tertiary industry – The industry uses finished products from secoundary industry to service customers, i.e. transporation.

Moreover, characteristics of the industry's finished products are also taken into account. It is carried out into 2 types;

(1) Heavy industry – Manufacturing of heavy products using high investment in captial, labor resource, and materials.

(2) Light industry – Manufacturing of light products that requires lower investments on the manufacturing resources, i.e. textile, food, electronics industries.

According to Thailand Standard Industrial Classification 2009 (TSIC) published by the Natioanl Statistical Office of Thailand under the Ministry of Information and Communication Technology with cooperation of the Ministry of Labour. TSIC is the classification structure of economics activiteis based on a set of agreed concepts, definitions, principles and classification rules. The purpose of TSIC is to classify groups of similar economic activities and organizational units, in order to facilitate the statistical data on manufacturing, labor resouce, and other statistical record for economics which can be used to analized in AEC and global regions for the monitoring, analysis and evaluation of the performance of an economy over time. TSIC is constructed and developed based on three primary issues, namely International Standard Industrial Classification of All Economic Activities Revision 4 (ISIC Rev.4), ASEAN Common Industrial Classification (ACIC), and East Asia Manufacturing Industrial Classification (EAMIC) Ver. 1.

TSIC is the industrial classification based on the concept of production-oriented or supply-based that groups the manufacturing/service units with similar economic activities together. TSIC also considers factors of production, processes and technology used of production, characteristics of finished products, and usage of finished products. TSIC classified industries into section, division, group, class, and activity as presented in Table 2.2.

Table 2.2 TSIC classifications

Section	Group of industries at top level	21 sections	A - U
Division	Group of industries divided from section level	88 divisions	00
Group	Group of industries divided from division level	243 groups	000
Class	Group of industries divided from group level	440 classes	0000
Activity	Group of industries at bottom level	1,089 activities	00000

In identifying a specific industry, the code consists of letter from A-U and is followed by numbers from two digits (00) to five digits (00000) depending on the classification level. For example, C10 represents the manufacture of food products where C is classified as section (manufacturing) and 10 is division.

The individual categories of TSIC have been aggregated into the following 21 sections (Table 2.3).

Table 2.3 Individual categories of industry (ISIC and TSIC, 2009)

Section	Description
A	Agriculture, forestry and fishing
B	Mining and quarrying
C	Manufacturing
D	Electricity, gas, steam and air conditioning supply
E	Water supply; sewerage, waste management and remediation activities
F	Construction
G	Wholesale and retail trade; repair of motor vehicles and motorcycles
H	Transportation and storage
I	Accommodation and food service activities
J	Information and communication
K	Financial and insurance activities
L	Real estate activities
M	Professional, scientific and technical activities
N	Administrative and support service activities
O	Public administration and defence; compulsory social security
P	Education
Q	Human health and social work activities
R	Arts, entertainment and recreation
S	Other service activities
T	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use
U	Activities of extraterritorial organizations and bodies

Since the main context of this research is labor-intensive manufacturing industry, Section C is only investigated with division level. Following to TSIC, Section C or Manufacturing is divided into division 10 - 33 (24 divisions) as presented in Table 2.4.

Table 2.4 Divisions of Section C : Manufacturing

Section	Devision	Description
C Manufacturing	10	Manufacture of food products
	11	Manufacture of beverages
	12	Manufacture of tobacco products
	13	Manufacture of textiles
	14	Manufacture of wearing apparel
	15	Manufacture of leather and related products
	16	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
	17	Manufacture of paper and paper products
	18	Printing and reproduction of recorded media
	19	Manufacture of coke and refined petroleum products
	20	Manufacture of chemicals and chemical products
	21	Manufacture of pharmaceuticals, medicinal chemical and botanical products
	22	Manufacture of rubber and plastics products
	23	Manufacture of other non-metallic mineral products
	24	Manufacture of basic metals
	25	Manufacture of fabricated metal products, except machinery and equipment
	26	Manufacture of computer, electronic and optical products
	27	Manufacture of electrical equipment
	28	Manufacture of machinery and equipment
	29	Manufacture of motor vehicles, trailers and semi-trailers
	30	Manufacture of other transport equipment
	31	Manufacture of furniture
	32	Other manufacturing
	33	Repair and installation of machinery and equipment

From Table 2.4, the divisions of manufacturing section are divided into 24 divisions. However, the manufactures of food products, textiles/wearing apparel/leather and related products, plastics products, and basic metals are some examples that are classified as labor-intensive industries with respect to the aforementioned characteristics.

With a wide range of manufactturing industries, this research therefore investigates the semi-skilled worker selection and grouing from ten samples of labor-intensive manufacturers which include food products, textiles/wearing apparel/leather products, plastics products, and iron/steel products, in order to perceive more understanding of labor-intensive nature from the real manufacturing practice.

2.2 Background of workforce management

In the relevant literatures, different words have been used to represent “workforce” such as employee, worker, operator, and labor. However, this research focuses on the labor-intensive manufacturing environment in the production line which is operated by “workers”. The assembly line consists of two main drivers, workers and machines. According to the labor-intensive manufacturing natures as above-mentioned, workers are the important key players which highly effect the overall production performance. It is found that workforce management has become a great concern in such environment since the performance relies heavily on how well the workers are managed.

Workforce management (WFM) has been studied in a wide range of context in today’s literature. It is provided with various definitions, however workforce management is mainly related to all activities required to achieve a productive workforce. Decision-making regarding to workforce is concerned in workforce management activities and sometimes referred to human resource management, such as payroll and benefits, forecasting and scheduling, learning and training management, and performance management.

A number of existing literature on the workforce management problem has been studied by considering slightly different in sub-problems (Talarico and Duque, 2015). Talarico and Duque (2015) proposed an optimization algorithm for the workforce management in a retail chain. However, the problem is mainly focused on a workforce scheduling to determine the mix of full-time and part-time workers. From their study, this kind of workforce management problem is a staff planning problem in forecasing and schduling activities which are only a partial domain in the entire workforce manamgent system. The staff planning process of Talarico and Duque (2015) is illustrated in Figure 2.1. The model consists of demand planning process includes sales forecast, service level, demand of personnel, followed by the optimal workforce generation, and staff assignement processes. Similarly, Menezes *et al*. (2006) developed a model to efficiently manage workforce within a group of retail chain. A worker allocation problem is solved in the study to determine the optimal workforce that each store needs on a weekly basis.

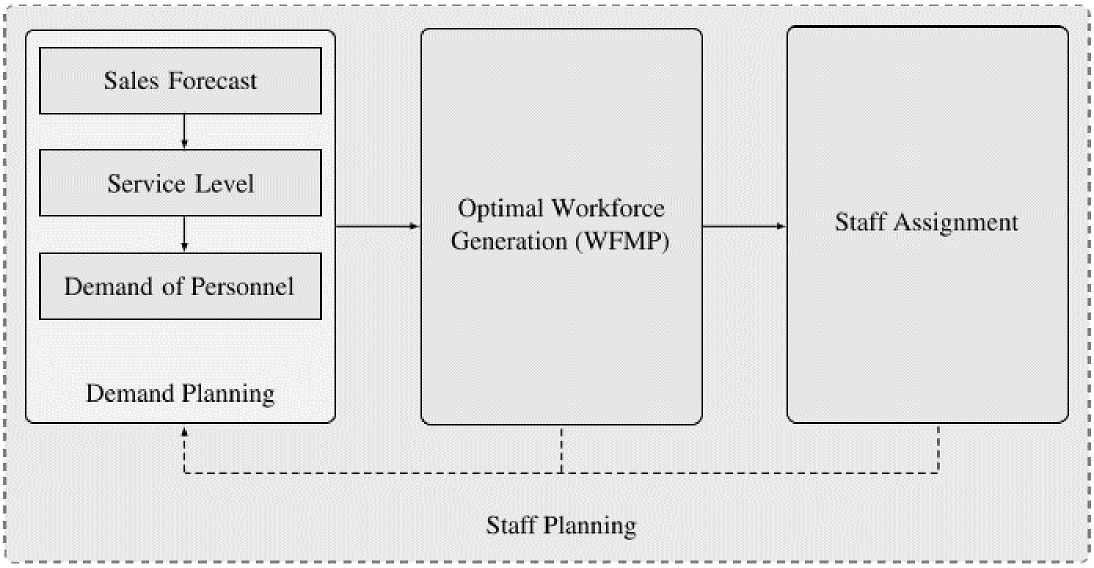


Figure 2.1 Staff planning process (Talarico and Duque, 2015)

Also, in Kabak *et al*., (2008) a two phase of decision support system (DSS) is presented to minimize the total cost of workforce. In the first phase, hourly staff requirement is detrmined where in the second phase the assignement of workers with daily shifts is examined. This study considered two workforce manamgen problems, worker scheduling and allocation. However, this is just a few samples on studies related to workforce management domain. In this research, the workforce management is mainly focused on selection and grouping phases in the operational level of labor-intensive industry, as per discussed in Section 2.2.4.

Most of the workforce problem in today's literature is carried out into two phases, (1) worker allocation, and (2) worker scheduling. However, Majozi and Zhu (2005) stated that there are four different phases concerning on workforce management which are, worker evaluation, selection, allocation, and followed by worker scheduling.

This workforce management classification correspond to Şen and Çınar (2010) which focused on the worker evaluation and pre-worker allocation phase. In pre-worker allocation phase, worker selection and grouping are included. Similarly, Nembhard and Bentefouet (2014) also classified decision-making regarding the workforce into three major phases, namely selection, assignment, and scheduling. Also, the grouping phase is added up into workforce management by Nembhard and Bentefouet (2015), they explained that worker allocation problem is enclosed with the selection of workers from a pool, grouping workers based on their individual characteristics, and assignment of groups of selected workers to tasks.

From above-mentioned literatures, there are five phases which had been addressed in the workforce management, namely evaluation, selection, grouping, allocation, and scheduling. In short, *evaluation* refers to the performance measurement of workers (e.g. competency, experience, personal characteristics), *selection* refers to the question of "who" will be selected? (Nembhard and Bentefouet, 2014), while *grouping* is concerned with the clusters of selected workers who have any similar competencies. Majozi and Zhu (2005) briefly explained that worker *allocation* is concerned with "who works where?" while worker *scheduling* is concerned with "who works when?" which is aimed to determine when and how long each worker has to work to comply with legal constraints.

The problems of worker allocation and scheduling have been widely published in today's researches. In workforce management literatures, worker allocation and scheduling are considered as the final management decisions, while there are prior activities which have been less focused in those research areas. The prior activities in this study is hereafter mentioned as "pre-worker allocation management", it directly refers to the worker selection and grouping phases. Before the worker allocation decision will be made, it is necessary to properly select the workers based on their individual performance in order to properly allocate the right workers into the right tasks with respect to their capabilities.

This research aims to fill this gap by focusing on the pre-worker allocation management which is primarily divided into two phases, namely (1) *worker selection*, and (2) *worker grouping*. The relevant literatures are investigated as given in Section 2.4 and 2.5.

2.3 Semi-skilled worker

Regarding to the importance of labor resource in labor-intensive industry, worker's capabilities and skills have become a challenging criteria in an organization. An individual worker who has various abilities or skills, is able to perform different specific tasks. Generally, skill levels indicate an individual performance of worker in terms of operational understanding and response times which have a great impact to the overall production performance. This research also investigates the existing research gaps concerning about worker skill presented in Section 2.3.1, types of worker skills and skill levels in the production line is described with respect to labor-intensive environment.

2.3.1 Worker skill gaps

The skilled workers are the most powerful assets in achieving the business goals (Güngör *et al*., 2009). In labor-intensive environment, it is commonly agreed that worker skill has a strong impact on overall manufacturing performance. Skill is defined as one's ability to apply knowledge and use the know-how to perform tasks well. Generally, skills may be cognitive (use of logical, intuitive and creative thinking) or practical (use of methods, materials and tools) (Chryssolouris *et al*., 2013). In the context of a learning process, skills generally involve the following elements, observation and replication of actions, task reproduction from instruction or memory, reliable execution independent of help, adaptation/integration of expertise to meet requirements and automated (Bloom *et al*., 1956).

Smits (2007) classified worker skills into two types; (1) generic skills and, (2) industry-specific skills. It is important for worker to have not only skills in specific industry, but also generic skills that create a wide range of applicability. Heijke *et al*. (2003) explained that generic skills are defined from a combination of learning abilities, analytical abilities, and problem solving abilities. On the other hand, Hendarman and Tjakraatmadja (2012) categorized skills into two types, one is soft skills and the other is hard skills. Soft skills refer to personal attributes that enhance an individual's interactions with work performance, while hard skills are a person's skills set and ability to perform a certain task. However, the skill list of Consoli and Rentocchini (2015) were stated from the manufacturing which machines are the major resource.

Worker skill in this research is classified into two different types; (1) general skills and, (2) technical skills. In whilst, general skills mainly refer to any fundamental skills which can be applied in different industry sector (i.e. analytical thinking, communication, learning), unlike technical skills which mainly focus on any specific skills used in operations of a specific industry sector (i.e. production and processing, quality control).

In production planning and designing systems, workers are commonly assumed to be equal in their abilities and perform tasks at a steady pace (Bentefouet and Nembhard, 2013) and most of the mathematical models consider worker resource with only one skill (Wongwai and Malaikrisanachalee, 2011). Generally, these assumptions totally conflict the real world problem. Ignoring the impact of workers with various skills would result the effectiveness of services provided which lead to the organization's outcomes (Lee, 2004).

Regarding to the worker allocation and scheduling problems, Warner *et al*. (1997) assigned workers to machines based on their human and technology skills. Wongwai and Malaikrisanachalee (2011) proposed the augmented heuristic algorithm for resource scheduling which multiple skills had been considered. The benefits of worker with multiple skills was also mentioned in their study. Workforce with multiple skills tends to increase the product quality, productivity and continuity of work. Moreover, the managers have more flexibility in assigning tasks to workers. Fowler *et al*. (2008) studied decisions in workforce management with respect to differences in individual workers measured by general cognitive ability (GCA). The workforce flexibility was focused as an effective way to deal with the various variabilities in manufacturing systems. A mixed integer programming (MIP) model is used to determine different staffing decisions (i.e. hire, cross-train and fire) to minimize workforce related costs. It is seen that all of the afore-mentioned literature has emphasized on dealing with the differences of worker skills by generating skill level and placing it as a constraint in mathematical models. On the other hand, Mori *et al*. (2015) presented a quantitative approach for design and formation of workforce skills using simulations to achieve the efficient assembly. The skill of workers is one major cause of uncertainties. Demand fluctuations also cause the difficulty in maintaining the efficient skilled workers in machine tool production. From the existing studies, it is found that there are a few studies on workforce management with the consideration on worker skills in the context of labor-intensive manufacturing nature.

In the manufacturing which labor is the primary production resource, worker variability has become a significant concern since it directly creates the uncertainties to overall production performance. Similarly, in labor-intensive industry (e.g. apparel industry), worker is the main resource which has a great impact to the assembly line and the production system. Because of this, worker skills have been considered as one potential factor that indicates the level of worker's ability and the level of flexibility of the entire manufacturing system. From its large impact of worker skill, this research therefore highlights worker skill as one of the important criteria in worker selection model of labor-intensive industry.

2.3.2 Definitions of semi-skilled worker and its impact

In the scenarion of labor-intensive manufacturing which worker-related factors play an important role in the production performance, worker that acquires various skills is the powerful resouce in the production system. Practically, this production environment usually requires job rotations to avoid boredom and fatigue faced by worker during operations and also cause lower production performance.

Workers are classified into types or levels depending on their efficiencies to perform tasks, as know as skills. A number of the existing literature stated different types of worker skills, Winchester et al. (2006) classified worker in the manufacturing into four types using hierarchical clustering techniques; namely highly-skilled, skilled, semi-skilled, and unskilled. The study constructed a new method for identifying groups of worker with similar skills characteristics that considered both academic and vocational qualifications. In determing labour types, Winchester *et al*. (2006) proposed two common methods to divide worker into different components, one is job classifications to create proxies for skilled and unskilled worker and the other employs educational characteristics to measure skills. Job classification approaches rely on the International Standard Classification of Occupations which most occupations are divided into non-production and production groups to estimate skilled and unskilled worker consequently. For methods using educational characteristics are generally based on academic qualifications. The worker classification of Winchester *et al*. (2006) can be illustrated in Figure 2.2.

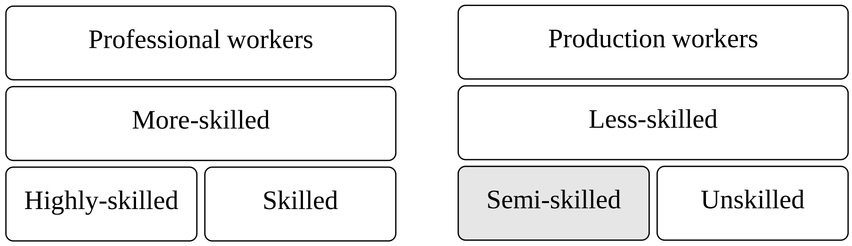


Figure 2.2 Worker classification (Winchester *et al*., 2006)

From Figure 2.2, worker is classified into four distinct type includes highly-skilled, skilled, semi-skilled, and unskilled. However, the highly-skilled and skilled workers are described as professional workers (more-skilled) whereas semi-skilled and unskilled workers are production workers (less-skilled).

Manufacturing worker employment, often being required with few work-related skills, and little knowledge, or experience (Carless *et al*., 2007). Carless *et al*. (2007) investigates unskilled and semi-skilled manufacturing employees in Australia and revealed that the task performed by unskilled and semi-skilled workers considerably differs from that white skilled workers. In that they usually have less discretion about how their work is performed (Pannone, 1994).

In labor-intensive manufacturing, worker resource with semi-skilled characteristics largely benefit an organization in operating various tasks in the production system. Semi-skilled worker primarily refers to worker that is partly skilled or trained but not sufficiently to perform specialized work, in term of industrial relations and human resource terms. From the manufacturing perspective, this type of worker does not require the advanced training or education and it typically takes a short period to fully learn a semi-skilled task. Moreover, semi-skilled worker also provide a higher level of flexibility in the production system since an individual worker is able to operate multiple tasks and the environment of job rotation is allowed with respect to labor-intensive manufacturing. Hence, the semi-skilled worker is only focused in this research.

Regarding to the labor force skills, Consoli and Rentocchini (2015) proposed an empirical study of multi-industry labor force skills from 290 industrial sectors in the United States (US) based on the employment structures and job content of occupations. Two questions were addressed including skill configurations that characcterize industries and sectors, and the association of particular skill configurations to spectific industy types. It is found that, all skills are categorized into two factors namely (1) interactive and abstract as non-routine task, and (2) technical and analytical as routine activities whereas 26 skills were considered in the first factor and 9 skills for the second factor. It is also evident that skills categories are similar to the above-mentioned literatures that consider skills in two point of views, general and technical skills. However, four categories of basic, processing, social, and technical abilities are additionally addressed. Accordingly, Consoli and Rentocchini (2015) selected the important industrial skills based on worker attributes and job characteristics database maintained by the U.S. Department of Labor (DOL) in which industrial skills are carried out into 6 groups including (1) basic skills, (2) complex problem solving skills, (3) resource management skills, (4) social skills, (5) systems skills, and (5) techinical skills. Morover, the industry is managed into 6 categories including (1) complex production, (2) basic production and distribution, (3) people service, (4) manufacturing, (5) service, and (6) other e.g. agriculture, mining, utilities. Thorugh the methodology, occupational analysts, job incumbents, occupational experts were asked to score to the laid above 35 types of skills.

In worker selection phase of this research, the taxonomy of multi-industry labor force skills proposed by Consoli and Rentocchini (2015) significantly supports worker selection criteria considered in worker skill aspect with respect to the characteristics of semi-skilled worker and labor-intensive industry. The general skills include active learning, critical thinking, reading comprehension, speaking, writing, problem solving, coordination and monitoring while the technical skills consist of equipment selection, installation, operation and control, operation monitoring, and quality control. These general labor fource skills are addressed in the research questionnaire which would be responsed by ten experts from five case studies.

2.4 Worker selection

In order to effectively manage the semi-skilled worker in selection phase, worker performance is an essential information which strongly supports the decision-making regarding to labor resource. Regarding to the study of Frank *et al*. (1998), one of the most critical decision in workforce management is that of rating personnel in stating the quality of employee which entirely influence to success of business organization. The personnel evaluation problem is basically a problem of identification, weighting, and evaluation. The decision maker must first identify all attributes which are perceived to be significant in evaluating potential candidates.

Worker performance measurement practice is hence investigated in this research. Brilon (2015) stated that the performance of a worker in most jobs depends on may things, such as level of expertise, capacity to concentrate and organize, as well as analytical and communication skills. Consequently, it is necessary to individually indicate the performance of each worker before the worker selection decision will be made properly.

For labor-intensive manufacturing, worker performance measurement is an important operation since the productivity highly depends on the performance of workers. The objective of worker performance measurement is to identify the strengths and weaknesses of each worker to achieve the productivity gains (Rani *et al*., 2014).

Das *et al*. (2006) classified workers into two dimensions, (1) permanent and temporary, and (2) skilled and unskilled. The study focused on temporary worker in the apparel industry. There are several qualifications which have been considered to determine the worker skill level, given in the following;

- *Familiarity* with the manufacturing operations
- Working *knowledge* in the manufacturing equipment.
- Working *experience* in the related field

Similarly, Şen and Çınar (2010) proposed a worker evaluation method using AHP and max-min approach. The worker performance measurement criteria were divided into two levels, main criteria and sub-criteria. The main criteria includes worker *competency*, *experience*, *personal characteristics* and *production capability* while sub-criteria are more specific to the manufacturing natures. The criteria were prioritized and weighted, then each workers’ performance was individually measured.

Rani *et al*. (2014) proposed a comparisons of the different multi-criteria decision making methods (MCDM); AHP, FAHP, ELECTRE, PROMETHEE II, TOPSIS, and VIKOR, used to measure the workers' performance and to rank the workers. There are six major criteria investigated, namely competency, experience, skill, teamwork, time punctuality, personal characteristics, capability, and work outcome, derived from literature review and consensuses from the management of a case study company. The study reveals that AHP and FAHP methods resulted the outcome criteria which refers to quality and quantity of work, is the most important measurement criteria. Majozi and Zhu (2005) also developed a combined fuzzy set theory (FST) and MILP approach to deal with an integration of planning and scheduling which worker performance evaluation and allocation are taken into account. Moreover, the worker measurement criteria is presented, there are five key criteria which are expertise, skill, age, health, and availability.

In practical, the worker performance measurement is one key factor that all manufacturing requires, due to the differences among workers such as experience, learning capability, in-use knowledge, skills, expertise, etc. The worker performance measurement hence indicates the different levels of workers which strongly support the decision-making on selecting the qualified workers.

In the existing literatures, worker selection phase has not been received much attention while it is an important decision that strongly supports worker allocation problem. It is commonly agreed that workers with different skill levels will have different abilities in terms of operational understanding and response times, this highly effect the overall production performance, especially in labor-intensive industry. Worker performance such as knowledge, capability, skill, and other abilities plays an important role in achieving success of an organization. To select the effective methods of ranking a group of workers with the different competencies is the most challenging goal of all organizations (Güngör *et al*., 2009).

Personal selection directly effects the quality of employees, it has always been a concern issue for organizations (Afshari *et al*., 2010). Various approaches have been developed to support organizations in making best worker selection decisions. It is evident that the selection of qualified worker is a key success factor in organizations, as stated in the study of Afshari *et al*. (2010). The study presented personnel selection problem using Simple Additive Weighting approach (SAW). A real application is taken into account with respect to the opinion of expert, seven qualitative criteria is defined amongst five personnel. The seven criteria consist of ability to work in different business units, past experience, team player, fluency in a foreign language, strategic thinking, oral communication skills, and computer skills.

Majozi and Zhu (2005) proposed an application of fuzzy set theory (FST) for worker selection with a consideration of worker evaluation (grading) and ended up with allocating workers into different manufacturing plants which require different groups of workers. The selection criteria are defined, namely expertise, skill, age, health, and availability, to individually indicate worker performance by ranking. “Expertise” in their paper is mainly based on education and training level of worker, while skill is concerned with experience, health is based on number of worker absent (sick) days per month, and availability is primarily considered of residence for each worker. Worker was individually ranked based on the selection criteria and then allocated to the different manufacturing plants in accordance with his/her capability. The worker selection in this paper is prior decision to allocation problem which worker performance is measured in order to achieve an effectively justified match.

Similarly, Şen and Çınar (2010) used a combined fuzzy AHP and max-min approach as research tools to deal with pre-worker allocation decision. The proposed pre-worker allocation decision is concerned with worker selection phase which is based on worker’s individual performance. Moreover, the powerful worker selection criteria are determined by reaching consensus from manufacturing experts. The selected criteria is divided into 2 levels which are main criteria and sub-criteria, where the main criteria includes worker competency, experience, personal characteristics, assembly capability and control capability. The proposed methodology is applied to an electronic industry to represent a real life setting. Güngör *et al*. (2009) proposed a worker selection system based on Fuzzy Analytic Hierarchy Process (FAHP) to achieve the best qualified worker dealing with the weighting of both qualitative and quantitative selection criteria. A hierarchy for worker selection problem of *Güngör et al*. (2009) is presented in Figure 2.3.

Figure 2.3 A hierarchy for worker selection problem (Güngör *et al*., 2009)

Figure 2.3 illustrates that, there are three main categories in worker selection criteria, namely general work factors, complimentary work factors, and individual factors. General work factors consist of work experience, foreign language, academic background, analytical thinking, and basic computer skill. Complimentary work factors consist of decision making, working in teams, effective time using, determination of goal, long term learning, and willingness. And individual factors consist of core ability, appearance, age, culture, and communication ability. Güngör *et al*. (2009) further explained the importance of these three major criteria that the general factors mainly refer to the knowledge base, skills, and individual abilities in organization. The skilled workers are the most powerful assets in achieving the business goals. Similarly, the attitude, self-esteem, personal goal, motivation, teamwork, and flexibility of workers, are taken into account as the complimentary factors. While the individual performance which includes communication ability, core abilities, culture and personal characteristics, and appearance are described as the individual factors. Salgado *et al*. (1997) also explained that the personality or individual criteria is generally described as emotional stability, extraversion, openness, agreeableness, and conscientiousness.

On the other hand, Nembhard and Osothslip (2005) also presented an approach on worker selection based on worker individual learning and forgetting characteristics to facilitate the worker allocation phase. Worker selection policies for a multifunctional workforce was examined by Nembhard and Bentefouet (2014), the study focused on selection and assignment of workers to tasks with the consideration of ratio of generalists to specialists of workers, level of multi-functionality and workforce heterogeneity in car radio assembly process. Five selection policies those used to rank and select workers are illustrated, including the performance of each policy which measured by the assembly system output.

Nembhard and Bentefouet (2014) described that worker selection phase is addressing the question of “who” should be selected from a ranking method. An inspected station at car radios production lines was studied, to satisfy the real world problem. In the selection phase, they examined the question of how to select a worker for a production system. Each worker will be ranked based on the highest overall or highest maximum value of the considered parameters, namely worker learning, knowledge transfer and expected output including steady state of production rate and prior level of expertise which finally result ten worker selection criteria.

Frank et al. (1998) proposed the personnel evaluation using AHP approach. The employee hiring process shown in Figure 2.4 is an overview of the entire personnel evaluation steps from human resource management perspective. It is introduced with identificantion of needed employee from HR plan then the recruitment of internal and external souces is processed with a pool of candidates. The important process is employee selection by comparing each candidate with job requirements via different method, to select the most appropriate employee with respect to job requirements, job descriptions and specifications. Finally, the accepted employee will be placed to the job.

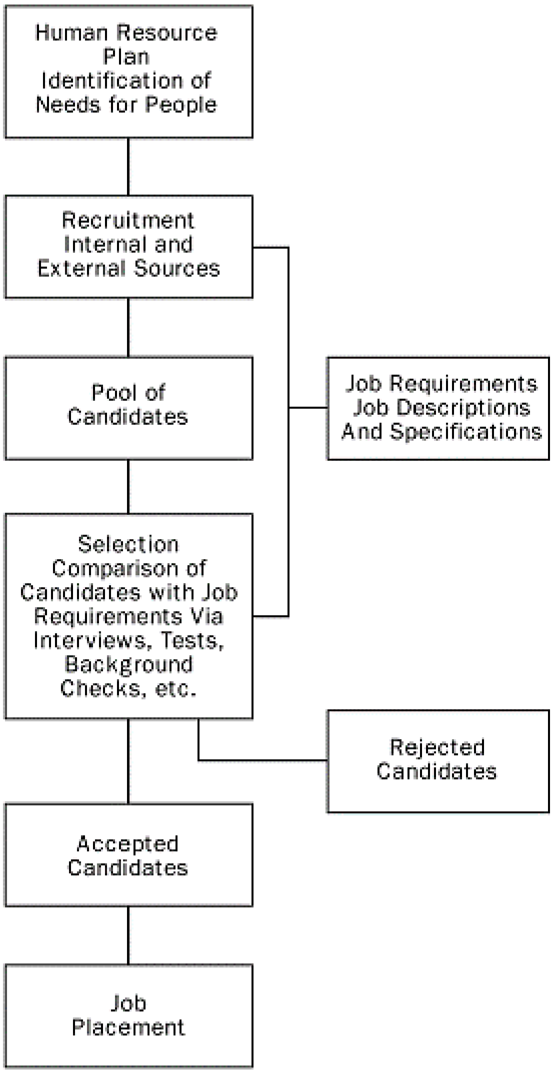


Figure 2.4 Hiring process (Frank *et al.*, 1998)

In this research, worker selection phase is the important area of concern which refers to the question of "how to effectively select" the semi-skilled workers in accordance with their capabilities in the productional level of labor-intensive manufacturing. Once worker performance has been measured based on the influencing worker selection criteria, all workers' scores are ranked. The competent workers then can be selected and will be further managed in the next grouping phase.

2.5 Worker grouping

Once the worker selection process is completed, the selected workers will be organized into groups based on their performance. In the previous studies, only a few attentions have been paid to worker grouping phase. Nembhard and Bentefouet (2015) presented the grouping workers based on their individual characteristics which focused on transfer of knowledge when workers perform similar tasks in a general environment. In grouping phase, it is important to know "who knows what" which has been highlighted when studying in group dynamics. However, the grouping method was illustrated, the selected workers were grouped into different teams following to the different machine types. Generally, different machine types require different groups of workers with various skills. This grouping method was primarily based on variances among workers with respect to their learning and knowledge-transfer characteristics. Koltai and Tatay (2013) proposed a general framwork to model skill requirements and skill conditions for assembly line balancing model. "Skill" in their study represents the skill in general of worker that indicates his/her individual performance. The skill constraints are divided into three types, which are low skill, high skill, and exclusive skill. Workers in low skill are able to performan only some single tasks, while high skill considers taks which require higher than average skill of workers. For exclusive skill refers to workers that are specialized in specific tasks.

Majozi and Zhu (2005) also addressed the categories of worker as determined by firm regulations. The selected workers were categorized into three different groups, namely highly competent, reasonably competent and not competent. A partial worker conclusion matrix from the literature is given in Figure 2.5.

In Figure 2.5, the worker selection criteria were drawn with five dimensions, i.e. expertise, skill, health, age, and availability. Each of criteria is divided into three levels with high, medium, and low. For "age", there are three different ranges where "Y" stands for young, "M" stands for medium, and "O" stands for old. The selected workers are categorized into three groups as above-mentioned, Group A (highly competent), Group B (reasonably competent), and Group C (not competent). This figure is also represented as the decision table (Bojadziev and Bojadziev, 1995) or the conclusion matrix (Ammar and Wright, 2000) which can improve the effectiveness decision-making regarding workforce management.

Health	Skill	Expertise: High								
		Availability								
		High			Medium			Low		
		Age			Age			Age		
		Y	M	O	Y	M	O	Y	M	O
Good	High	A	A	B	A	B	B	B	B	B
	Medium	A	A	B	A	B	B	B	B	B
	Low	B	B	C	B	C	C	B	C	C
		Age			Age			Age		
		Y	M	O	Y	M	O	Y	M	O
Moderate	High	A	A	A	A	B	B	B	B	C
	Medium	A	B	B	A	B	B	B	B	C
	Low	B	B	C	B	C	C	C	C	C
		Age			Age			Age		
		Y	M	O	Y	M	O	Y	M	O
Poor	High	C	C	C	C	C	C	C	C	C
	Medium	C	C	C	C	C	C	C	C	C
	Low	C	C	C	C	C	C	C	C	C

Figure 2.5 Worker Conclusion Matrix (Majozi and Zhu, 2005)

Şen and Çınar (2010) defined the set of effective workers using max-min approach. To represent the real world problem, an electronic industry was studied in their literature. After worker selection criteria were determined, workers were individually measured to indicate their performances i.e. experience, skills, and knowledge. They proposed the use of an extended form of max-min approach to maximize and minimize the best performance of a worker against the best target measures of each worker performance. The final worker set were illustrated into a graph presented in Figure 2.6.

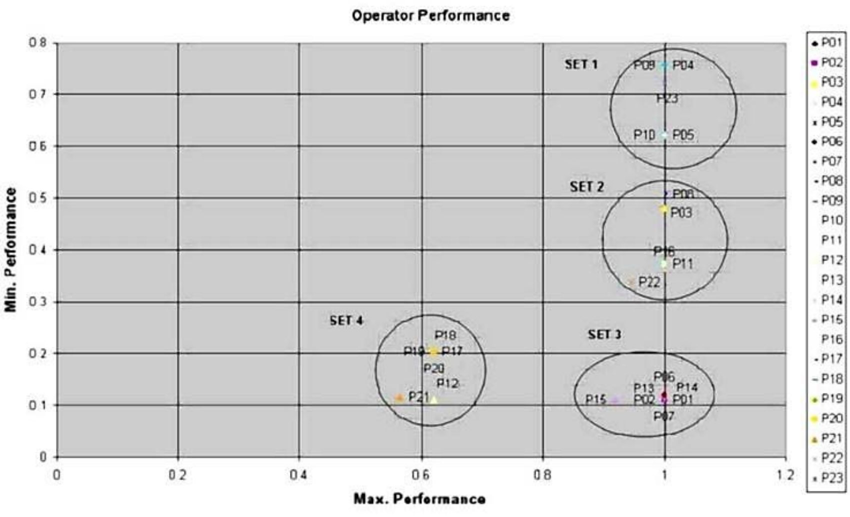


Figure 2.6 Sets of Effective Workers (Şen and Çınar, 2010)

The effective workers as shown in Figure 2.6 were grouped into four different sets. Each of set consists of workers with similar capabilities. This graph presented the performances of 23 workers as “P (number)”. The analysis resulted that, Set 1 is the most effective set of workers with highest performances.

From the literature review process, there is a few studies focused hardly on worker grouping phase in workforce management. Most of the relevant literatures addressed different groups of workers based on various perspectives. Nembhard and Bentefouet (2015) categorized workers based on their learning and knowledge-transfer characteristics with respect to machine types. On the other hand, some literatures group workers based on their capabilities or performances. As per described above, Majozi and Zhu (2005) divided workers into three different groups include highly competent, resonably competent, and not competent. However, from Figure 2.5, health, expertise, availability, and age are also considered in grouping workers. Srivastava *et al*. (2014) classified workers into two types based on their performance, one is skilled worker and the other is semi-skilled worker. The study focused on skills required at the production floor in ready-made garment industry. Similarly, Das *et al*. (2006) categorized workers into two groups, skilled and unskilled workers. In the study of van 't Ooster *et al*. (2015), workers are carried out into four groups given in the following, practice, low skilled workers, generalists, and specialists. It is evident that most of the existing literatures classified workers based on their performances. Rani *et al*. (2014) classified workers into four groups regarding the performance score of workers obtained from Analytic Hierarchy Process (AHP), Group 1, Group 2, Group 3, and Group 4 refer to worker with good performance, average performance, satisfactory performance, and poor performance respectively.

Worker grouping is an important process in workforce management practice that allows a manager to perceive the performances of worker in groups. Moreover, it essentially facilitates the final worker allocation decisions and enables the overall workers performances for effective decision-making in putting the right groups of workers into various tasks.

Table 2.5 Summary of previous studies

Reference	Workforce Management			Tool	Area of Application	
	Phase 1 Selection	Phase 2 Grouping	Phase 3 Allocation		Labor Intensive	Machine Intensive
Nembhard and Bentefouet (2015)	✓	✓	✓	• Heuristics approach • Max-min approach	-	Automobile (Car radio)
Nembhard and Bentefouet (2014)	✓		✓	• Max-min approach • Math-programming	-	Automobile (Car radio)
Rani et al. (2014)	✓			• AHP • FAHP • ELECTRE • PROMETHEE II • TOPSIS • VIKOR	Food manufacturing	-
Afshari et al. (2010)	✓			• SAW	-	Telecommu-nication sector
Şen and Çınar (2010)	✓	✓	✓	• FAHP • Max-min approach	-	Electronic (audio/video intercom system)
Güngör et al. (2009)	✓			• FAHP	Not specify	
Majozi and Zhu (2005)	✓		✓	• FST • MILP approach	Not specify	
Brilon (2015)			✓	• Peter Principle	Not specify	
Ramezanian and Ezzatpanah (2015)			✓	• Goal programming approach • ICA	Not specify	

Table 2.5 Summary of previous studies (continued)

Reference	Workforce Management			Tool	Area of Application	
	Phase 1 Selection	Phase 2 Grouping	Phase 3 Allocation		Labor Intensive	Machine Intensive
Rani and Ismail (2014)			✓	• Computer simulation • DEA	Food manufacturing	-
Wong et al. (2012)			✓	• PUDDE • DES	Apparel industry	-
Nakade and Nishiwaki (2008)			✓	• Proposed algorithm	Not specify	
Yang and Kuo (2007)			✓	• MIP	Electronic (TFT-LCD)	-
Yang et al. (2007)			✓	• AHP • TOPSIS • Fuzzy-based logic	Electronic (Integrated Circuit)	-
Song et al. (2006)			✓	• Recursive algorithm	Apparel industry	-
Ertay and Ruan (2005)			✓	• DEA	Not specify	
Süer and Bera (1998)			✓	• Hierarchical approach • MIP • IP	Jewelry industry	-

* TFT-LCD : Thin Film Transistor Liquid Crystal Display
* FST : Fuzzy Set Theory
* FAHP : Fuzzy Analytic Hierarchy Process
* AHP/ANP : Analytic Hierarchy/Network Process
* MILP : Mixed-Integer Linear Programming
* MIP : Mixed-Integer Programming
* IP : Integer Programming
* DEA : Data Envelopment Analysis
* PUDDE : Pareto Utility Discrete Differential Evolution
* DES : Discrete Event Simulation
* TOPSIS : Technique for Order of Preference by Similarity to Ideal Solution

* VIKOR : VlseKriterijumska Optimizacija I Kompromisno Resenje
* SAW : Simple Additive Weighting
* ICA : Imperialist Competitive Algorithm

2.6 Research Tools

According to the existing literature and studies, there are many different decision making approaches presented with various contexts of research problems. Since semi-skilled worker selection and grouping in labor-intensive industry drawn from the real manufacturing enviroment is focused, the efficient research tools which are suitable with the research problems and work well in investigations of industry experts are required. In order to reflect the realistic problem, academical theories only are insufficient. Hence, exploring the facts from manufacturing experts in human resource management process of an organization are the significant data for this study. Two primary research tools are used, (1) Analytic hierarchy process (AHP) and (2) In-depth Interview. For the in-depth interview, the percieved data would be used to analyze semi-skilled worker selection and grouping practice in labor-intensive industry with different points of view in four specific industy types, and also hardly support AHP weighting process of all selection criteria for prioritization. Labor-intensive manufacturing experts are selected to investigate selection criteria, selection or evaluation practice and grouping practice from the real environment. The selected experts are people who work closely in the related field of human resource management or production line, since the familiarities with production workers are important to reveal the important qualifications required by the production system and the effects of worker criteria is also important. It is evident that these data plays an important role in this study to reflect the realistic industrial problem as aforementioned.

2.6.1 Analytic hierarchy process (AHP)

AHP is a multi-criteira decision-making method (MCDM) developed by Thomas L. Saaty, it is found wide range of applications in today’s studies and industry area. AHP is a simple tool to deal with complex, unstructured and multi-attributed problems using a hierarchical structure and utilizes pairwise comparisons. A core issue to influence the final decision choice in AHP is prioritization of the reciprocal matrix (Yuen, 2010). Furthermore, modeling the problem and identifying the decision hierarchy is the key factor in using AHP. In multi-criteria analysis, AHP is suggested as a tool for implementing a multiple criteria performance scheme (Güngör *et al.*, 2009). In AHP, verbal judgments are provided by decision makers, to be used in pairwise comparison, the reciprocal matrices are transformed from linguistic labels to numerical values (Yuen, 2010). The strength of AHP method is that it reduces the number of decision variables that must be considered simultaneously from many to two (Frank *et al.*, 1998).

Much of the existing literature used AHP as the multi-criteria decision-making approach, Albayrak and Erensal (2004) used AHP to determine the global priority weights for different management alternatives, to improve human performance. Similarly, Yuen (2010) proposed a prioritization worker selection approach by using an application of AHP domain, to select the most appropriate workers based on the significant measurement criteria. In other words, the prioritization of worker represents worker ranking method which refers to the algorithms of deriving a ranking vector from the reciprocal matrix. An analytic hierarchy prioritization process in the AHP application was developed as AHPP. The study explained that the best prioritization worker highly relies on the content of a pairwise matrix, and none of prioritization methods performs better than others in every inconsistent case. However, this paper presented the AHPP for evaluating the worker ranking methods to enable decision makers to make the correct choice. The structure of AHPP is hereby given (Figure 2.7).

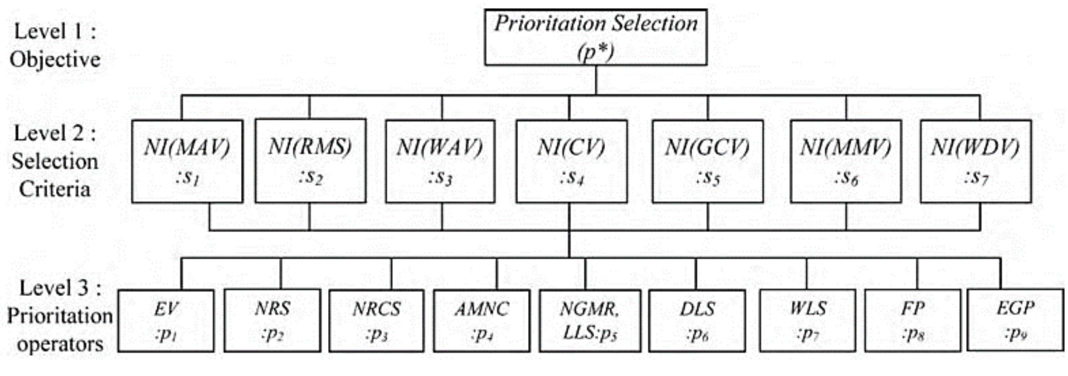


Figure 2.7 The structure of AHPP (Yuen, 2010)

In Figure 2.7, the structure of AHPP (Yuen, 2010) is constructed into hierarchy with three levels include objective as level one, selection criteria as level two, and prioritation operators as level three. The results reveal that the most appropriate prioritization operator is dependent of the content of the reciprocal matrix and AHPP is an appropriate method to address the prioritization problem to make better decisions.

AHP was also used to determine the importance weights of attributes in evaluating rope shovel operators in surface coal mining, the study was investigated by Kecojevic and Vukotic (2014). Multi-objective optimization was conducted to minimize energy consumption and maximiz production rate. Similarly, Rani *et al*. (2014) proposed operator performance evaluation using multi-criteria decision-making methods include AHP, FAHP, ELECTRE, PROMETHEE II, TOPSIS, and VIKOR. Based on these six methods used in their study, AHP is identified as the suitable method in operator performance evaluation for food manufacturing company.

Frank *et al*. (1998) proposed AHP approch for the personnel evaluation problems. The study is introduced with the question of how to carry out the "comparison of candidates with job requirements". Regards to the problem that is basically a problem of identification, weighting and evaluation, AHP is the most effective tool which benefits in comparing a pool of candidates. An example of school ratings is presented with respect to all six characteristics, namely learning, friends, school life, vocational training, college prep and music. The preference rating with scale from 1 to 9 based on Thomas L. Saaty, is used to rate each criteria of three schools. On the other hand, different scenario was investigated by Korpela *et al*. (2007) where AHP is applied in warehouse operator selection. In the study, AHP is combined with data envelopment analysis (DEA methodologies). The alternative warehouse operators were evaluated by AHP approach using multiple, both qualitative and quantitative criteria. The result of the AHP analysis is a preference priority for each alternative operator describing the expected performance level. The DEA method was then used to solve the multi-criterion problem by developing a DEA model for measuring efficiency of warehouse operators' using the information obtained from AHP analysis.

It is evident that AHP has been used a wide range of application. Most of the existing literatures used AHP in worker selection problem, to determined the weights of importance and prioritize criteria and alternatives. The results obtained from AHP highly support the decision-making in workforce management practice, especially in labor-intensive industry which workers are the major resource. In this research, AHP is used to weight and prioritize each selection criteria in worker selection phase. The computational results obtained from AHP model is subsequently used to measure the individual worker performance in the context of labor-intensive industry.

2.6.2 In-depth interview

In-depth interview is a qualitative research technique that has been used to conduct intensive individual interviews with a small number of respondents. In order to investigate their perspectives on a particular idea, program, or situation (Boyce and Neale, 2006). Generally, in-depth interview involves not only questionings, but also the systematic recording and documenting of responses. This research uses an in-depth interview to study the workforce management from manufacturing experts in labor-intensive industry. In worker selection phase, an in-depth interview is used to weight and prioritise worker selection criteria which are the important input data in the AHP model.

CHAPTER III
RESEARCH METHODOLOGY

This chapter presents the research framework and methodology which is used to study semi-skilled worker selection and grouping in labor-intensive manufacturing. It also describes the procedures that were built up in sequence to accomplish the useful data and information in different perspectives drawn from previous literature, manufacturing practice, and case studies of labor-intensive industry in Thailand.

In this research, the overall research methodology consists of the following parts, (1) Inputs, (2) Methodology/Tools, and (3) Outputs, as illustrated in Figure 3.1. The figure presents steps of the study by introducing inputs as the primary data that is used to support methodology. The methodology is described what the research aims to study using the selected research tools. Finally, the outputs are identified as the results derived in each step. The rest of the chapter is organized as follows:

3.1 Observation and literature review

3.2 Preliminary study

3.3 Data Collection

- 3.3.1 Sources of data
- 3.3.2 AHP questionnaire construction
- 3.3.3 Samples selection

3.4 Semi-skilled worker selection using AHP approach

- 3.4.1 Worker selection criteria
- 3.4.2 Importance weights of worker selection criteria
- 3.4.3 Worker performance measurement

3.5 Preliminary approach of semi-skilled worker grouping

3.6 Methodology discussion

The research framework and methodology of this research are presented in Figure 3.1.

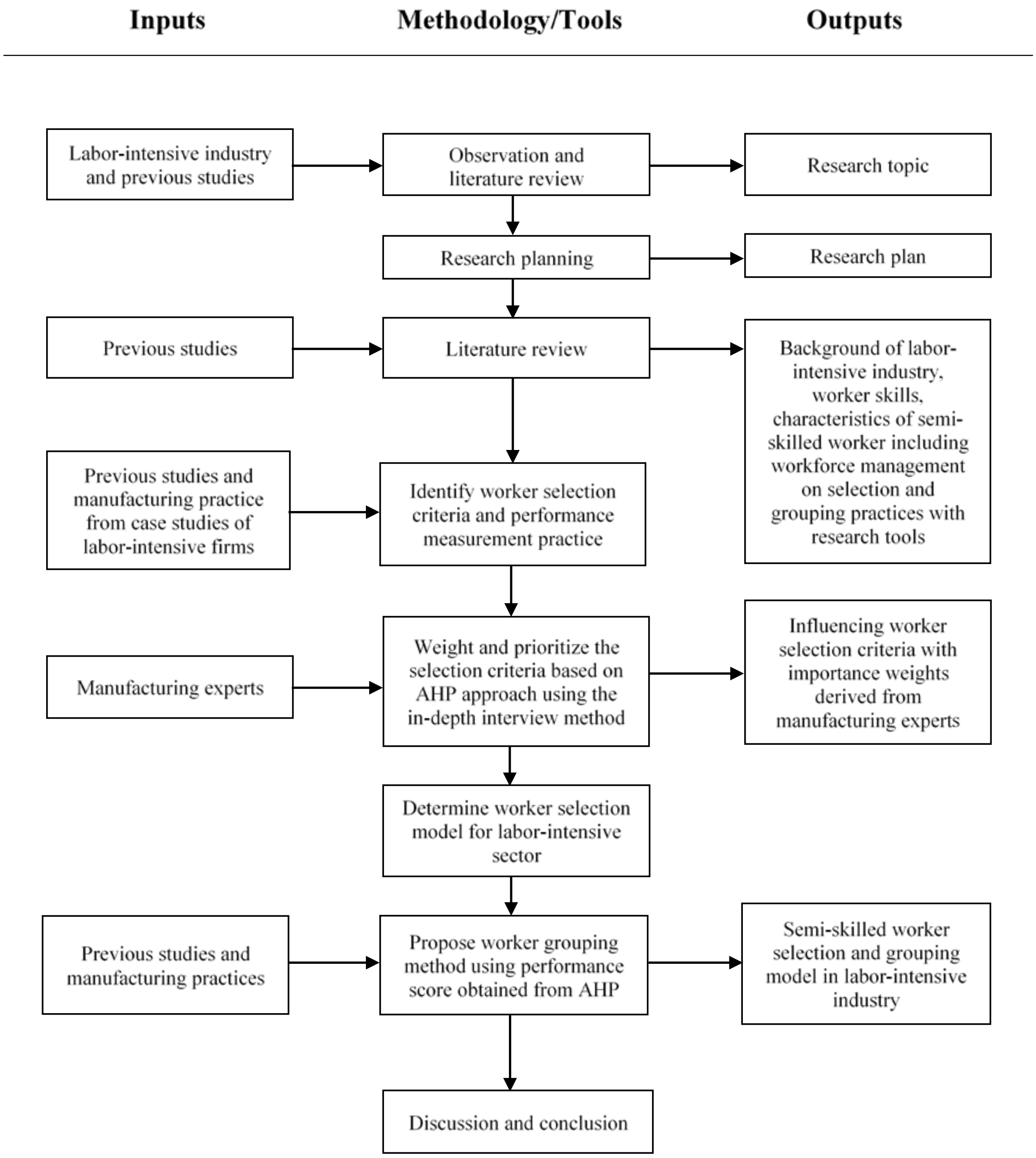


Figure 3.1 Research framework and methodology

3.1 Observation and literature review

Observation and literature review on labor-intensive manufacturing from previous studies and industry sector, are investigated to find the research gaps and to propose the research topic.

In labor-intensive manufacturing, it is evident that worker selection and grouping are the critical decisions that greatly impact to the overall production performance since the major resource is labor. This workforce management hence becomes a key point to achieve higher performance in terms of cost, productivity gain, and resource utilization.

However, from the literature review in Chapter II, much of the existing literature solves the final worker allocation decisions in assigning worker to task problem while worker selection and grouping phases have been slightly focused as the study area. Moreover, the differences among worker resource (i.e. skill levels, capabilities, performances) were also assumed to be equal which does not comply with the real world practice. Accordingly, this research aims to fill the gaps by covering the various perspectives on the selection and grouping of worker with semi-skill characteristic drawn from the academic area to the real manufacturing setting.

3.2 Preliminary study

After the research topic is pinned, the research plan is then followed. The relevant literature from previous studies has been deeply reviewed, in order to study the characteristics and background of labor-intensive industry which is the focused area in this research, i.e. worker skill gaps, nature of semi-skilled worker including workforce management on selection and grouping practices with research tools used.

Furthermore, the worker selection and grouping of semi-skilled worker are intensely investigated from both previous literature and the real labor-intensive manufacturing firms. The collected data consist of the relevant criteria, methods and tools used in semi-skilled worker selection and grouping.

A number of the existing literature revealed the unique characteristics of labor-intensive manufacturing. In today’s industry, most of manufacturing employs labor as the major resource which plays an important role in achieving the business goal.

The industry with this manufacturing nature is considered as labor-intensive industry, some examples are hereby given; namely apparel and garment, construction, mining, agriculture, furniture, and food processing. However, other industries can also be considered as labor-intensive regarding to production natures aforementioned.

In labor-intensive environment, an inappropriate perform of workforce management in selection and grouping tends to affect the entire manufacturing performance. The semi-skilled worker selection and grouping of this research, are investigated through *previous studies* and *manufacturing practice from the real case studies of labor-intensive firms* with different manufacturing environments.

Since the input data and tools used in each phase are different, the methodology is explained separately in how to achieve the support data and launch with various research tools. However, the relationship of each phase is also illustrated in Figure 3.1.

3.3 Data collection

3.3.1 Sources of data

In order to propose the semi-skilled worker selection and grouping models from both academic and manufacturing perspectives, the relevant data are collected based on two sources;

(1) *Primary data* which refers to the data that highly relies on the real manufacturing practice. The data is primarily derived through the case study firms from labor-intensive industry with the selected experts as the decision makers (DMs) that frequently involved in worker-related activities in the manufacturing of labor-intensive industry. In this study, the number of DMs is defined as ten based on previous literature (see Section 3.3.3). According to a wide range of labor-intensive industry that may create difference in manufacturing perspectives, this research aims to present the semi-skilled worker selection and grouping which covers four major industries which are (1) food products (Rani *et al*., 2014; Rani and Ismail, 2014; Süer *et al*., 2009) , (2) textiles/wearing apparel products (Egilmez *et al*., 2014; Fligenspan *et al*., 2015; Jakhar and Kumar, 2015; Lee *et al*., 2013; Scott, 2006; Song *et al*., 2006), (3) plastic products

(Schönberger and Hoffstetter, 2016; Egilmez *et al*., 2014; Runckel *et al*., 2006), and (4) steel products (Unni, 2012) including experts from recruitment outsourcing sector which are selected from the Department of Employment in Bangkok area, who are familiar with human resource selecting process to recruit the right people for the right firms, are selected and investigated using the in-depth interview as a research tool. Two manufacturing experts are selected from each case study as shown in Figure 3.2.

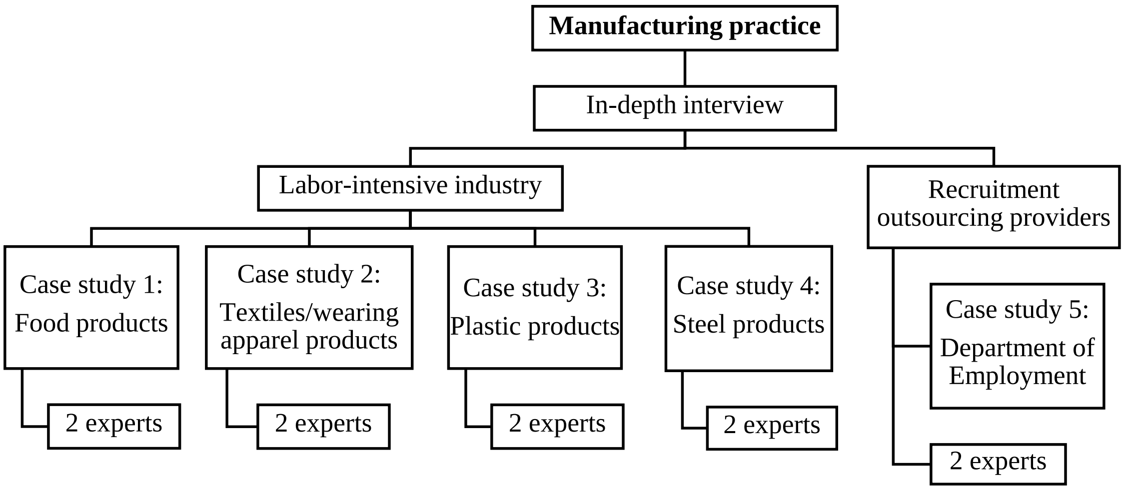


Figure 3.2 Primary data of semi-skilled worker selection and grouping

(2) *Secondary data* which refer to the data from previous studies on worker selection and grouping phases in labor-intensive industry including the methods and tools used.

Following to the main context of this research in labor resource selection and grouping, the number of existing literature has proposed various approaches to investigate and find solutions for the multi-criteria decision-making problems. Rani *et al*. (2014) examined a comparisons of the different multi-criteria decision making methods (MCDM); AHP, FAHP, ELECTRE, PROMETHEE II, TOPSIS, and VIKOR, used to measure the workers' performance and to rank the workers. Based on these six methods, it is evident that AHP is identified as the suitable method in operator performance evaluation for a case study of labor-intensive manufacturing. Moreover, AHP is one of the multi-criteria decision making tool widely used and suggested as a tool for implementing a multiple criteria performance scheme (Güngör *et al*., 2009). The approach helps the decision maker facing a complex problem with multiple conflicting and subjective criteria (Ishisaka, 2009). As aforementioned that the primary data in this study are mainly derived through the real case study firms from labor-intensive manufacturing, the selected experts are investigated and their results interpret more in verbal judgement which AHP is an effective method to create the hierarchical modelling of the problem and transform linguistic judgement into numerical values. Accordingly, AHP is determined as a primary tool to deal with the semi-skilled worker selection problem in this research.

3.3.2 AHP questionnaire construction

Since questionnaire is the main research tool in this study, to qualitatively investigate semi-skilled worker selection and grouping in labor-intensive industry from ten selected experts. Steps of constructing the effective questionnaire have become an important factor that strongly impacts data accuracy. The AHP questionnaire is thus carefully constructed following sections and steps described below;

The questionnaire consists of three main sections, firstly the introduction page for explaining the brief and general information about the reseach including the main context of questioning. Secondly, questioning on personal/organization information of the experts such as job position and type of organization. Thirdly, the main context to reponse research objectives is constructed to collect all relevant data by allowing the experts to express their opinions in various openned questions experienced from industry perspectives.

Procedures of constructing the AHP questionnaire in this study are carried out into seven steps as written below;

Step 1 Clarify what to measure

The main context of questionning is constructed based on research questions and framework. Theoretical and practical semi-skilled worker selection and grouping in labor-intensive industry are investigated from the relevant literatures.

Step 2 Identify types of question

Generally, types of question are carried out into two elements respectively, (1) Open Ended Question and (2) Close Ended Question. In this study, both types of questions are included in the research questionnaire. For the Open Ended Question, it is constructed to allow experts with free answering, in order to investigate opinions from their real practices, whereas the Close Ended Question is constructed by guiding experts to select any specific area of answers.

Step 3 Draft reseach questionnaire

After the scope and question types are identified, the research questionnaire is briefly drafted according to the following details.

1) Research questions are responsed to the research objectives.

2) The questions are clear and effective in the area of study.

3) A number of items in questionning cover the research context.

4) The questions are in well-ordering, following to the worker selection and grouping procedures.

5) The questions are maintained with easy understanding texts, related to the research objectives. Any confidential context is not investigated to avoid biased data from experts.

In AHP questionnaire, it is primarily consisted of providing an importance weight for each single criterion. Following to the research context of semi-skilled worker selection and grouping in labor-intensive study, the multiple criteria could be constructed into two different layouts for AHP pairwise comparison/importance weighting, as given below;

1) Matrix Layout

From Figure 3.3, three criteria including criterion A, criterion B, and criterion C are investigated. The selected experts or metioned as “decision maker (DMs)” has to weight each pair of criteria (pairwise comparison), criteria A and B, criteria A and C, and criteria B and C in the white cells. Accordingly, numbers in the grey cells are reversely-generated. To provide the importance weight, the intensity of importance developed by Thomas L.Saaty is used with numbers of 1 to 9 explained in Table 3.1.

Table 3.1 Intensity of Importance (Saaty, 2008)

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two criteria contribute equally to the objective
2	Weak or slight	-
3	Moderate importance	Experience and judgement slightly favor one criterion over another
4	Moderate plus	-
5	Strong importance	Experience and judgement strongly favor one criterion over another
6	Strong plus	-
7	Very strong or demonstrated importance	A criterion is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	-
9	Extreme importance	The evidence favoring one criteria over another is of the highest possible order of affirmation
Reciprocals of above	If criterion i has one of the above non-zero numbers assigned to it when compared with criterion j, then j has the reciprocal value when compared with i	A reasonable assumption

In term of “reciprocals”, the importance weight of 8 is given for criteria A and B which means criterion A has a very strong importance compared to criterion B. Correspondingly, it also means that criterion B is less important than criterion A with 1/8 weight in the grey cells. Similarly for criteria A and C which 1/3 is given in the white cell, means criterion A is less important than criterion C or criterion C has a moderate importance compared to criterion A with 3 in the grey cell, as shown in Figure 3.3.

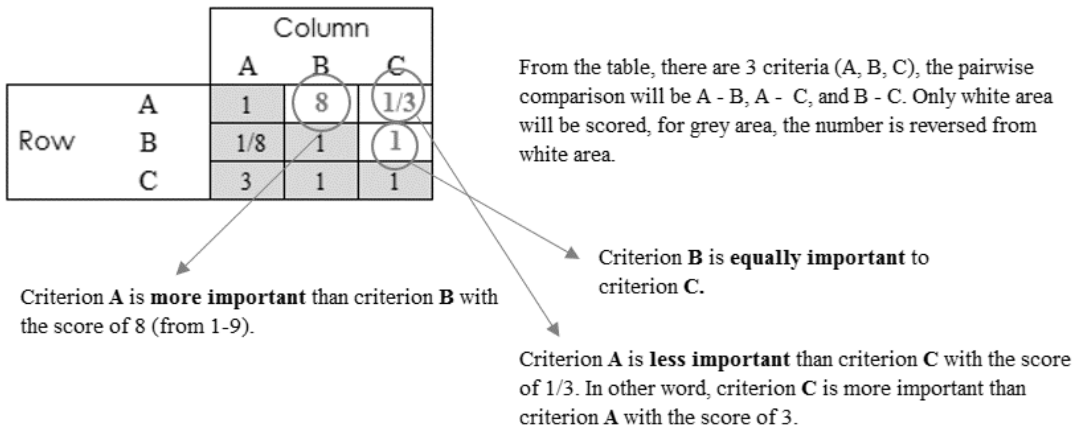


Figure 3.3 Matrix layout with sample weights

2) Scale Layout

In the scale layout, Decision Makers (DMs) have to weight a pair by pair of criteria. One scale represents a pair of criteria as shown in Figure 3.4. Three criteria of A, B, and C are investigated. To launch the pairwise comparison, three pairs of criteria are presented, i.e. the first pair of criteria A and B, the second pair of criteria A and C, and the last pair of criteria B and C. Each scale of comparison consists of numbers, 9 to 1 for the left hand side and 1 to 9 for the right hand side. These numbers represent the weights that DMs have to provide according to the importance of any criteria. Weighting numbers in the left hand side means that criteria in the left are more important than criteria on the right. Similarly, weighting numbers in the right hand side means that criteria in the right are more important than criteria on the left.

The sample weights represent exactly the same weighting with the matrix layout afore-mentioned. The first row of criteria A and B, criterion A is strongly more important than B with the score of 8. By the second row of criteria A and C, criterion C is more important than A with the score of 3. Correspondingly, the last row presents criteria B and C pairwise comparison with the score of 1 which means they are equal.

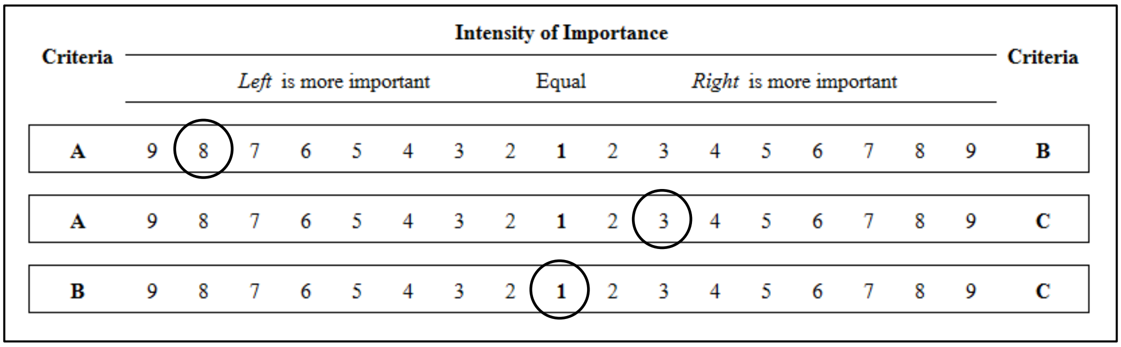


Figure 3.4 Scale layout with sample weights

However, AHP importance weighting is quite complicated for any general questionnaire respondent who is not familiar with the academic perspective. Hence, the scale layout is primarily used to construct the questionnaire in this study. Since the scale layout is simple and understandable, the DMs have to only provide the weight by marking circles on numbers for each pairwise comparison.

Step 4 Improve research questionnaire

The constructed questionnaire is reviewed to find gaps. In this study, the research questionnaire is firstly reviewed and revised by the researcher, and then it is secondly validated by an expert from labor-intensive industry who has both academic and practical perspectives in worker selection and grouping context.

Step 5 Finalize research questionnaire

All gaps are fixed and improved, including texts and sentences used for questionning in order to providing the effective research questionnaire to experts which generate a great value for the study.

Step 6 Implement research questionnaire

The completed research questionnaire is distributed to ten selected experts from labor-intensive industry, to support the indepth-interview process in data collection section.

3.3.3 Samples selection

- Manufacturing firms

As afore-mentioned in Section 3.3.1 Sources of data, five groups of samples are investigated in this study. It consists of (1) manufacturer of food products, (2) manufacturer of textiles/wearing apparel products, (3) manufacturer of plastic products, (4) manufacturer of steel products, and (5) recruitment outsourcing sector, respectively. To select the sample firms as case study, selection criteria and conditions are proposed. Since this research mainly focuses on labor-intensive industry, the characteristics and production environment are investigated in the literature review chapter to conduct the selection criteria.

Figure 3.5 represents the selection process of manufacturing firms as case studies in this research. The figure includes pool of production factories located in the industrial estates of Bangkok areas in Thailand. Five main selection criteria are conducted from labor-intensive industry characteristics and natures, listed as follow.

- *Industry type* is categorized by its finished products or materials mainly used in the production. Industry type is an important criterion which represents overview of the manufacturing firms especially the production natures. Hence, four industry types are selected as labor-intensive manufacturing firms, (1) manufacturer of food products, (2) manufacturer of textiles/wearing apparel products, (3) manufacturer of plastic products, and (4) manufacturer of steel products.

- *Nature of a production line* is related to the industry type, since the industry type significantly reflects the nature of production line. Most of the operations in production line of any selected manufacturing firms have to be manual, or at least the manual processes existed.

- *Size of a firm* is generally carried out into three groups, small, medium, and large. To consider size of firm, number of the employed workers in operational level is focused. According to the overview of labor-intensive industry, they are mostly lack of the proper worker selection and grouping processes.

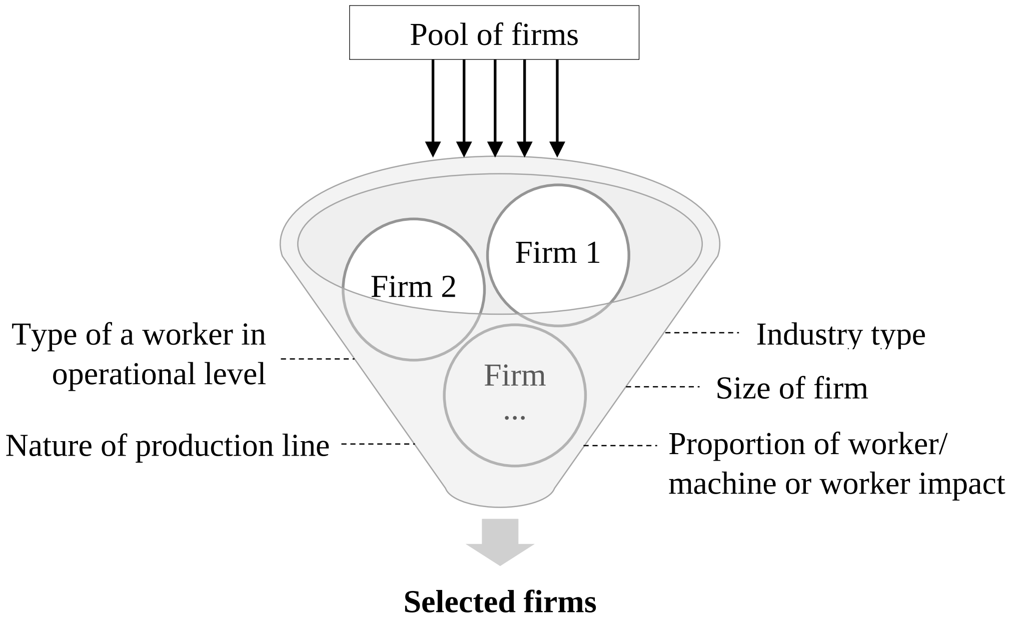


Figure 3.5 Selection process of manufacturing firms

- *Proportion of a worker/machine* or *worker impact* plays an important role in considering if a firm is labor-intensive industry or not. The selected manufacturing firms employ a large number of workers compared to a number of machines that operate in its production line or in this case, workers have a great impact to the production system.

- *Type of a worker in operational level* is classified using “skill” criteria. Three types of worker in production line are presented in a number of literatures including skilled worker, semi-skilled worker, and unskilled worker. However, the manufacturing firms with semi-skilled worker are only selected.

- Recruitment sub-contractor company

In order to investigate more in worker selection and grouping procedures, the third party of semi-skilled worker recruitment section is additionally investigated. Since the recruitment companies primarily work on labor recruitment process as outsourcing company for manufacturing firms, hence these outsourcing companies also play an important role in selecting workers with required qualifications to operate in the manufacturing firms. According to the general practice in recruiting operational workers, most of the small and medium manufacturing firms select workers from the Department of Employment provided by governement, to avoid handling the excessive cost. In this research, two labor specialists are selected from the Department of Employment (Ministry of Labour Thailand) since they are directly concerned with worker selecting/grouping process for manufacturing industries.

- Decision Maker (DMs)

Regarding to the approach of Anatical Hierachy Process (AHP), Decision Makers (DMs) are assigned as primary element of the entire AHP to judge the pairwise comparison of multiple criteria. A number of existing literatures investigated DMs with various numbers from one judgement metric (individual model) to a group of judgement metrices (consensus model). Moreover, it is also found that the group decision making using AHP could be categorized into small group, and large group or population (Basak and Saaty, 1993). Unfortunately, any specific number of judgment metrices or decision makers is not addressed. Afshari et al. (2010) considered a real application of personnel selection approach using the qualitative judgement from one expert with seven criteria in telecommunication company while Şen and Çınar (2010) used consensus by investigating three decision makers (DM_1, DM_2, DM_3) with five main criteria and 18 sub-criteria for evaluation and pre-allocation problems.

Accordingly, the number of DMs used to provide AHP qualitative judgement for five main criteria and 36 sub-criteria of this study should be ≥ 6. Since five different case studies are investigated by choosing two experts from each sector, hence the appropriate number of DMs in this study is defined as ten (see Figure 3.2). It is obviously seen that making decision in AHP approach has a large impact on the final result, thus the DMs must be selected carefully following to the selecting criteria conducted from literature review and manufacturing practice. The selected DMs are required to comply all the criteria including experience and job function, working related to workers in operational level, or understanding of production process/operations. The DMs selection process is shown in Figure 3.6.

The selection criteria of DMs shown in Figure 3.6 consist of four main factors, in order to select the eligible DMs who experience the semi-skilled worker selection and grouping in labor-intensive industry.

- *Year of experience* of the selected DMs is required to be 3 to 5 years or more than, working in the related field includes human resource management and production line.

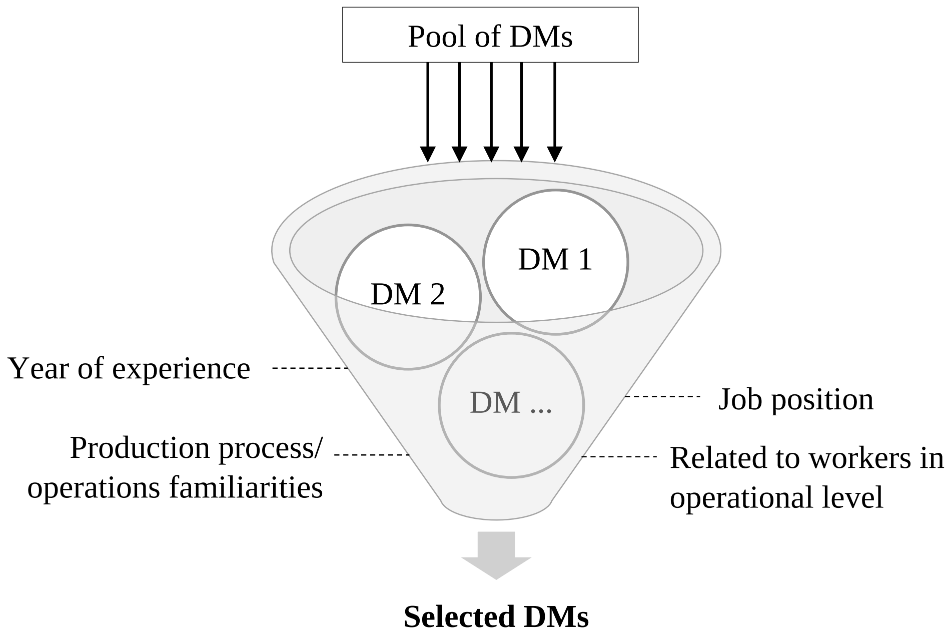


Figure 3.6 Selection process of DMs

- *Job position* or *job function* is related to worker selection and grouping procedures. The DMs selected in this study are production manager/supervisor and human resource manager who work directly in labor recruiting process including familiarities in production lines.

- *Related to workers in operational level* and *Production process/operations familiarities* primarily refer to any experienced person in the manufacturing firms who work closely to the operational workers and also familiar with operations in production system. These selected DMs know what kind of worker needed for a single job in operations including worker skills or general qualifications required by the production process.

Table 3.2 Summary of selected Decision Makers (DMs) from five sectors

Selection criteria	Food		Textile/ apparel		Plastic		Steel		Recruitment outsourcing	
	DM_1	DM_2	DM_3	DM_4	DM_5	DM_6	DM_7	DM_8	DM_9	DM_{10}
	F1	F2	T1	T2	P1	P2	S1	S2	R1	R2
Manufacturing firms										
• Industry type Related to labor-intensive	✓	✓	✓	✓	✓	✓	✓	✓	-	-
• Size of firm -Small (S) -Medium (M) -Large (L)	S	M	L	L	M	L	M	S	-	-
• Proportion of worker/machine - Worker impact	✓	✓	✓	✓	✓	✓	✓	✓	-	-
• Type of worker in operational level -Semi-skilled worker	✓	✓	✓	✓	✓	✓	✓	✓	-	-
• Nature of production line Manual line exists -Automatic (A) -Manual (M) -Semi-automatic (A/M)	A/M	M	M	M	M	A/ M	A/ M	A/ M	-	-
Experts (DMs)										
• Year of experience -3 to 5 years at least	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
• Job position/ function	General Manager	Marketing Asst. Mgr.	Chief Information Officer (CIO)	IE Officer	Vice President	President	Production Mgr./HR	General Manager	Labor Specialist	Labor Specialist

Table 3.2 Summary of selected Decision Makers (DMs) from five sectors (continued)

Selection criteria	Food		Textile/ apparel		Plastic		Steel		Recruitment outsourcing	
	DM_1	DM_2	DM_3	DM_4	DM_5	DM_6	DM_7	DM_8	DM_9	DM_{10}
	F1	F2	T1	T2	P1	P2	S1	S2	R1	R2
• Related to workers in operational level	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
• Production process/operations familiarities	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

In Section 3.4 and 3.5, the research methodology of semi-skilled worker selection and grouping in labor-intensive industry are presented. Figure 3.7 briefly examines the relationship diagram of phase one (selection) and phase two (grouping) including the input data, output data, connected data, and research tool.

3.4 Semi-skilled worker selection using AHP approach

3.4.1 Worker selection criteria

To achieve the effective worker selection, the relevant data are collected from both previous studies and manufacturing practice as described in Section 3.3. In this phase, worker selection criteria are the powerful factor which directly effects to the final decision-making of workforce management. From the literature review, there is only a few papers dealt with worker selection phase. Nevertheless, the evaluation of worker performance and selection criteria were investigated in a number of studies to identify all influencing criteria with respect to labor-intensive manufacturing.

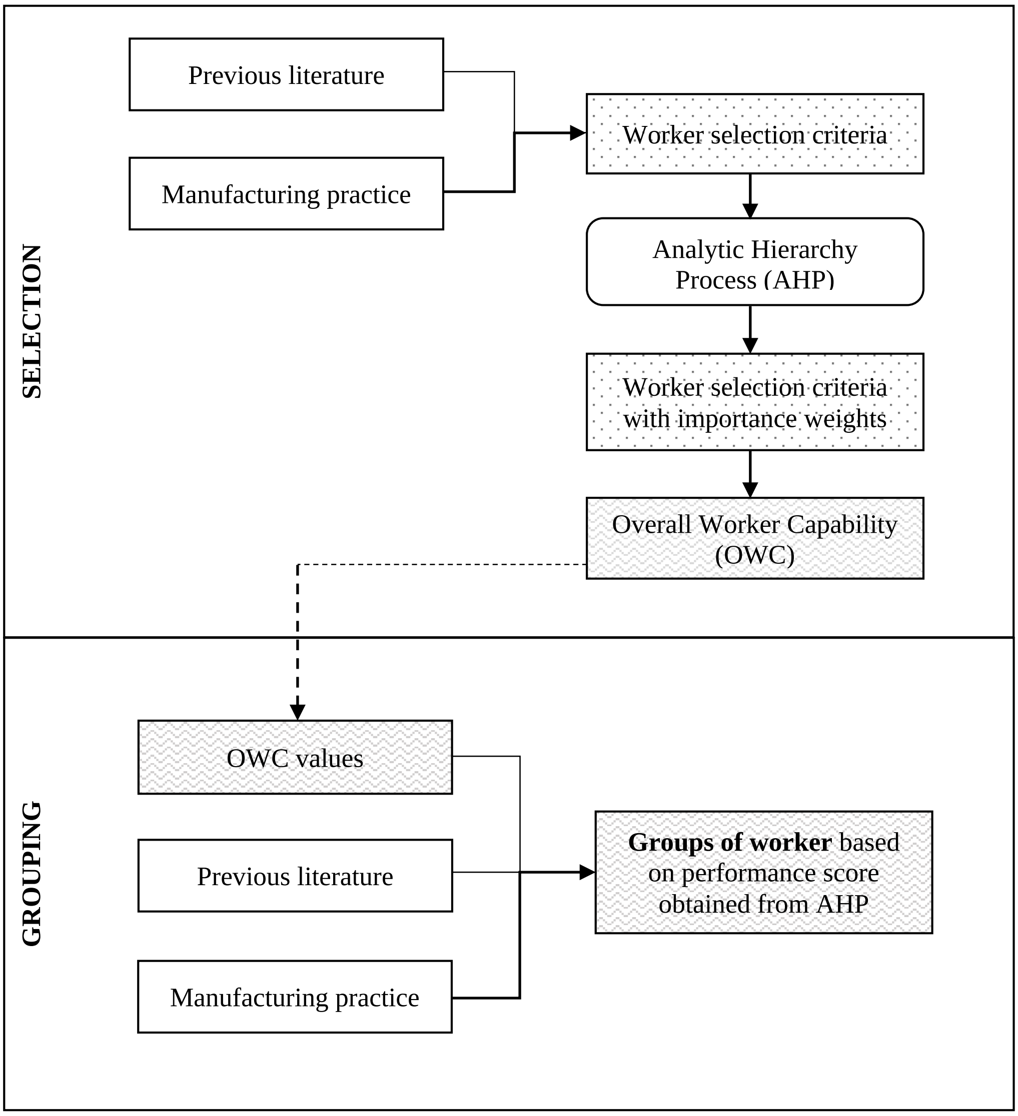


Figure 3.7 Semi-skilled worker selection and grouping relationship diagram

Worker selection criteria in this research is derived from two primary data, previous studies and ten selected case studies of labor-intensive firms with different manufacturing environments. First all relevant selection criteria from previous literature are studied. Then, the selection criteria are identified by the selected manufacturing experts from each case study of labor-intensive industry. The summary of worker selection criteria derived from previous studies is presented in Table 3.1, the criteria is divided into two types, one is main criteria while another is subordinate criteria which is branched from the main criteria.

Table 3.3 Summary of worker selection criteria in labor-intensive manufacturing based on previous studies and manufacturing practice

Main Criteria	Sub-Criteria	Majozi and Zhu (2005)	Das et al. (2006)	Şen and Çınar (2010)	Güngör et al. (2009)	Rani et al. (2014)	Nembhard and Bentefouet (2014)	Consoli and Rentocchini (2015)	Nembhard and Bentefouet (2015)	Manufacturing practice
C1: Competency	• Educational background	●		●	●	●				●
	• Qualification or job title									●
	• Training level	●				●				●
	• Working licenses									●
C2: Experience	• Year of experience		●	●	●	●				●
	• Operations familiarity		●							●
	• Working knowledge		●	●						●
C3: Personal Characteristics	• Age/Seniority	●			●					●
	• Appearance									●
	• Culture									●
	• Determination of goal									●
	• Health	●								●
	• Royalty and honesty					●				●
	• Time punctuality					●		●		●
	• Willingness				●					●
	• Adaptation of change			●		●				●
	• Social perceptiveness							●		●
	• Leadership									●
	• Attendance			●		●				●
	• Negotiation/persuasion							●		●
	• Service orientation							●		●

Table 3.3 Summary of worker selection criteria in labor-intensive manufacturing based on previous studies and manufacturing practice (cont.).

Main Criteria	Sub-Criteria	Majozi and Zhu (2005)	Das et al. (2006)	Şen and Çınar (2010)	Güngör et al. (2009)	Rani et al. (2014)	Nembhard and Bentefouet (2014)	Consoli and Rentocchini (2015)	Nembhard and Bentefouet (2015)	Manufacturing practice
C4: Skill	*General Skill*	•				•				•
	• Active learning				•		•	•	•	•
	• Decision-making/ trouble shooting				•			•		•
	• Analytical Thinking				•					•
	• Situation awareness									•
	• Communication			•	•	•		•		•
	• Basic computer software				•					•
	• Working in teams/ cooperation				•	•		•		•
	Technical Skill									•
	• Task preparation and prioritization									•
	• Equipment selection							•		•
	• Equipment installation							•		•
	• Production/Processing			•				•		•
	• Operation monitoring							•		•
	• Maintaining standards/ following protocol									•
C5: Operational Output	• Quality of part produced					•				•
	• Production rate					•			•	•

From Table 3.3, the influencing worker selection criteria and sub-criteria are conducted by reviewing from previous literature and manufacturing practices with respect to the unique characteristics of labor-intensive perspective. The selection criteria are organized into five main criteria, namely competency, experience, personal characteristics, skill, and operational output.

Subsequently, the semi-skilled worker selection criteria are individually investigated through the selected manufacturing experts from each industry type.

- C1: Competency

The competency criteria here pertain to work mainly on the basis of educational background, qualification or job title, previous job training achievements, and working licenses.

- C2: Experience

In labor-intensive manufacturing, worker experience is the most powerful factor which indicates the related working experience of workers in the operational term. With the level of experience, the working performance can be predicted. As it is the working basis, the operational performance of workers with high experience level can be quickly enhanced compared to the workers with lower experience level.

- C3: Personal characteristics

Personal characteristics primarily introduce the individual qualifications in attitude, personal goal setting, nature, and seniority.

- C4: Skill

The criteria on working skill directly create the enhancement on operational performance. In this study, the skill is categorized into two groups which are (1) general skill and (2) technical skill. The general skill is concerned with all basic skill required while the technical skill here refers to the worker with specific skills required to perform tasks in terms of operations.

Worker skill criteria are categorized into two different groups, namely general skill, and technical skill. In general skill, it directly refers to all basic requirements on worker's capabilities which are applicable in wide range of functions in the various industries or sectors. The general skill in this study consists of five sub-criteria which are active learning, communication, situation awareness, troubleshooting, and teamwork. On the other hand, technical skill is also determined as the powerful skill which refers to the operation-related skill or specific skill used in various operations. A different technical skill is required following to the natures of each specific operations which vary from one industry to another industry. There are six related skills, namely equipment selection/installation, production/processing, operation monitoring, task preparation and prioritization, and maintaining standards/following protocol.

• C5: Operational output

Regarding to the natures of labor-intensive manufacturing, the operational output which transforms from raw material to final products is highly depended on workers which play an important role in the overall process. These criteria mainly introduce the worker performance in terms of production quantity and quality.

With respect to the five main criteria as described above, the *skill criteria are extended* in this research with regard to labor-intensive manufacturing environment. Sub-criteria in terms of worker skill are then investigated through the relevant theories, previous studies, and manufacturing practice.

According to the research methodology, after all worker selection criteria are derived from the related previous studies, the important criteria in the context of semi-skilled worker in labor-intensive industry are only selected and validated by 10 manufacturing experts from four major industry, (1) food products, (2) textiles/wearing apparel products, (3) plastic products, and (4) steel products including recruitment outsourcing sector. In order to validate the important worker selection criteria, the questionnaire is constructed.

3.4.2 Importance weights of worker selection criteria

All influencing criteria used in semi-skilled worker selection are determined. Each criterion in both main criteria and sub-criteria is weighted and prioritized using AHP as multi-criteria decision making (MCDM) tool. Ten decision makers (DMs) are selected from labor-intensive industry and the in-depth interview is used to collect data.

As aforementioned, a tool used to prioritize worker selection criteria is Analytical Hierarchy Process (AHP). AHP is developed by Thomas L. Saaty, which has found a wide range of applications in today’s studies and industry area. In AHP, verbal judgments are provided by decision makers, to be used in pairwise comparison, the reciprocal matrices are transformed from linguistic labels to numerical values (Yuen, 2010). Traditionally, there are many ways to process data, including by hand, spreadsheet program, or the specialized AHP software. Regarding to a semi-skilled worker selection problem from many criteria, this research uses the specialized AHP software called *Super Decisions* which is developed by Saaty as a decision making software based on AHP. However, in order to understand how the software works, the primary procedures of AHP are investigated, and given in the following steps.

Problem modelling

Step 1: All criteria are constructed as a hierarchy that the top level is the goal and the subsequent levels are main criteria and sub-criteria. The example of AHP hierarchy is shown in Figure 3.8.

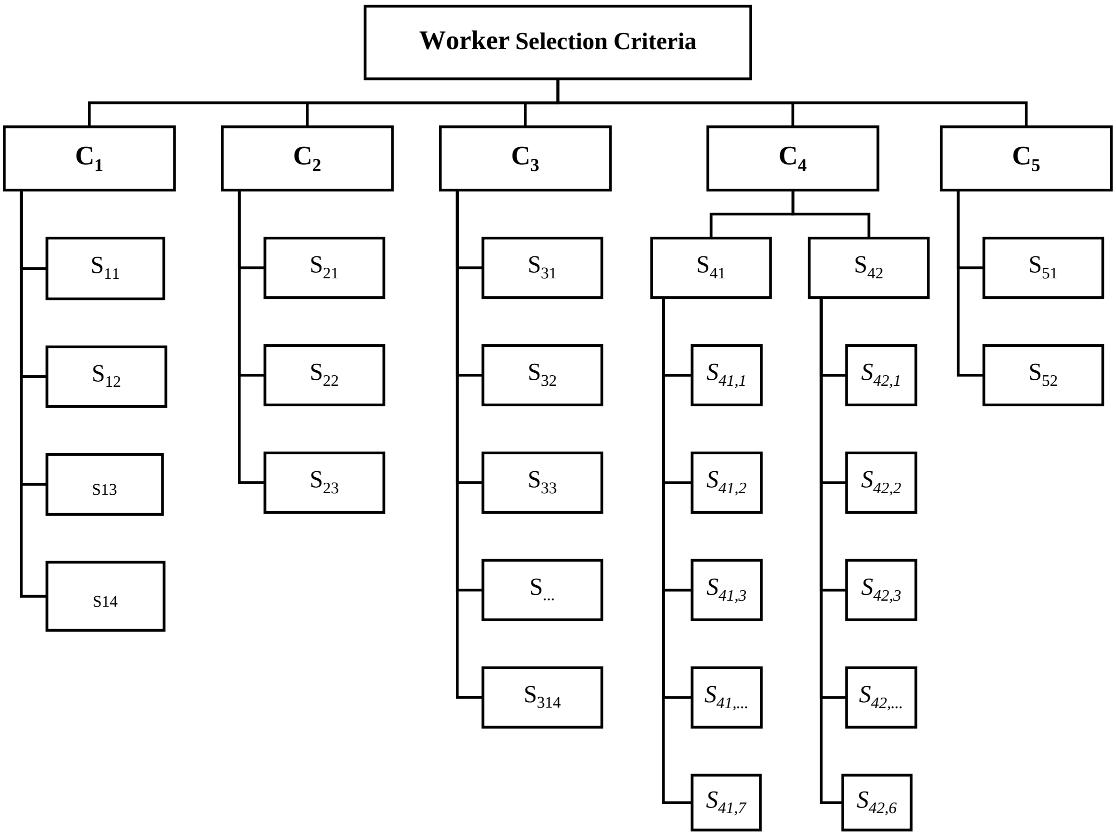


Figure 3.8 Hierarchical structure of worker selection criteria

From Figure 3.8, C_i is main criteria i (while $i = 1, 2,\ldots, 5$). S_{ij} is sub-criteria j of main criterion i (while $j = 1, 2,\ldots, n$) and $S_{ij,k}$ is 2nd level sub-criteria k of sub-criteria j under main criterion i (while $k = 1, 2,\ldots,m$).

Pairwise comparisons and judgement scales

Step 2: The pairwise comparison matrix is built up with respect to the intensity of importance (Saaty, 2008) shown in Table 3.1, to determine the priorities of different main criteria and sub-criteria respectively. In this step, the selected DMs from labor-intensive industry provide numbers from Table 3.1 to each pairwise criterion.

Priorities derivation

Step 3: The importance weights of each criterion are computed according to the steps given below.

First, the normalization is obtained by dividing each score with its total as illustrated and exemplified in Table 3.4 and 3.5.

Table 3.4 Example of AHP comparison matrix

Criteria	**A**	**B**	**C**
A	1	1/2	1/5
B	2	1	1/5
C	5	5	1
Total	*8*	*6.5*	*1.4*

The calculation of criterion A is computed as follows, 1 is divided by the total which is 8 and equals to 0.125. Then, the steps are repeated for each element. The total is normalized into 1 as shown in Table 3.5.

From Table 3.5, the total row is computed with grand total of 3. The importance weights of each criterion are finally calculated by dividing each row total with the grand total. For example, the importance weight of criterion A is 0.345 divided by 3 and equals to 0.115 or 11.5%.

Table 3.5 Calculation of the importance weights

Criteria	**A**	**B**	**C**	**Row Total**	***Importance weights***
A	0.125	0.077	0.143	*0.345*	*0.115*
B	0.250	0.154	0.143	*0.547*	*0.182*
C	0.625	0.769	0.714	*2.109*	*0.703*
Total	*1*	*1*	*1*	*3*	*1*

Consistency

Step 4: To validate the obtained scores and importance weights, the consistency ratio is used. First, the consistency index (CI) is calculated for each pairwise comparison matrix using the equation below:

$$CI = \frac{\lambda_{max} - N}{N - 1}$$

λ_{max} is the maximum eigenvalue (importance weight) while N is the number of criteria being compared. Then, the consistency ratio (CR) is calculated using the following equation:

$$CR = \frac{CI}{RI}$$

RI is Random Index shown in Table 3.6 (Saaty, 1980). The value of CR must be less than or equal to 0.10 to reach a consistent pairwise comparison matrix. If CR value is greater than 0.10, means the pairwise comparison matrix is inconsistent. Then the evaluation process should be repeated until the consistent numerical value is obtained.

Table 3.6 Random Index (RI)

N	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40	1.45	1.49

Aggregation

Step 5: The last step to figure the global priorities from the local priorities across all criteria with the normalization of the sum of the local priorities to unity as the equation below;

$$p_i = \sum_j w_j \cdot l_{ij}$$

where p_i : global priority of criteria i, l_{ij} : local priority w_j : weight of criteria *j*.

Finally, the importance weights of each single criterion are obtained using the steps above-mentioned. In *Super Decision*s, the primary input data used to process the software is the importance weight of a single pairwise comparison criteria judged by decision makers from each case study. Figure 3.9 presents the system of *Super Decisions* software.

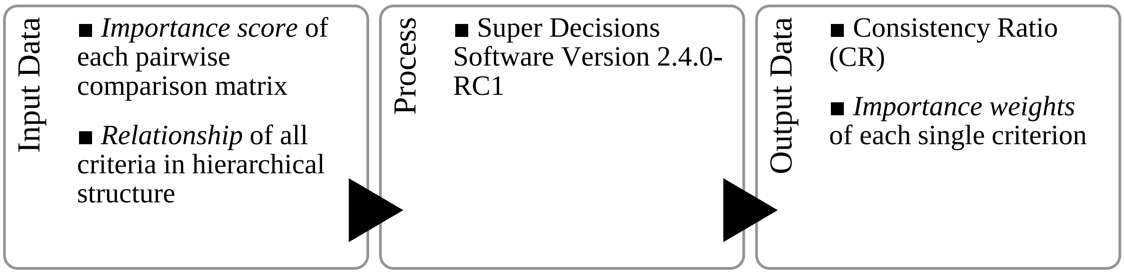


Figure 3.9 Super Decisions steps

As the output data which include importance score of pairwise comparison matrix and the relationship of all criteria constructed in hierarchical structure. To define the relationship, sub-criteria are set under main criteria, and main criteria are set under the goal whereas sub-criteria represents node and main criteria as cluster. Then, the software processes all input data and generate the output data. The derived output data consist of the final consistency ratio (CR) and the importance weight of each single criterion with priorities.

In this study, ten decision makers from five different labor-intensive manufacturing companies are selected (as discussed in Section 3.33 Samples selection). Various natures of operations result different worker selection criteria and policies implemented in the organizations including food products, textiles/wearing apparel products, plastic products, steel products, and recruitment outsourcing providers which play an important role in facilitating worker

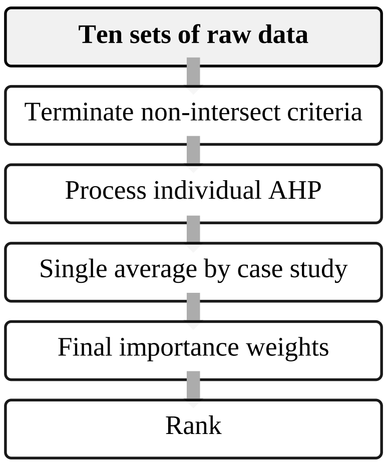


Figure 3.10 Raw data processing

selection for industries. Figure 3.10 given in the following presents flow and steps of AHP data processing derived from ten decision makers (5 case studies).

Ten selected decision makers (DMs) from five different case studies are investigated to obtain ten sets of raw data, which are weights of each pairwise comparison criteria. Regarding to the differences in production characteristics, the considered criteria in worker selection practice of each DM are significantly different. Hence, only the intersected criteria are discussed as AHP input data. Accordingly, ten sets of data are individually processed through AHP software to obtain the importance weights from each data set. Then, the derived importance weights of semi-skilled worker selection criteria are calculated to find averages by case studies. Finally, the final importance weights and ranks of selection criterion are achieved with respect to each five case studies.

Next step, the performance of workers will be individually evaluated with respect to the importance weights of each selection criteria derived from AHP.

3.4.3 Worker performance measurement

The performance of each worker is evaluated with respect to the importance weights of semi-skilled worker selection criteria obtained from AHP. A person who is in charged from a firm (i.e. a production manager) to assess workers performance in all dimensions using the determined selection criteria, provides scores to each worker individually.

For example, the *overall worker performance of a worker* equals to the equation given in the following;

$$Overall\ Worker\ Capability\ (OWC) = \sum_{i=1}^{5}\sum_{j=1}^{n}\sum_{k=0}^{m}\left(W_{ijk} \times R_{ijk}\right)$$

i is main criteria i ; $i = 1,\ldots,5$

j is sub-criteria j ; $j = 1,2,\ldots,n$

k is the second level sub-criteria k ; $k = 1,2,\ldots,m$

If $k = 0$ (one level sub-criteria) then, W_{ij} is the importance weight of sub-criteria j under main criterion i. Similarly, R_{ij} is raw score of sub-criteria j under main criterion i achieved by a worker.

If $k > 0$ (two levels sub-criteria) then, W_{ijk} is the importance weight of the second level sub-criteria k under sub-criteria j of main criterion i. Similarly, R_{ijk} is raw score of the second level sub-criteria k of sub-criteria j under main criterion i achieved by a worker.

Note: The overall worker performance as per equation above, is for the performance evaluation of an individual worker. Traditionally, raw score (R) on each criteria of a single worker is assessed by a production manager or any related sector who is in charge of an organization. However, the raw score of each worker is assumed in this study, to demonstrate the preliminary results of worker selection model with worker performance scores obtained from AHP. And the total number of workers are defined as 10 (ten workers).

3.5 Preliminary approach of semi-skilled worker grouping

In this phase, the proposed worker grouping method is derived from previous literatures and labor-intensive manufacturing practice. The selected workers are categorized into four different groups according to the performance obtained from AHP in worker selection phase.

- Worker group 1 – High performance
- Worker group 2 – Average performance
- Worker group 3 – Satisfied performance
- Worker group 4 – Poor performance

From this grouping method based on Performance Level (PL), worker group 1 refers to worker with high performance, while worker group 2 and 3 represents worker with average and satisfied performance respectively, and worker 4 refers to worker in the lowest ranking which is grouped as poor performance. In this research, the performance level of each group is defined using labor-intensive manufacturing practice. The final result is carried out into two types as below;

(1) Worker performance by a single dimension of main criteria

- Competency
- Experience
- Personal characteristics

- Skill
- Operational output

(2) Overall worker performance in all dimensions

However, the above-mentioned approach is primarily derived from the existing literature. In this study, worker grouping criteria and process are also investigated through the real case study of five different manufacturing companies of labor-intensive industry, i.e. food products, textiles/wearing apparel products, plastic products, and steel products to understand the facts in the real practice.

3.6 Methodology discussion

According to the research methodology described previously, it is primarily focused on semi-skilled worker selection from the real manufacturing practices with respect to labor-intensive industry of five case studies.

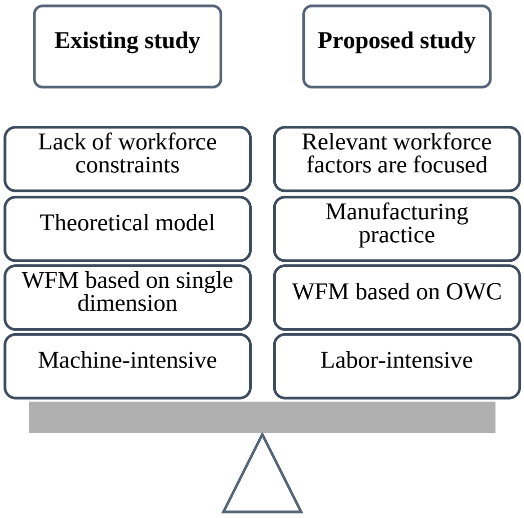


Figure 3.11 Existing studies and proposed methodology

The literature review section reveals that a number of related studies hardly focus on theoretical context with mathematical models while the actual manufacturing practices have been slightly considered. Gaps of worker skill are also discussed, since workers are commonly assumed to be equal in their abilities and perform tasks at a steady pace (Bentefouet and Nembhard, 2013). Moreover, it is found that the final management decision problems of worker allocation and scheduling have been widely published in the existing researches, whereas the prior phases of difference measurement on worker variabilities in terms of competency, experience, personal characteristics, skill, and productivity. With regard to the research gaps, this study constructs research methodology which fulfills gaps of prior workforce management phases, selection and grouping to investigate the individual measurement methods of semi-skilled worker based on different five case studies in labor-intensive manufacturing includes food products, textiles/wearing apparel products, plastic products, steel products, and a case study from recruitment outsourcing providers who play an important role in selection and grouping semi-skilled workers for manufacturing firms.

Figure 3.11 and Figure 3.12 present the different contexts and focuses of the existing literatures and proposed research methodology. It is obviously evident that most of related studies focus in machine-intensive industry which maintains the distinct characteristics compared to labor-intensive industry. Since machine is the critical production resource in its manufacturing system whereas human is the primary resource that highly impacts the overall production system in labor-intensive industry. Moreover, mathematical model is hardly focused which threats the application in real manufacturing firms and a single phase/partial WFM is only investigated.

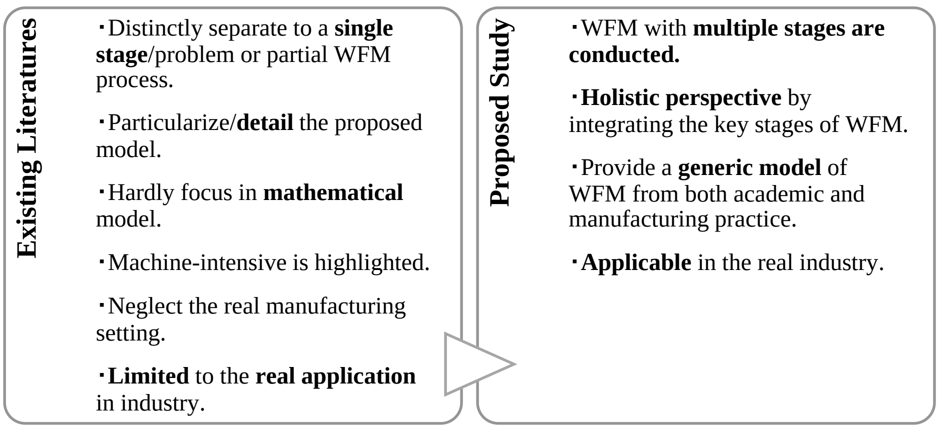


Figure 3.12 Overview gaps of existing literatures and proposed methodology

However, it is found that a few literatures examine worker performance measurement based on labor-intensive case study with less focus on human factors and operator constraints.

Analytical hierarchy process (AHP) is widely used as multiple criteria decision making (MCDM) tool in related studies. With respect to the context of semi-skilled worker selection in this research, various human factors are investigated to indicate differences among operational workers which is essential to be known before allocating them to operations. Various aspects and goals are constructed in AHP model to response research questions.

Correspondingly, AHP is also applied in this study in order to achieve the semi-skilled worker criteria in labor-intensive industry. Selection and grouping phases are conducted as the pre-allocation worker problem based on holistic perspective of integrating phases from the beginning of WFM process, to finally provide the generic model which is applicable in real industry setting.

CHAPTER IV
RESULTS

The derived semi-skilled worker selection and grouping from five investigated areas include manufacturing of food products, textiles/wearing apparel products, plastic products, steel products and the recruitment outsourcing providers, are presented. The overall results obtained from this study are carried out into three main parts as given below:

4.1 Computational results of AHP approach and selection criteria

4.1.1 Labor-intensive industry

- Case study 1 : Food products
- Case study 2 : Textiles/wearing apparel products
- Case study 3 : Plastic products
- Case study 4 : Steel products

4.1.2 Recruitment outsourcing providers

- Case study 5 : Recruitment outsourcing providers

4.1.3 Case studies analysis

4.1.4 Worker selection policies obtained from case studies

4.2 Semi-skilled worker selection and grouping model based on manufacturing practices and previous studies

4.3 Numerical example

In worker selection phase, the computational results derived from AHP model using Super Decisions software are presented with priorities of a worker selection criteria in different perspectives of industries and recruitment outsourcing providers. The final results are summarized with respect to the environment of labor-intensive industry for both selection criteria and manufacturing practice. Respectively in worker grouping phase which is primarily based on manufacturing practice, the preliminary grouping criteria and manufacturing practice are introduced. Lastly, the final semi-skilled worker selection and grouping model for labor intensive industry is proposed.

4.1 Computational results of AHP approach and selection criteria

In worker selection phase, Super Decisions is used as a decision making software based on AHP. The importance weights of all single criterion with priorities are obtained. The preliminary hierarchical structure of all worker selection criteria in labor-intensive industry is illustrated in Figure 4.1.

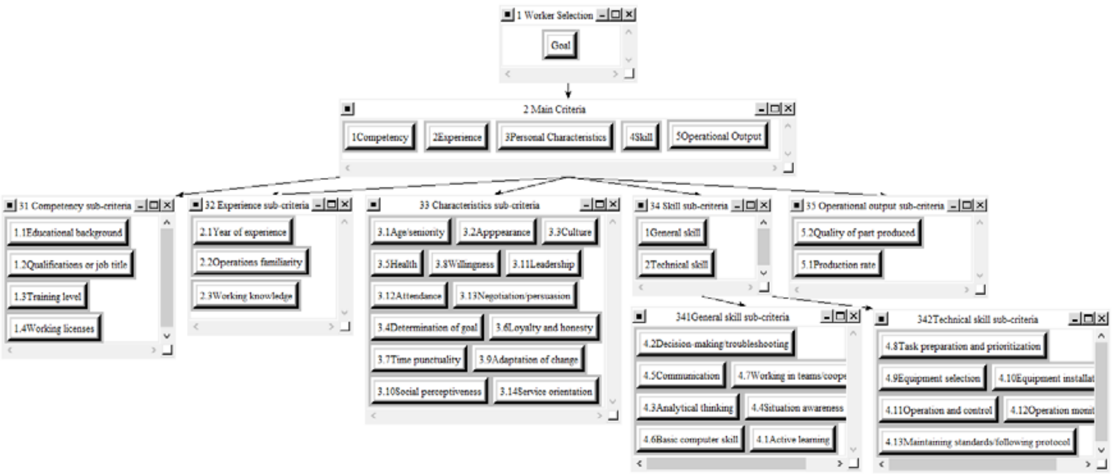


Figure 4.1 Preliminary AHP hierarchical structure

The AHP model shown in Figure 4.1 is structured into hierarchy with four levels. Worker selection is set as goal in the first level, followed by five main criteria in the second level. Sub-criteria of each main criterion are constructed in the third level, and sub-criteria of general skills and technical skills are in the fourth level. The arrows appeared in the figure represent relationships of goal, main criteria, sub-criteria, and second level sub-criteria respectively. Each single criterion is called "Node", nodes will be contained in the big box called "Cluster" which represents groups of criteria.

After the hierarchical structure is constructed with correct nodes, clusters, and relationship arrows. The importance score of each pairwise comparison matrix is then required as the primary input data, shown in Figure 4.2.

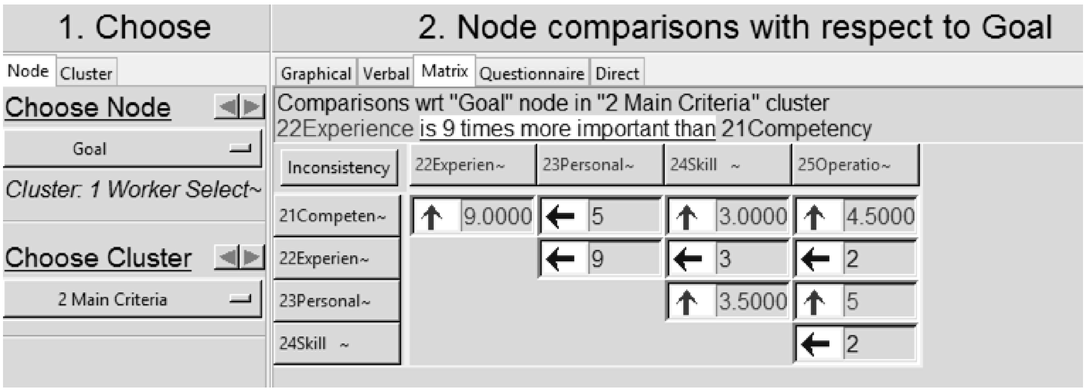


Figure 4.2 Pairwise comparison matrix of main criteria by Super Decisions

In Figure 4.2, at the first step goal node is chosen with cluster of main criteria to compare each single main criterion by providing scores into the matrix. A pair of criteria is compared with numbers in Saaty's scale explained in the previous chapter. Directions of the arrows present the comparative importance between row and column criteria, up-arrow means that a column criteria is more important than a row criteria with score of *x* while *x* varies from 1 to 9. On the contrary, left-arrow means that a row criteria is more important than a column criteria with score of *x*. For example, the first column that is compared between competency and experience criteria with the score of 9 and up-arrow, means experience (column) is 9 times more important than competency (row).

Figure 4.3 presents the results of AHP model obtained from Super Decisions software, for the main criteria pairwise comparison matrix. It includes five main criteria in the first column (competency, experience, personal characteristics, skill, and operational output). The second and third column presents the importance weight of each criterion in priorities. And the consistency ratio (CR) on top is at 0.09878 which is less than 0.10. It means input data is in the consistent range. In case that CR value is greater than 0.10, the process of scoring will be repeated until the consistent value of CR is reached.

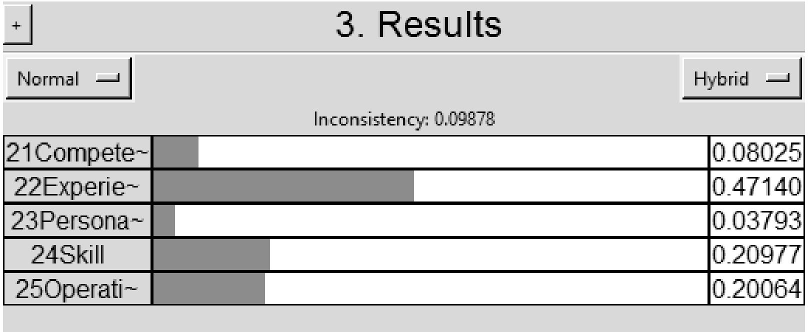


Figure 4.3 Pairwise comparison matrix results by Super Decisions

The importance weights are filled up to complete six dimensions of pairwise comparison matrix which includes main criteria, competency sub-criteria, experience sub-criteria, personal characteristics sub-criteria, skill sub-criteria, and operational output sub-criteria. For skill sub-criteria, it is extended into two sub-criteria (second level sub-criteria) which consist of general skills and technical skills second level sub-criteria.

4.1.1 Labor-intensive industry

- Case study 1: Food products

The hierarchical structure of all worker selection criteria in food products case study is illustrated in Figure 4.4.

The hierarchical structure of semi-skilled worker selection criteria obtained from two companies of food products with respect to its labor-intensive context is summarized. Five main criteria include competency, experience, personal characteristics, skill, and operational output. The competency pillar consists of three important sub-criteria namely (1) educational background, (2) qualifications or job title, and (3) training level. Three criteria are considered in the experience pillar, (1) year of experience, (2) operation familiarity, and (3) working knowledge. The personal characteristics include four sub-criteria, (1) age/seniority, (2) health, (3) time punctuality, and (4) willingness. In skill main criterion, the general skills are branched into two sub-criteria (1) active learning and (2) communication. Similarly, the technical skills include (1) task preparation and prioritization, (2) equipment selection, (3) operation and control, and (4) maintaining standards/following protocol. Then the final cluster of "operational output" is carried out into production rate and quality of part produced.

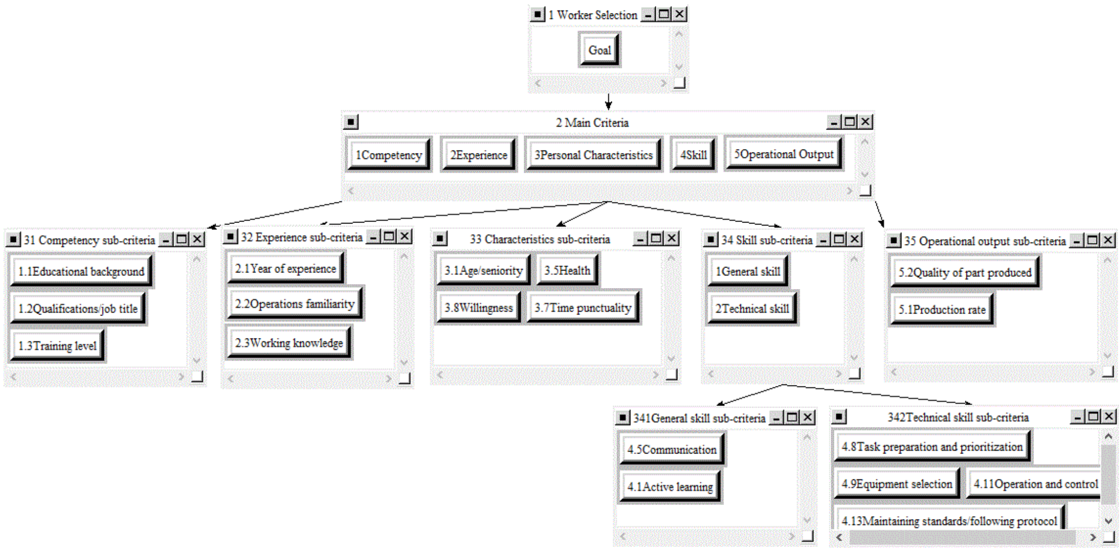


Figure 4.4 Case study 1 : Hierarchical structure of selection criteria

The computational results of AHP derived from Super Decision software are presented in Table 4.1. The table consists of six columns, namely main criteria, cluster priority, consistency ratio (CR), sub-criteria, local weight, and global priority. The cluster priority represents the importance weights of each main criterion or defined as cluster. The consistency ratio presents two different figures of F1 and F2, two companies of food products which all CR values are less than 0.1 or in the acceptable CR range. The local weight column introduces a single importance weight of each sub-criteria compared within its cluster. On the other hand, global priority column presents a single importance weight in percentage of each sub-criteria compared to all sub-criteria which is 100 % as total.

Table 4.1 Case study 1 : Computational results of AHP

Main criteria	Cluster priority	Consistency Ratio (CR)	Sub-criteria	Local weight	Global priority
Competency	0.04187	$F_1$0.00675 $F_2$0.09609	Educational background	0.08002	0.34%
			Qualifications or job title	0.68029	2.85%
			Training level	0.23970	1.00%
Experience	0.10144	$F_1$0.00000 $F_2$0.05156	Year of experience	0.18123	1.84%
			Operational familiarity	0.58004	5.88%
			Working knowledge	0.23874	2.42%
Personal characteristics	0.17059	$F_1$0.09191 $F_2$0.09263	Age/seniority	0.04128	0.70%
			Health	0.24572	4.19%
			Time punctuality	0.35642	6.08%
			Willingness	0.35659	6.08%
Skill	0.21323	-*	*General skills*	*0.16667*	
			Active learning	0.51192	1.82%
			Communication	0.48808	1.73%
		$F_1$0.09999 $F_2$0.09636	*Technical skills*	*0.83333*	
			Task preparation and prioritization	0.15646	2.78%
			Equipment selection	0.38353	6.81%
			Operation and control	0.11470	2.04%
			Maintaining standards/following protocol	0.34532	6.14%
Operational output	0.47287	-*	Production rate	0.26667	12.61%
			Quality of part produced	0.73333	34.68%

*The Consistency Ratio (CR) is possible to obtain with more than or equal to three factors (n≥3).

Figure 4.5 – 4.10 presents AHP computational results of semi-skilled worker selection from case study 1 (food products) in charts, categorized by clusters.

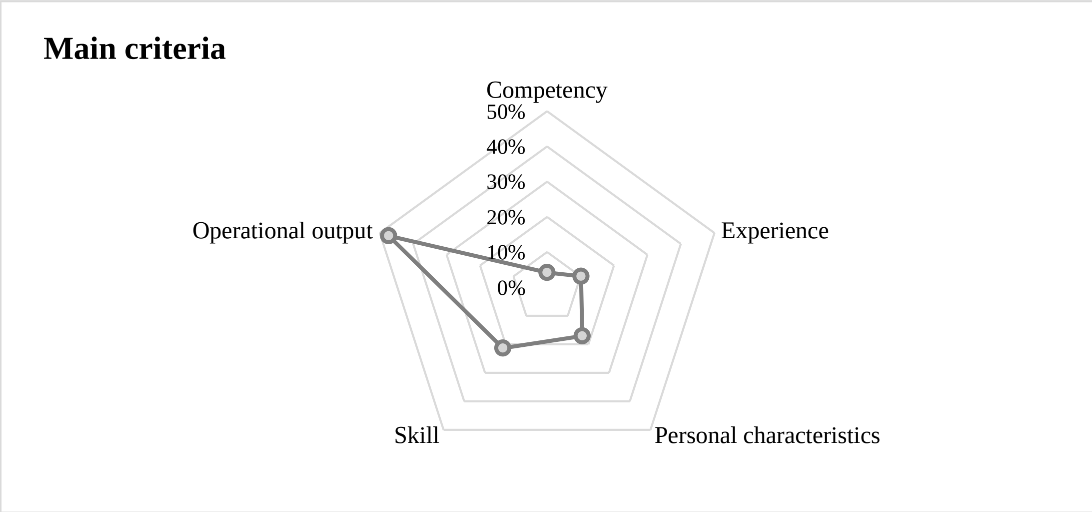


Figure 4.5 Case study 1 : Main criteria priority matrix

Following to Figure 4.5, the main criteria priority matrix is presented. In the manufacturing of food products, it is found that the operational output yields the highest weight with 47.29%, followed by skill cluster 21.32%, personal characteristics 17.06%, experience 10.14%, and competency 4.19% respectively. With respect to the food production processes, semi-skilled worker in operations is significantly focused in the operational output that includes worker's ability to produce/process their task as process (WIP) or finished products in terms of quantity and quality. Moreover, the skill of worker are secondly highlighted since the manufacturing of food products requires some specific skills in order to maintain its production quality.

The AHP chart of competency cluster is shown in Figure 4.6. It is evident that qualifications of job title sub-criteria yields the highest weight with 68.03%, and training level 23.97% respectively. The educational background is found to achieve the lowest ranking, 8.00%.

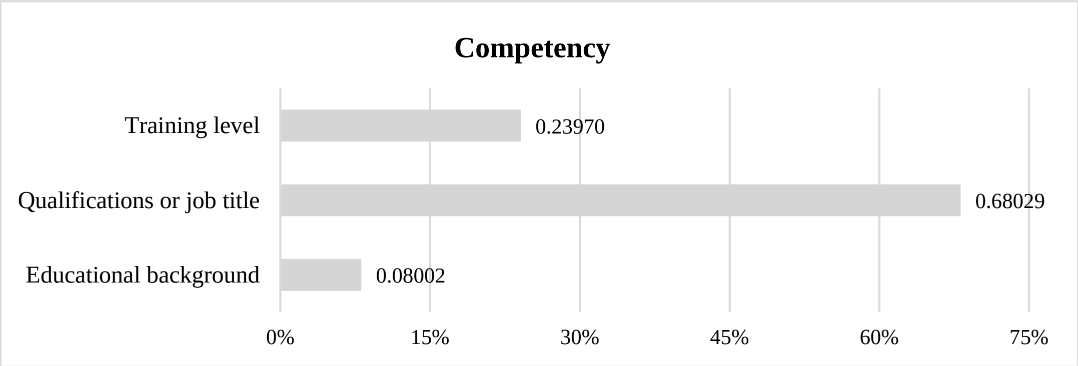


Figure 4.6 Case study 1 : AHP chart of competency main criterion

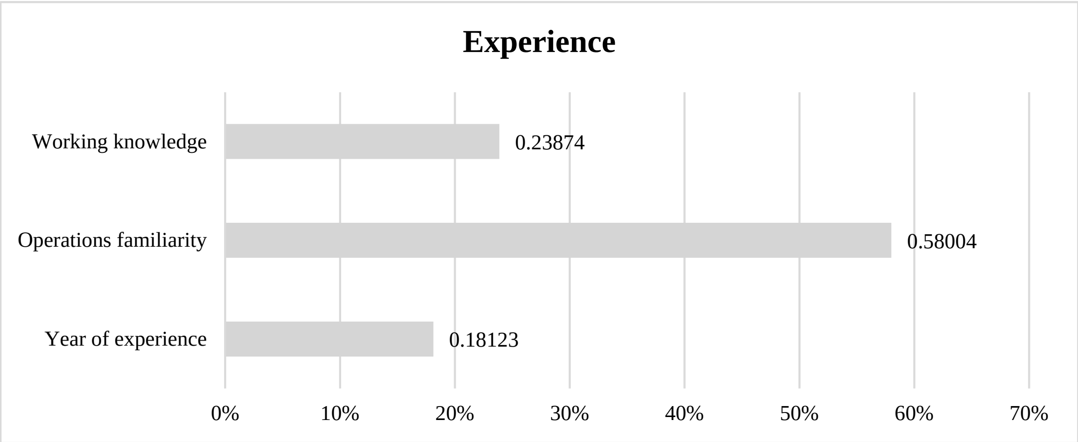


Figure 4.7 Case study 1 : AHP chart of experience main criterion

Figure 4.7 presents the importance weights of experience sub-criteria, i.e. year of experience, operational familiarity, and working knowledge. From the chart, "operational familiarity" obviously yields the highest ranking by 58.00%. The second and third rankings are quite close with small differences between working knowledge 23.87% and year of experience 18.12% respectively.

Sub-criteria of willingness and time punctuality yield 35.66% and 35.64% in personal characteristics cluster shown in Figure 4.8. Health is the third ranking with 24.57% and age/seniority 4.13% respectively.

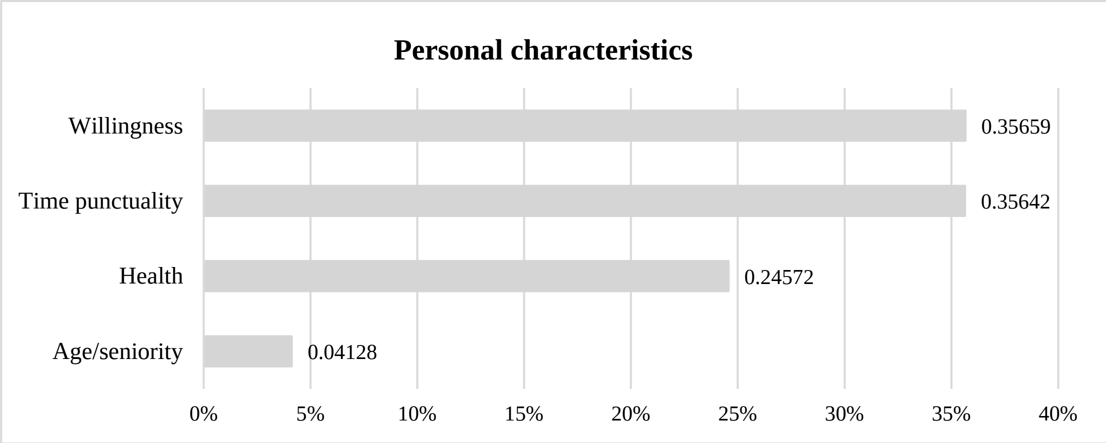


Figure 4.8 Case study 1 : AHP chart of personal characteristics main criterion

In the case study of food products, the following sub-criteria are not considered as an important semi-skilled worker selection criteria in personal characteristics cluster. Namely, appearance, culture, determination of goal, loyalty and honesty, adaptation of change, social perceptiveness, leadership, attendance, negotiation/persuasion, and service orientation. The selected experts from food factories explained that these characteristics are not important regarding to the natures of food products manufacturing and the factors slightly impacts to the operational output.

With respect to the skill cluster, it is carried out into two main types of general skills and technical skills. The technical skills obviously yield higher weight with 83.33% compared to the general skills 16.67% shown in Figure 4.9.

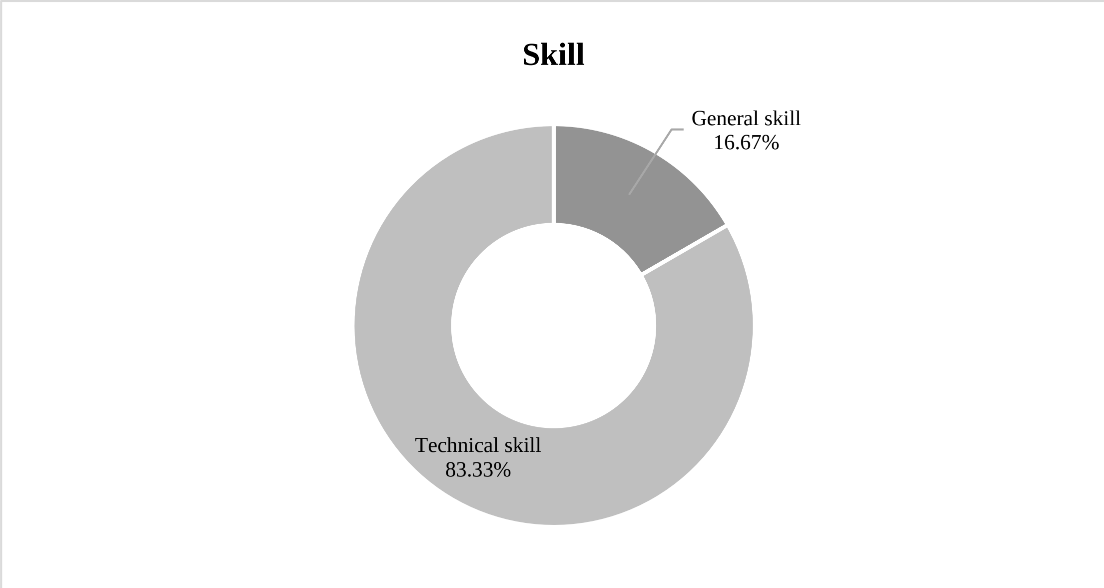


Figure 4.9 Case study 1 : AHP chart of skill main criterion

There are only two sub-criteria considered as the general skills, active learning and communication with weights of 51.19% and 48.81% respectively. It is evident that learning and communication criteria are significantly closed in rankings. For general skills, decision-making/trouble shooting, analytical thinking, situation awareness, basic computer skill, and working in teams/cooperation are not considered with respect to the food manufacturing context. On the other hand, four criteria are focused in technical skills cluster, i.e. equipment selection 38.35%, maintaining standards/following protocol 34.53%, task preparation and prioritization 15.65%, and operation and control 11.47% respectively. However, equipment installation, operation monitoring are not considered since these two factors are not responsible by the operational workers in food productions. The AHP computational results of general skills and technical skills are presented in Figure 4.10.

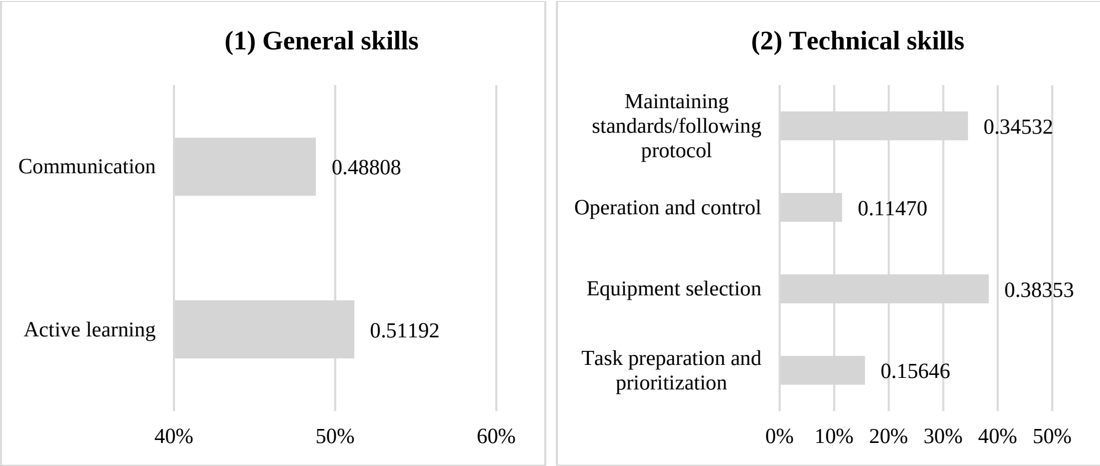


Figure 4.10 Case study 1 : AHP chart of skill sub-criteria

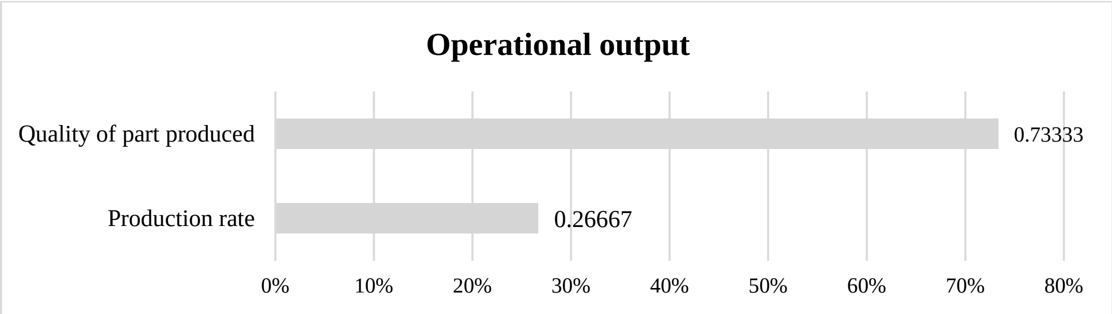


Figure 4.11 Case study 1 : AHP chart of operational output main criterion

Two sub-criteria in the final cluster of operational output are quality of part produced and production rate with yields of 73.33% and 26.67% respectively. The results are shown in Figure 4.11 that the quality of part produced is obviously outstanding in case study of the food products.

From Table 4.2, the summary ranking of semi-skilled worker selection criteria in the case study of food products is illustrated. It is categorized into two different rankings of main criteria (clusters) and sub-criteria (nodes).

The results derived in Table 4.2 reveal that the “operational output” outstandingly yields the highest ranking by 47.29%. The second ranking of cluster has been drawn by skill main criteria 21.32%. Then, personal characteristics 17.06%, experience 10.14%, and competency 4.19% respectively. The "operational output" cluster reached 47.29% compared to the other four main criteria.

Table 4.2 Case study 1 : Ranking of semi-skilled worker selection criteria

Main criteria	Global Ranking	Sub-criteria	Global Ranking
(1) Operational output	47.29%	Quality of part produced	34.68%
(2) Skill	21.32%	Production rate	12.61%
(3) Personal characteristics	17.06%	Equipment selection	6.81%
(4) Experience	10.14%	Maintaining standards/ following protocol	6.14%
(5) Competency	4.19%	Willingness	6.08%
		Time punctuality	6.08%
		Operations familiarity	5.88%
		Health	4.19%
		Qualifications or job title	2.85%
		Task preparation and prioritization	2.78%
		Working knowledge	2.42%
		Operation and control	2.04%
		Year of experience	1.84%
		Active learning	1.82%
		Communication	1.73%
		Training level	1.00%
		Age/seniority	0.70%
		Educational background	0.34%

In the viewpoint of sub-criteria, quality of part produced correspondingly achieved 34.68% as the first ranking. The second ranking is production rate criterion by 12.61% while the rest of the criteria yield less than 7% in the following, i.e. equipment selection 6.81%, maintaining standards/following protocol 6.14%, willingness 6.08%, time punctuality 6.08%, operations familiarity 5.88%, health 4.19%, qualifications or job title 2.85%, task preparation and prioritization 2.78%, working knowledge 2.42%, operation and control 2.04%, year of experience 1.84%, active learning 1.82%, communication 1.73%, training level 1.00%, age/seniority 0.70%, and educational background 0.34%.

It is evident that 75% of all personal characteristics sub-criteria yields between 4 – 6%, whereas the training level and educational background of competency and age/seniority of personal characteristics as the lowest ranking that is not greater than 1%.

- Case study 2: Textiles/wearing apparel products

The hierarchical structure of all worker selection criteria in textiles/wearing apparel products is illustrated in Figure 4.12.

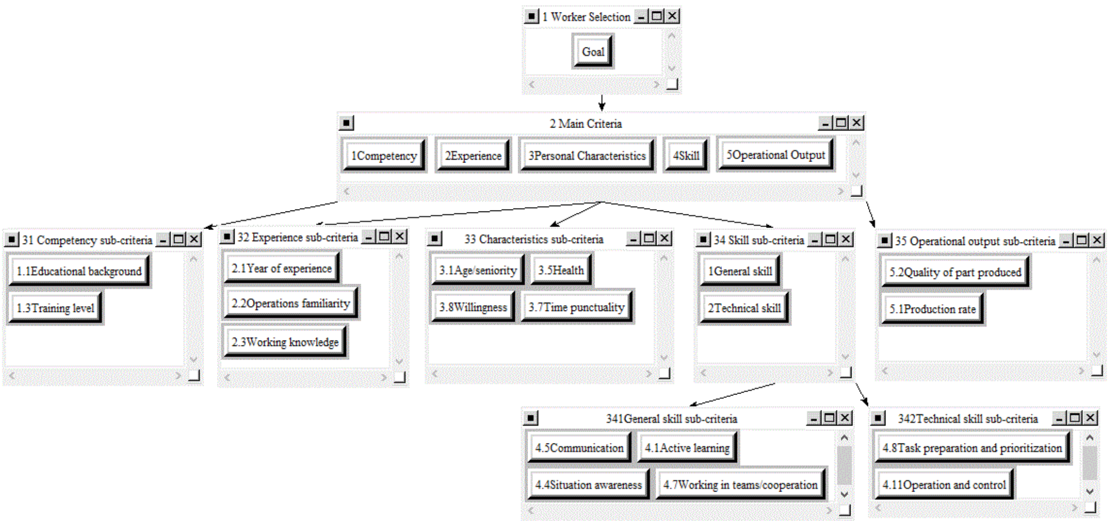


Figure 4.12 Case study 2 : Hierarchical structure of selection criteria

The hierarchical structure of semi-skilled worker selection criteria obtained from two companies of textiles/wearing apparel products with respect to its labor-intensive context is summarized, five main criteria include competency, experience, personal characteristics, skill, and operational output. The competency pillar consists of two important sub-criteria, educational background and training level whereas qualifications or job title and working license are not considered with respect to the operations which workers could learn through on the job training (OJT). Similarly to case study 1 of food products, three criteria are considered in the experience pillar, (1) year of experience, (2) operation familiarity, and (3) working knowledge. The personal characteristics include four sub-criteria, (1) age/seniority, (2) health, (3) time punctuality, and (4) willingness which also corresponds to case study 1. In skill main criterion, the general skills are branched into four sub-criteria (1) active learning, (2) situation awareness, (3) communication, and (4) working in teams/cooperation. The technical skills include task preparation and prioritization, and operation and control. The final cluster as operational output is carried out into production rate and quality of part produced.

The computational results of AHP derived from Super Decision software are presented in Table 4.3.

Table 4.3 Case study 2 : Computational results of AHP

Main criteria	**Cluster priority**	**Consistency Ratio (CR)**	**Sub-criteria**	**Local weight**	**Global priority**
Competency	0.15503	-*	Educational background	0.40476	6.27%
			Training level	0.59524	9.23%
Experience	0.30234	$T_1$0.05156	Year of experience	0.31880	9.64%
		$T_2$0.09040	Operational familiarity	0.44737	13.53%
			Working knowledge	0.23384	7.07%
Personal characteristics	0.03384	$T_1$0.09227	Age/seniority	0.04611	0.16%
		$T_2$0.09496	Health	0.40090	1.36%
			Time punctuality	0.23005	0.78%
			Willingness	0.32295	1.09%
Skill	0.13286	$T_1$0.09088	*General skills*	*0.14583*	
		$T_2$0.00531	Active learning	0.26615	0.52%
			Situation awareness	0.18370	0.36%
			Communication	0.22577	0.44%
			Working in teams/ cooperation	0.32438	0.63%
		-*	*Technical skills*	*0.85418*	
			Task preparation and prioritization	0.25000	2.84%
			Operation and control	0.75000	8.51%
Operational output	0.37595	-*	Production rate	0.41667	15.66%
			Quality of part produced	0.58334	21.93%

*The Consistency Ratio (CR) is possible to obtain with more than or equal to three factors (n≥3).

The priorities of main criteria and sub-criteria derived from the perspective of case study 2 (textiles/wearing apparel products) are summarized into charts as shown in Figure 4.13 – 4.19. With respect to the practice of the case study, it is noted that the *code of conduct on labor regulations* is taken into account for providing the qualitative judgement in AHP model.

According to the context of textiles/wearing apparel manufacturing, the operational output cluster yields the highest ranking by 37.60%. It is corresponding to the study of food products which operational output also achieved the first ranking. However, the second ranking is drawn by experience with 30.23%. The competency and skill clusters reached the third and fourth ranking, 15.50% and 13.29% respectively. The personal characteristics yield the lowest ranking by 3.38%, as presented in Figure 4.13.

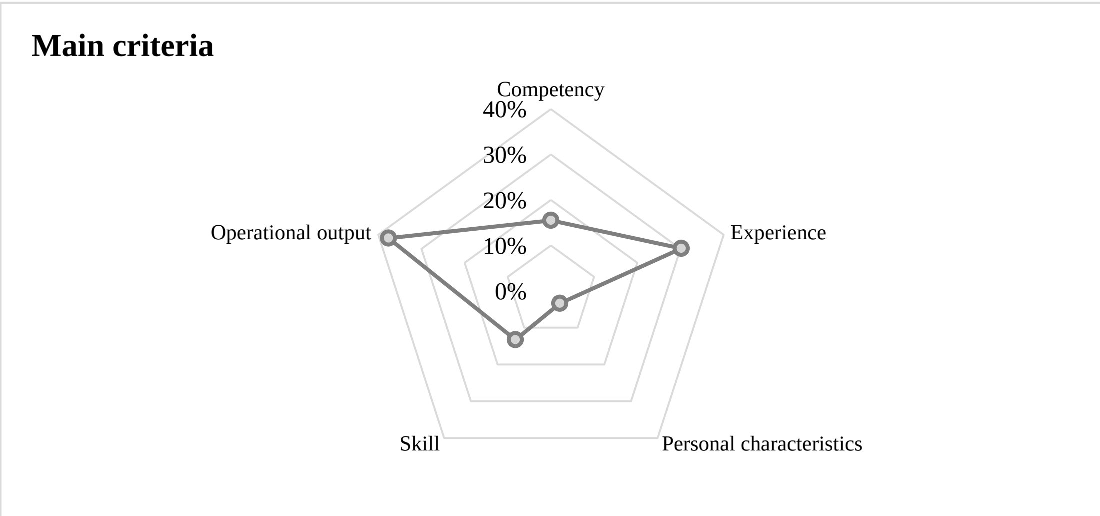


Figure 4.13 Case study 2 : Main criteria priority matrix

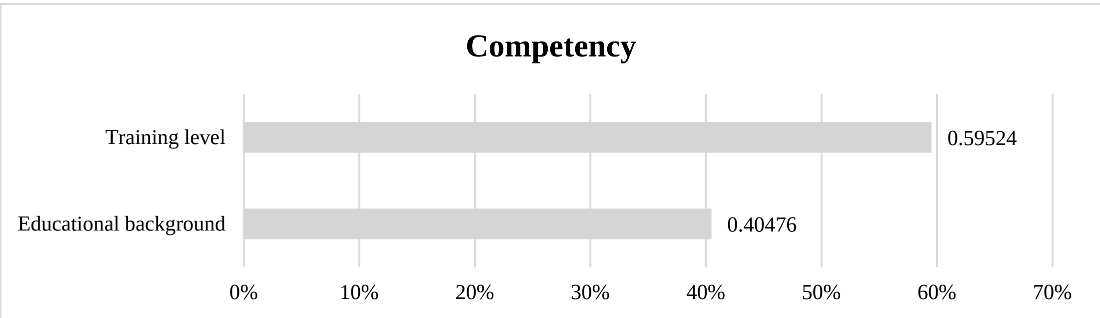


Figure 4.14 Case study 2 : AHP chart of competency main criterion

In the competency cluster, two criteria are considered including educational background and training level. With respect to textiles/wearing apparel manufacturing, the training level sub-criteria yields 59.52% which is 19% higher than the educational background (40.48%) as shown in Figure 4.14. It is evident from the results that qualifications or job title, and working licenses are not considered in this context.

Three sub-criteria are investigated in the experience cluster, (1) year of experience, (2) operation familiarity, and (3) working knowledge. Figure 4.15 reveals that operational familiarity yields the highest importance weight by 44.74%, followed by year of experience sub-criteria 31.88% and working knowledge 23.38%.

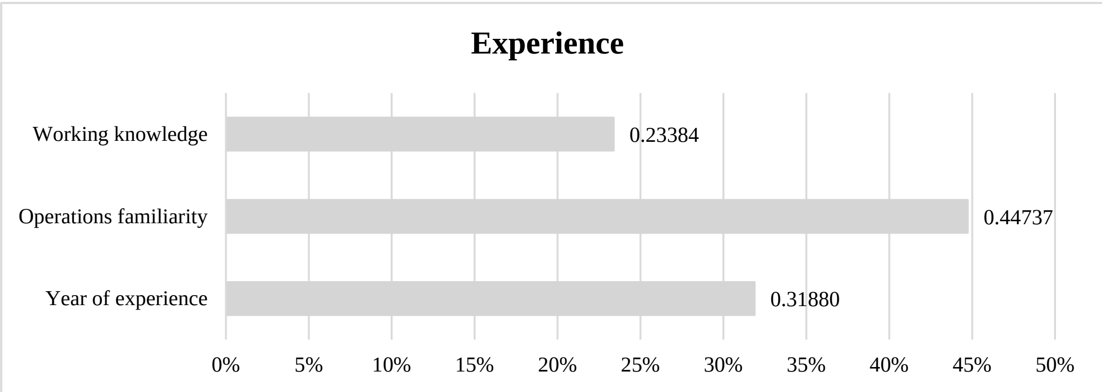


Figure 4.15 Case study 2 : AHP chart of experience main criterion

Figure 4.16 presents the AHP results derived in personal characteristics cluster, four sub-criteria are selected as the important selection criteria in textiles/wearing apparel environment which consists of age/seniority, health, time punctuality, and willingness. Among these four sub-criteria, 40.10% is achieved by health as the top ranking, and 32.30% by willingness as the second ranking. Time punctuality yields the third ranking with 23.01% and age/seniority as the lowest importance, 4.61% respectively

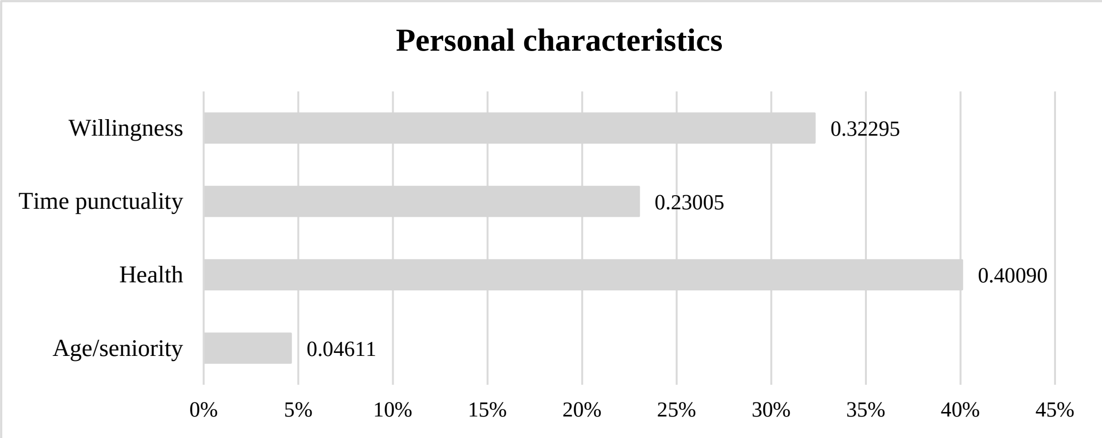


Figure 4.16 Case study 2 : AHP chart of personal characteristics main criterion

The skill cluster is carried out into general skills and technical skills, the results shown in Figure 4.17 and indicate that technical skills are obviously focused by 85.42% compared to general skills which yield only 14.58% or six times less than the technical skills.

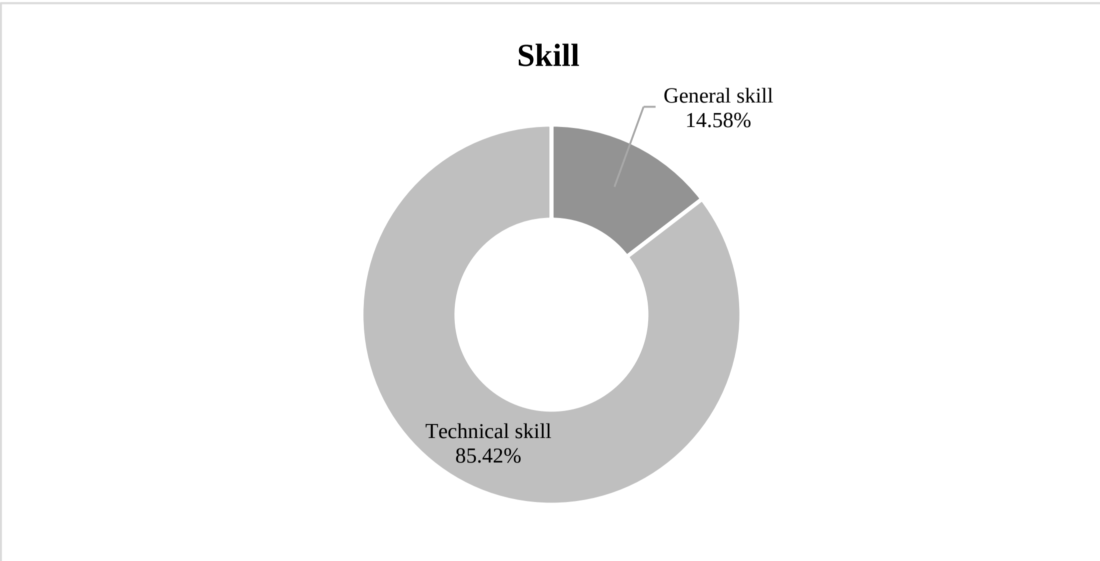


Figure 4.17 Case study 2 : AHP chart of skill main criterion

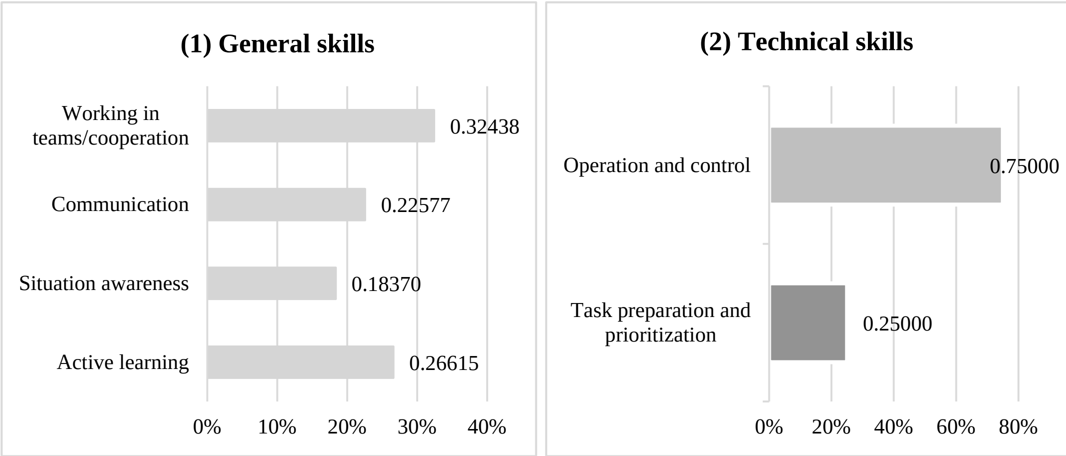


Figure 4.18 Case study 2 : AHP chart of skill sub-criteria

The general skills cluster include four sub-criteria in the context of textiles/wearing apparel products, (1) active learning, (2) situation awareness, (3) communication, and (4) working in teams/cooperation. From Figure 4.18, it is roughly seen that all four sub-criteria of the general skills are not clearly different from the lowest weight of 18% to the highest of 32%. "Working in teams/cooperation" is found to yield the top ranking in general skills cluster by 32.44%, and active learning as the second ranking with 26.62%. Followed by the communication and situation awareness, 22.58% and 18.37% consequently.

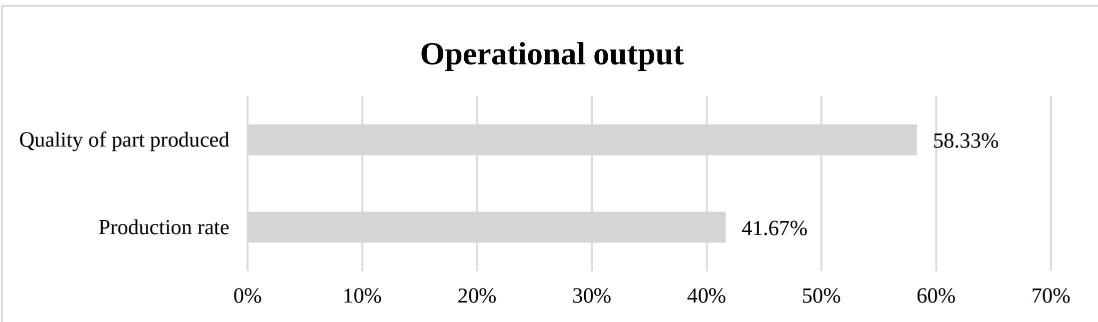


Figure 4.19 Case study 2 : AHP chart of operational output main criterion

Following to Figure 4.19, two sub-criteria are contained in the operational output cluster. It is evident that the quality of part produced and production rate sub-criteria are not huge different compared to each other, by 58.33% and 41.67%. However, the quality of part produced is focused in the manufacturing of textiles/wearing apparel products.

Table 4.4 Case study 2 : Ranking of semi-skilled worker selection criteria

Main criteria	Global Ranking	Sub-criteria	Global Ranking
(1) Operational output	37.60%	Quality of part produced	21.93%
(2) Experience	30.23%	Production rate	15.66%
(3) Competency	15.50%	Operations familiarity	13.53%
(4) Skill	13.29%	Year of experience	9.64%
(5) Personal characteristics	3.38%	Training level	9.23%
		Operation and control	8.51%
		Working knowledge	7.07%
		Educational background	6.27%
		Task preparation and prioritization	2.84%
		Health	1.36%
		Willingness	1.09%
		Time punctuality	0.78%
		Working in teams/cooperation	0.63%
		Active learning	0.52%
		Communication	0.44%
		Situation awareness	0.36%
		Age/seniority	0.16%

Table 4.4 presents the overall global rankings of semi-skilled worker selection criteria with respect to case study 2, textiles/wearing apparel products. The results reveal that “operational output” cluster yields the highest ranking with 37.60% and followed by experience 30.23% as the second ranking. Competency and skill are

evident to have similar importance weights by 15.50% (ranking 3) and 13.29% (ranking 4) respectively. The lowest ranking has been drawn to personal characteristics cluster with only 3.38%.

Furthermore, the global ranking of sub-criteria in Table 4.4 could be concluded into three groups of high, medium, and low ranking. The top three rankings, i.e. quality of part produced, production rate, and operations familiarity by 21.93% (ranking 1), 15.66% (ranking 2), and 13.53% (ranking3) respectively. While year of experience, training level, and operation and control, working knowledge, and education background similarly yield as medium rankings by 9.64%, 9.23%, 8.51%, 7.07%, and 6.27%. The low ranking subsequently includes task preparation and prioritization, health, willingness, time punctuality, working in teams/cooperation, active learning, communication, situation awareness, age/seniority by weight from 0.16% to 2.84%. It is evident that most of the sub-criteria in low rankings are in personal characteristics cluster which conform to the global ranking of main criteria that personal characteristics yield the lowest importance weight.

- Case study 3: Plastic products

The hierarchical structure of all worker selection criteria in steel products is illustrated in Figure 4.20.

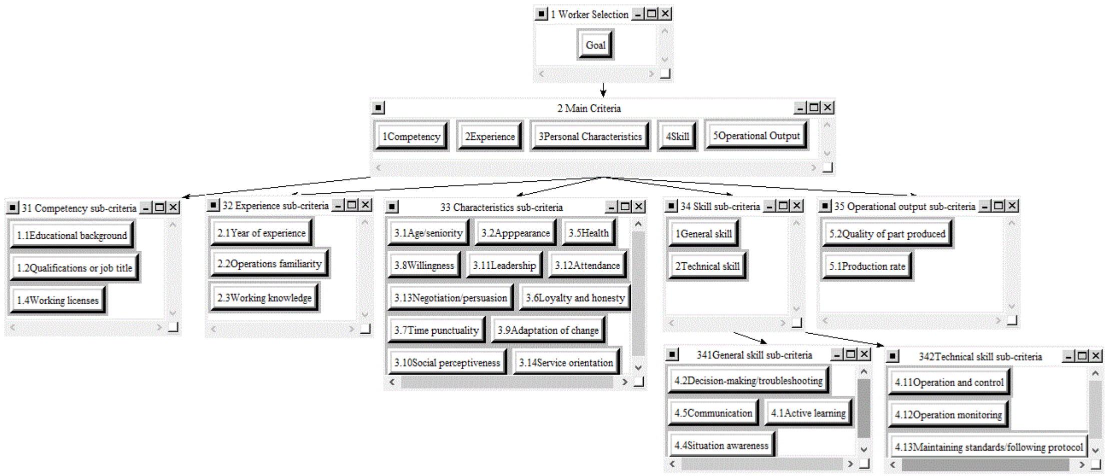


Figure 4.20 Case study 3 : Hierarchical structure of selection criteria

Following to the case study of plastic products, the hierarchical structure shown in Figure 4.20 with five main clusters are constructed. Three selection criteria are considered in the competency cluster, (1) educational background, (2) qualifications or job titles, and (3) working licenses, whereas the training level criterion is not taken into account. In the cluster of experience, all three criteria are included namely (1) year of experience, (2) operational familiarity, and (3) working knowledge.

It is found that personal characteristics cluster tends to be focused in semi-skilled worker selection practice based on plastic manufacturing perspective, twelve sub-criteria are discussed as follow age/seniority, appearance, health, loyalty and honesty, time punctuality, willingness, adaptation of change, social perceptiveness, leadership, attendance, negotiation/persuasion, and service orientation.

Similarly, the skill cluster is carried out into general skills and technical skills, where general skills include four sub-criteria, (1) active learning, (2) decision-making/troubleshooting, (3) situation awareness, and (4) communication. For technical skills, (1) operation and control, (2) operation monitoring, and (3) maintaining standards/following protocol, are taken into account. In the operational output cluster, both criteria of production rate and quality of part produced are considered.

Table 4.5 Case study 3 : Computational results of AHP

Main criteria	Cluster priority	Consistency Ratio (CR)	Sub-criteria	Local weight	Global priority
Competency	0.05508	$P_1$0.00885 $P_2$0.06239	Educational background	0.07918	0.44%
			Qualifications or job title	0.63866	3.52%
			Working licenses	0.28217	1.55%
Experience	0.33532	$P_1$0.09837 $P_2$0.09609	Year of experience	0.09884	3.31%
			Operational familiarity	0.60467	20.28%
			Working knowledge	0.29649	9.94%
Personal characteristics	0.06639	$P_1$0.09837 $P_2$0.09801	Age/seniority	0.01635	0.11%
			Appearance	0.01226	0.08%
			Health	0.03007	0.20%
			Loyalty and honesty	0.07765	0.52%
			Time punctuality	0.06573	0.44%
			Willingness	0.08303	0.55%
			Adaptation of change	0.07907	0.52%
			Social perceptiveness	0.10412	0.69%
			Leadership	0.13092	0.87%
			Attendance	0.15501	1.03%

Table 4.5 Case study 3 : Computational results of AHP (continued)

Main criteria	Cluster priority	Consistency Ratio (CR)	Sub-criteria	Local weight	Global priority
			Negotiation/persuasion	0.13105	0.87%
			Service orientation	0.11476	0.76%
Skill	0.14409	$P_1$0.09888	*General skills*	*0.18056*	
		$P_2$0.09233	Active learning	0.10820	0.28%
			Decision-making/ troubleshooting	0.37541	0.98%
			Situation awareness	0.17510	0.46%
			Communication	0.34130	0.89%
		$P_1$0.05156	*Technical skills*	*0.81945*	
		$P_2$0.00000	Operation and control	0.25175	2.97%
			Operation monitoring	0.17541	2.07%
			Maintaining standards/ following protocol	0.57285	6.76%
Operational output	0.39914	-*	Production rate	0.38334	15.30%
			Quality of part produced	0.61667	24.61%

*The Consistency Ratio (CR) is possible to obtain with more than or equal to three factors (n≥3).

All AHP importance weights derived from case study 3 of plastic products, are illustrated in Table 4.5. Includes five main clusters with CR values of each comparison matrix, it is evident that all CR values are in the acceptable range (less than 10% as aforementioned). The local weight column presents priorities within cluster while global priority column indicates an individual criterion weight compare to all other criteria. It is noted that the *code of conduct on labor regulations* is taken into account for providing the qualitative judgement in AHP model with respect to the practice of plastic manufacturing case study.

Figure 4.21 – 4.27 presents weights of each single sub-criteria categorized by clusters, given below.

The overview of main criteria shown in Figure 4.21, it is found that “operational output” yields the first important ranking by 39.91% compared to the other four clusters with respect to the manufacturing of plastic products. Experience achieves the second ranking by 33.53% which is approximately 7% less than the first ranking. However, 14.41% as the third ranking has been drawn to skill cluster. Whereas personal characteristics and competency are close by 6.64% (ranking 4) and 5.51% (ranking 5) respectively.

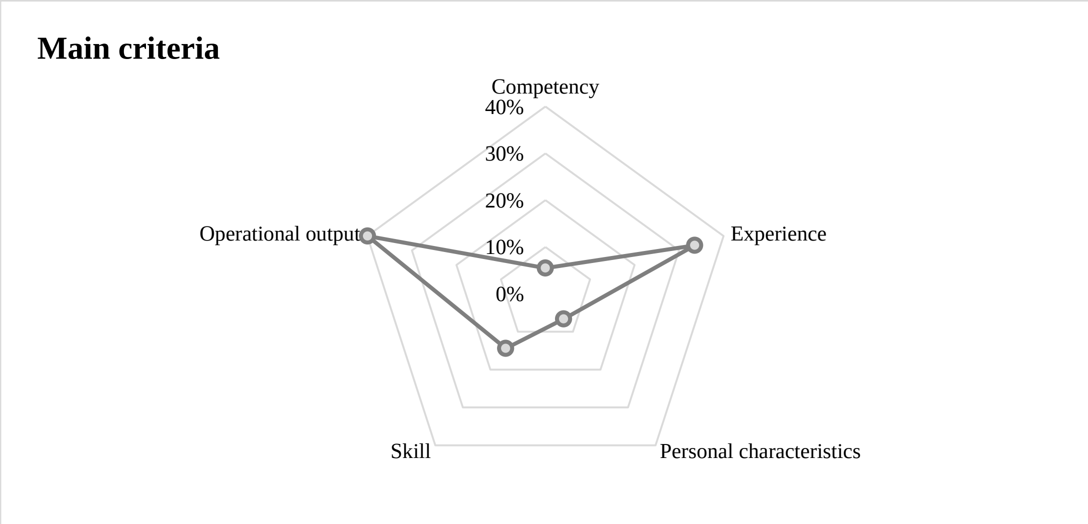


Figure 4.21 Case study 3 : Main criteria priority matrix

Following to the competency cluster presented in Figure 4.22, three sub-criteria are taken into account includes educational background, qualifications or job title, and working licenses. The AHP result reveals that "qualifications or job title" outstandingly yields the highest ranking by 63.87% importance weight compare to the other two sub-criteria, working licenses achieves the second ranking with 28.22% and educational background 7.92% as the lowest ranking respectively.

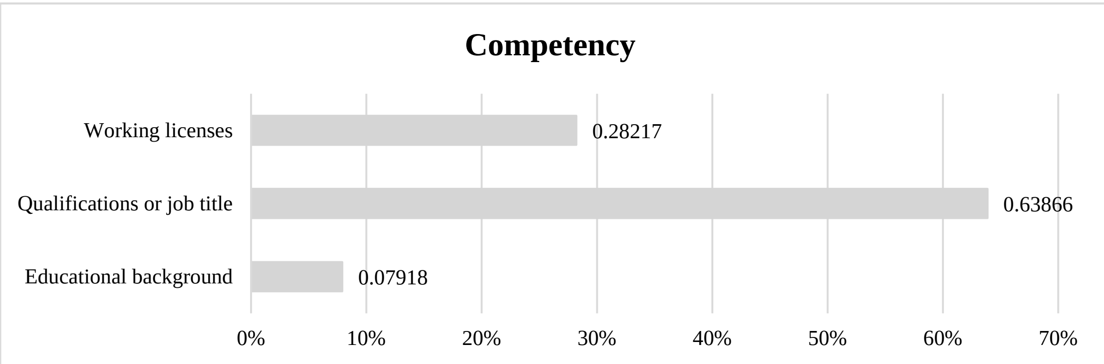


Figure 4.22 Case study 3 : AHP chart of competency main criterion

In the experience point of view, operations familiarity criterion obviously yields 60.47% as the highest ranking (see Figure 4.23). The second ranking which is approximately 30% less, achieved by working knowledge sub-criteria by 29.65%. And year of experience yielded the lowest priority by only 9.88%. According to plastic products manufacturing, working knowledge is evident to be an important semi-skilled worker selection criteria since its operations require workers with preliminary specific knowledge compared to other industries.

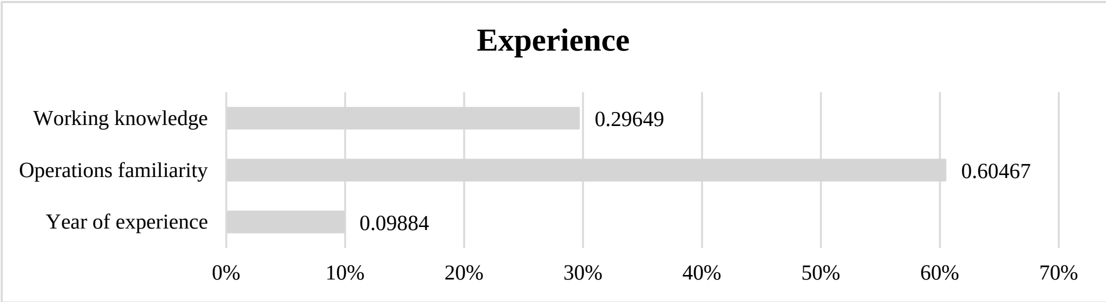


Figure 4.23 Case study 3 : AHP chart of experience main criterion

Figure 4.24 presents results obtained from AHP in the perspective of personal characteristics cluster. From the chart, attendance criterion yields the highest priority by 15.50% as the top ranking. However, the first ranking is not obviously different from the second and third ranking which are negotiation/persuasion 13.11% and leadership 13.09% respectively. Ranking 4 has been drawn to service orientation criterion by 11.48% and followed by 10.41% of social perceptiveness. In whilst, the remaining sub-criteria of willingness, adaptation of change, loyalty and honesty, time punctuality, and health, consequently yields between 1 – 8 %. The two lowest priorities are age/seniority by 1.64% and appearance 1.23% respectively.

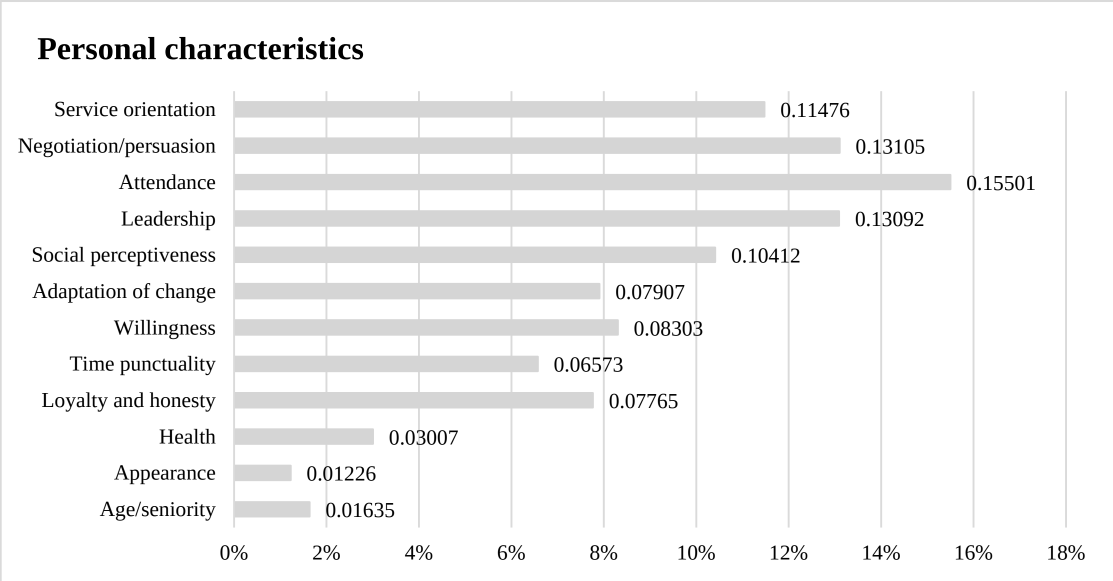


Figure 4.24 Case study 3 : AHP chart of personal characteristics main criterion

However, the importance weights and priorities obtained in personal characteristics cluster are not outstandingly different. Accordingly, compared to other case studies, plastics products companies tend to consider more personal characteristics sub-criteria which similar weights are provided.

On the other hand, skill clusters are categorized into general skills and technical skills. It is found that technical skills approximately yield 60% higher than the general skills, with 81.94% and only 18.06% achieved by general skills (see Figure 4.25).

From Figure 4.26, four criteria are considered in general skills cluster, namely active learning, decision-making/troubleshooting, situation awareness, and communication. However, analytical thinking, basic computer skill, and working in teams/cooperation are not included based on case study of plastic product.

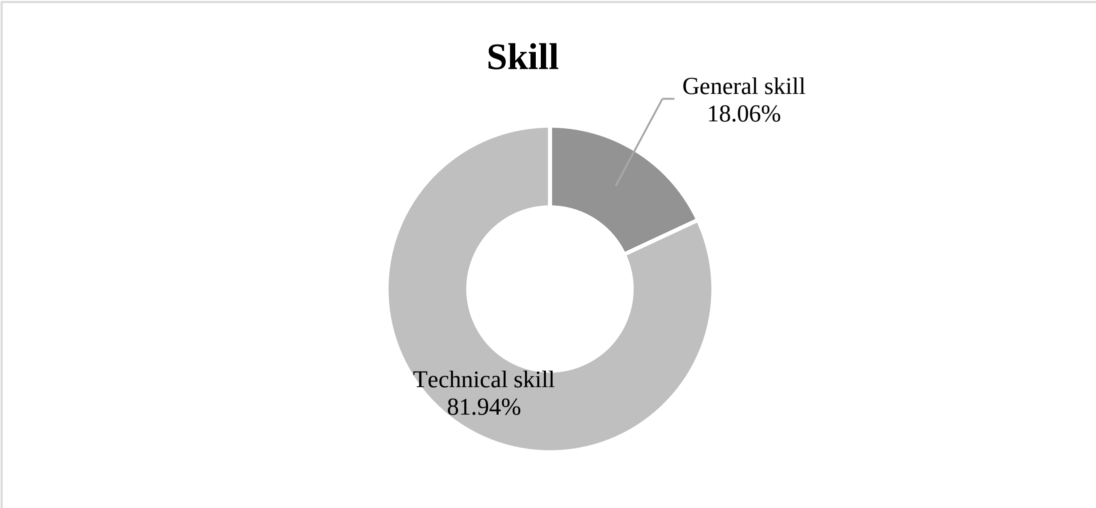


Figure 4.25 Case study 3 : AHP chart of skill main criterion

The results reveal that "decision-making/troubleshooting" criterion yield the highest importance weight in general skills cluster, by 37.54%. However the second ranking is achieved by communication criterion with 34.13%. Situation awareness 17.51% as the fourth ranking and active learning 10.82% as the lowest ranking.

On the other hand of technical skills, maintaining standards/following protocols plays an important role with the highest ranking by 57.29%. Whereas operation and control sub-criteria achieved 25.18% weight of the second ranking, and the bottom ranking 17.54% by operation monitoring criterion.

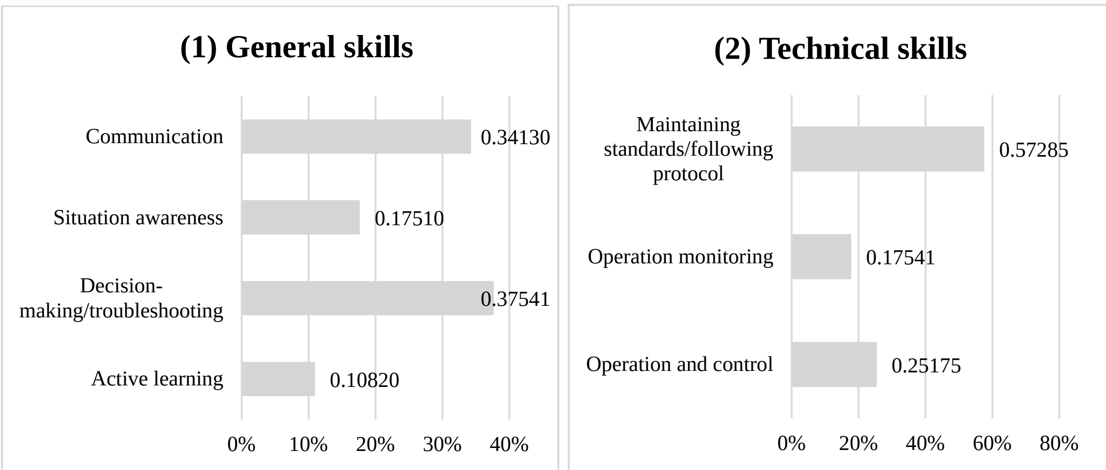


Figure 4.26 Case study 3 : AHP chart of skill sub-criteria

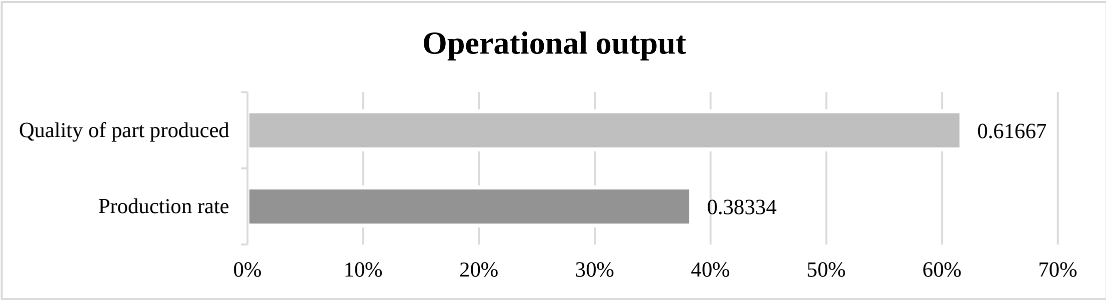


Figure 4.27 Case study 3 : AHP chart of operational output main criterion

With respect to the manufacturing of plastic products, operational output cluster yields the highest importance weight compared to other clusters. Figure 4.27 presents AHP result of operational output sub-criteria obtained from the case study companies, it reveals that the quality of part produced is obviously more important by 61.67% compared to the production rate which yields 38.33%.

Table 4.6 presents rankings and priorities obtained from case study 3 of plastic products, main criteria (cluster) and sub-criteria (node) are organized as follow.

Table 4.6 Case study 3 : Ranking of semi-skilled worker selection criteria

Main criteria	Global Ranking	Sub-criteria	Global Ranking
(1) Operational output	39.91%	Quality of part produced	24.61%
(2) Experience	33.53%	Operations familiarity	20.28%
(3) Skill	14.41%	Production rate	15.30%
(4) Personal characteristics	6.64%	Working knowledge	9.94%
		Maintaining standards/ following protocol	6.76%
		Qualifications or job title	3.52%
		Year of experience	3.31%
		Operation and control	2.97%
		Operation monitoring	2.07%
		Working licenses	1.55%
		Attendance	1.03%
		Decision-making/troubleshooting	0.98%
		Communication	0.89%

Table 4.6 Case study 3 : Ranking of semi-skilled worker selection criteria (continued)

Main criteria	Global Ranking	Sub-criteria	Global Ranking
-	-	Negotiation/persuasion	0.87%
		Leadership	0.87%
		Service orientation	0.76%
		Social perceptiveness	0.69%
		Willingness	0.55%
		Adaptation of change	0.52%
		Loyalty and honesty	0.52%
		Situation awareness	0.46%
		Time punctuality	0.44%
		Educational background	0.44%
		Active learning	0.28%
		Health	0.20%
		Age/seniority	0.11%
		Appearance	0.08%

From the viewpoint of clusters, it reveals that “operational output” obviously yields the maximum importance weight by 39.91%. While experience achieves 33.53% which is approximately 6% lower as the second ranking cluster. And 14.41% is weighted for skill main criterion (ranking 3). It is also found that personal characteristics and competency similarly yields by 6.64% and 5.51% as two lowest rankings respectively.

Accordingly the semi-skilled worker selection based on operations of plastic manufacturing, the top three rankings of sub-criteria includes quality of part produced 24.61% (first ranking), operations familiarity 20.28%, and production rate 15.30%. It is evident that two of those criteria are in the operational output cluster. Working knowledge achieves the third ranking by 9.94% and maintaining standards/following protocol by 6.76% respectively. Respectively, the criteria vary between 1.00% - 4.00% includes qualifications or job title 3.52%, year of experience 3.31%, operation and control 2.97%, operation monitoring 2.07%, working licenses 1.55%, and attendance 1.03%. Whereas the rest which is mostly in characteristics and competency clusters yields less than 1.00% importance weight, decision-making/troubleshooting, communication, negotiation/persuasion, leadership, service orientation, social perceptiveness, willingness, adaptation of change, loyalty and honesty, situation awareness, time punctuality, educational background, active learning, health, age/seniority, and appearance as the lowest ranking.

The overview of semi-skilled worker selection criteria in case study 3 of plastic products could be concluded that the “operational output” factor plays a great role in evaluating worker performance as well as the “experience”, which highly impacts the production efficiency. On the other hand, the skill cluster is weighted as the third ranking with only 14.41% or approximately 2.6 times lower than the operational output criterion. It is evident that skill of operational workers is not obviously outstanding. However, skill main criterion yields higher weight compared to personal characteristics and competency criterion. The competency criterion as the lowest priority indicates that educational background, qualifications or job title, and working licenses are less considered in the selection practice. Furthermore, compared to all other case study, it is found that working licenses in the competency cluster is considered only in plastic products case study while training level is neglected.

- Case study 4: Steel products

The hierarchical structure of all worker selection criteria in steel products is illustrated in Figure 4.28. It consists of five pillars (main criteria), competency, experience, personal characteristics, skill, and operational output. In competency main criteria, three sub-criteria is considered includes educational background, qualifications of job title, and training level. However the working licenses sub-criteria is not considered in this case. All three sub-criteria of experience cluster are highlighted, (1) year of experience, (2) operational familiarity, and (3) working knowledge. With respect to the perspective and context of steel industry, only four sub-criteria are taken into account namely age/seniority, appearance, health, and willingness. Meanwhile, the skill cluster is categorized into general skills and technical skills, active learning, communication, and working in teams/cooperation are weighted in general skills whereas task preparation and prioritization, operation and control, maintaining standards/following protocol are taken into account for technical skills. The operational output cluster similarly includes production rate and quality of part produced.

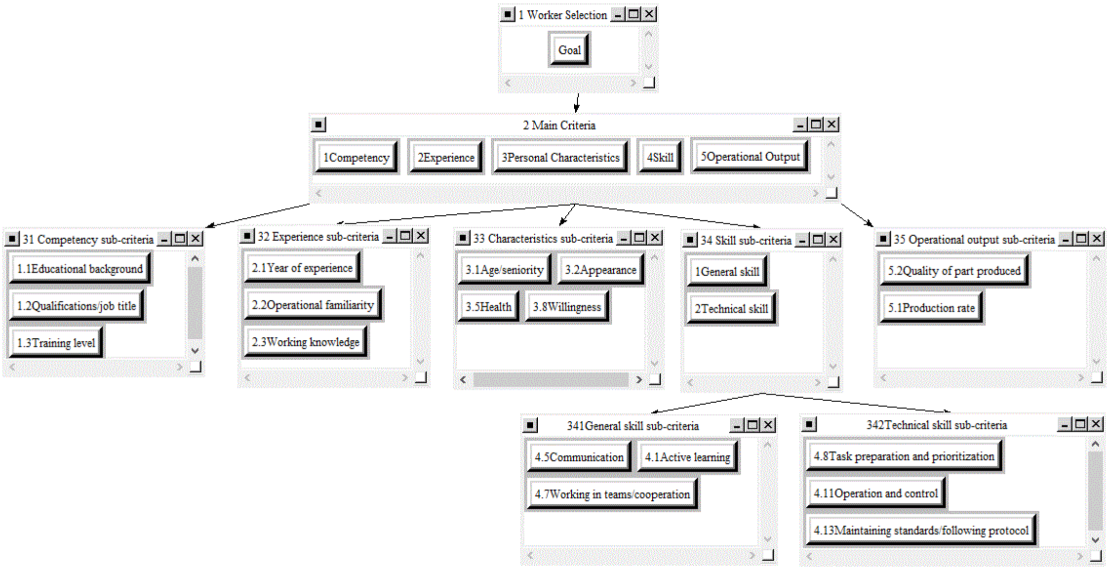


Figure 4.28 Case study 4 : Hierarchical structure of selection criteria

The AHP computational results of case study 4 (steel products) derived from Super Decision software are presented in Table 4.7.

Table 4.7 Case study 4 : Computational results of AHP

Main criteria	Cluster priority	Consistency Ratio (CR)	Sub-criteria	Local weight	Global priority
Competency	0.11481	$S_1$0.00000 $S_2$0.09837	Educational background	0.14545	1.67%
			Qualifications or job title	0.43576	5.00%
			Training level	0.41879	4.81%
Experience	0.15276	$S_1$0.05156 $S_2$0.09837	Year of experience	0.42186	6.44%
			Operational familiarity	0.36845	5.63%
			Working knowledge	0.20970	3.20%
Personal characteristics	0.21424	$S_1$0.03997 $S_2$0.09331	Age/seniority	0.17778	3.81%
			Appearance	0.06298	1.35%
			Health	0.37638	8.06%
			Willingness	0.38287	8.20%
Skill	0.17199	$S_1$0.00000 $S_2$0.05156	*General skills*	*0.35000*	
			Active learning	0.26456	1.59%
			Communication	0.32208	1.94%
			Working in teams/ cooperation	0.41336	2.49%

Table 4.7 Case study 4 : Computational results of AHP (continued)

Main criteria	Cluster priority	Consistency Ratio (CR)	Sub-criteria	Local weight	Global priority
		$S_1$0.01759 $S_2$0.00000	*Technical skills*	*0.65000*	
			Task preparation and prioritization	0.24511	2.74%
			Operation and control	0.22992	2.57%
			Maintaining standards/ following protocol	0.52498	5.87%
Operational output	0.34622	-*	Production rate	0.41667	14.43%
			Quality of part produced	0.58334	20.20%

*The Consistency Ratio (CR) is possible to obtain with more than or equal to three factors (n≥3).

From Table 4.7, it is evident that all CR values are less than 10% following to the acceptable range of conflict data within the cluster. Rankings and priorities of each single cluster are concluded and illustrated in charts from Figure 4.29 – 4.35.

Five dimensions of clusters with respect to case studies of steel products manufacturing (see Figure 4.29) indicate that, “operational output” cluster obviously yields the highest ranking by 34.62%. Moreover, it is found that 21.42% which achieved the second ranking has been drawn by personal characteristics cluster and it is the maximum weight compared to case study 1 and 2. The rest of clusters closely yield, skill by 17.20% (ranking 3), experience by 15.28% (ranking 4), and competency 11.48% as the lowest ranking.

In competency cluster, three sub-criteria are taken into account (1) educational background, (2) qualifications or job title, and (3) training level. Figure 4.30 reveals that the qualifications or job title sub-criteria yields the first ranking by 43.58%. However, 41.88% derived by the training level sub-criteria as the second ranking. And the educational background yields the lowest ranking by 14.55%. This reflects that the previous job description and training achievements of semi-skilled worker in steel production are highly focused compared to the educational background which is slightly considered. The AHP result of competency main criterion is shown in Figure 4.30.

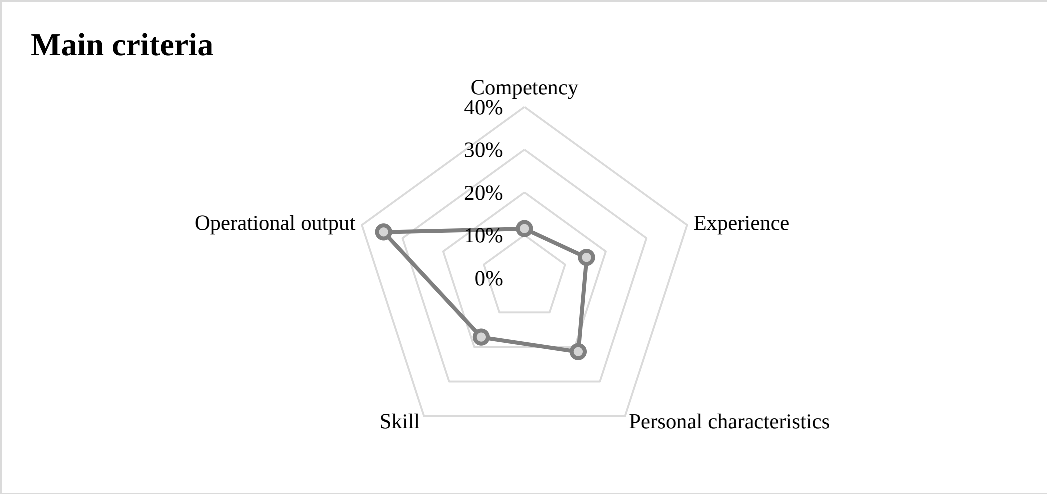


Figure 4.29 Case study 4 : Main criteria priority matrix

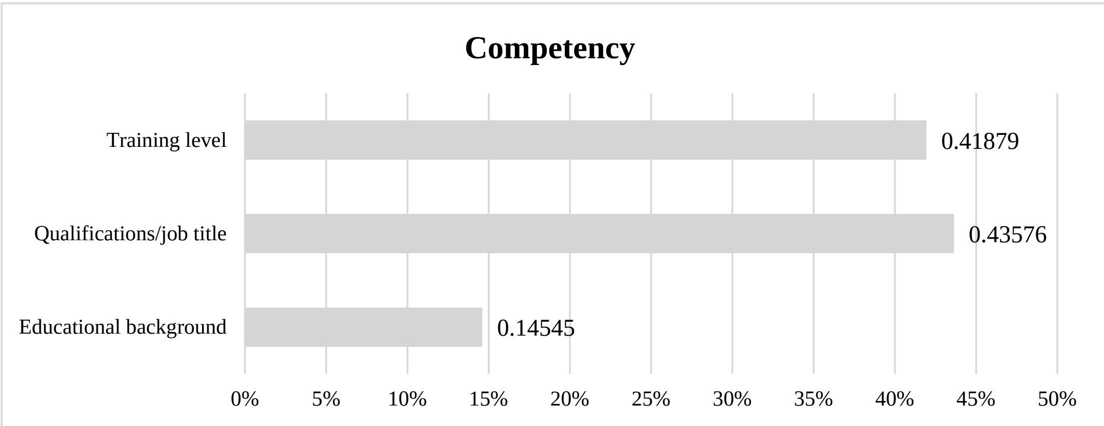


Figure 4.30 Case study 4 : AHP chart of competency main criterion

Year of experience sub-criterion yields the highest importance weight by 42.19% in experience cluster (see Figure 4.31). While operational familiarity achieves 36.85% and working knowledge 20.97% respectively. According to the manufacturing nature of steel products, year of experience in any related fields of semi-skilled worker plays any important role in operational working since it is considered as a specific manufacturing and technical professions are required.

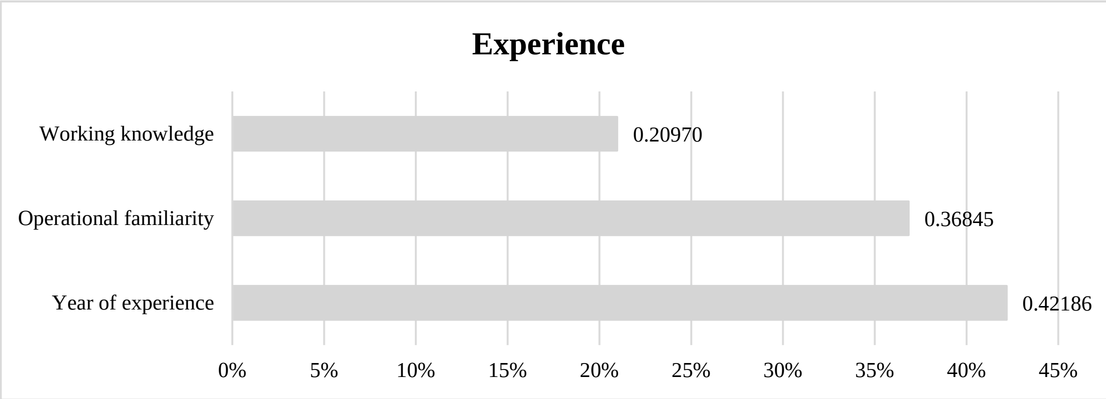


Figure 4.31 Case study 4 : AHP chart of experience main criterion

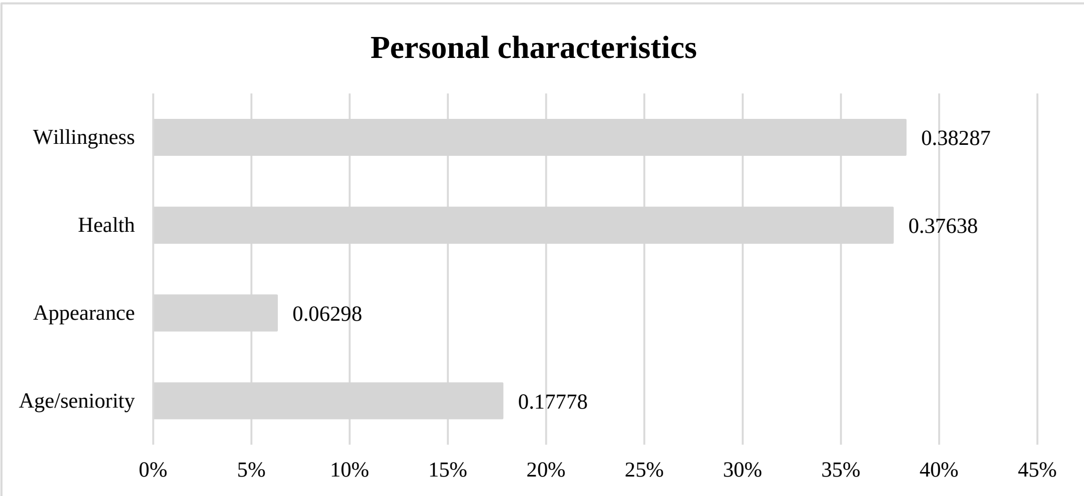


Figure 4.32 Case study 4 : AHP chart of personal characteristics main criterion

Figure 4.32 presents the AHP results derived from personal characteristics cluster, it is evident that willingness and health significantly achieve the similar yields by 38.29% and 37.64% as ranking 1 and 2 respectively. Whereas 17.78% is weighted by age/seniority as ranking 3. And the appearance sub-criterion achieves the lowest ranking with only 6.30%. However, culture, determination of goal, loyalty and honesty, time punctuality, adaptation of change, social perceptiveness, leadership, attendance, negotiation/persuasion, and service orientation are not taken into account with respect to the manufacturing of steel products based on case study.

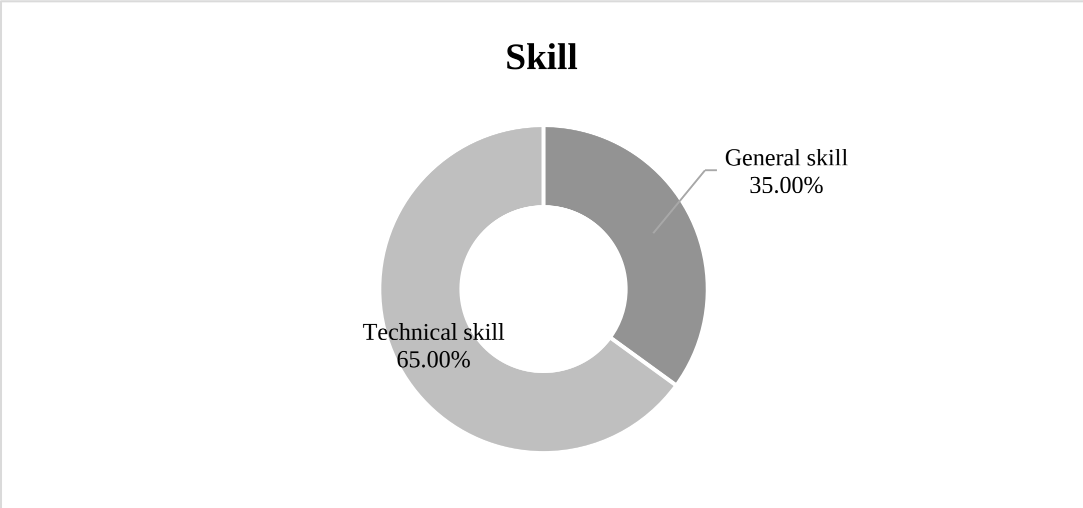


Figure 4.33 Case study 4 : AHP chart of skill main criterion

The skill cluster are similarly categorized into two sub-criteria, general skills and technical skills as shown in Figure 4.33. According to the AHP, it reveals that technical skills yield the higher weight by 65.00% and 35% for the general skills based on case study 4 of steel products.

For general skills (see Figure 4.34), three sub-criteria are considered includes (1) active learning, (2) communication, and (3) working in teams/cooperation. It is found that those three criteria are not obviously different from weights achieved. However, 41.34% as the first ranking is yielded by working in teams/cooperation criterion, 32.21% for communication (ranking 2), and the lowest ranking by 26.46% for active learning criterion.

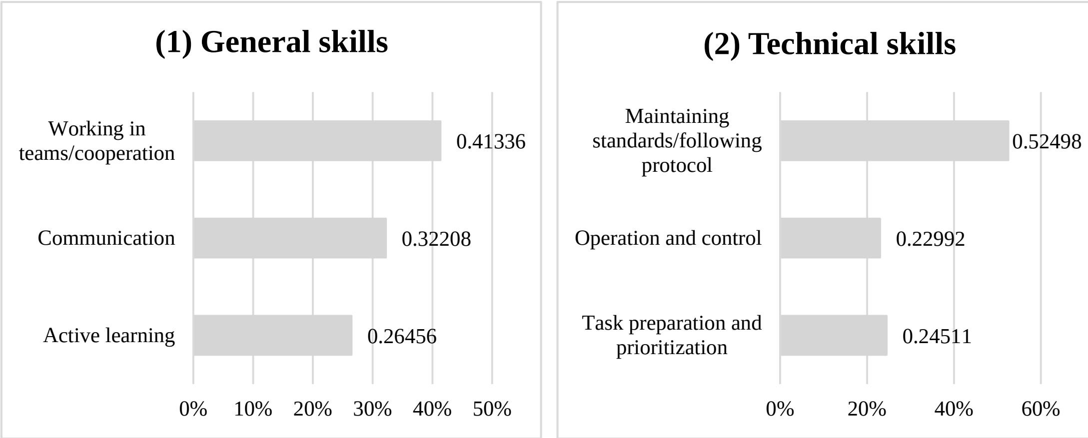


Figure 4.34 Case study 4 : AHP chart of skill sub-criteria

On the other hand, Figure 4.34 has shown that "maintaining standards/following protocol" yields the first ranking by 52.50% while task preparation and prioritization criterion achieves 24.51%, and 22.99% for operation and control respectively.

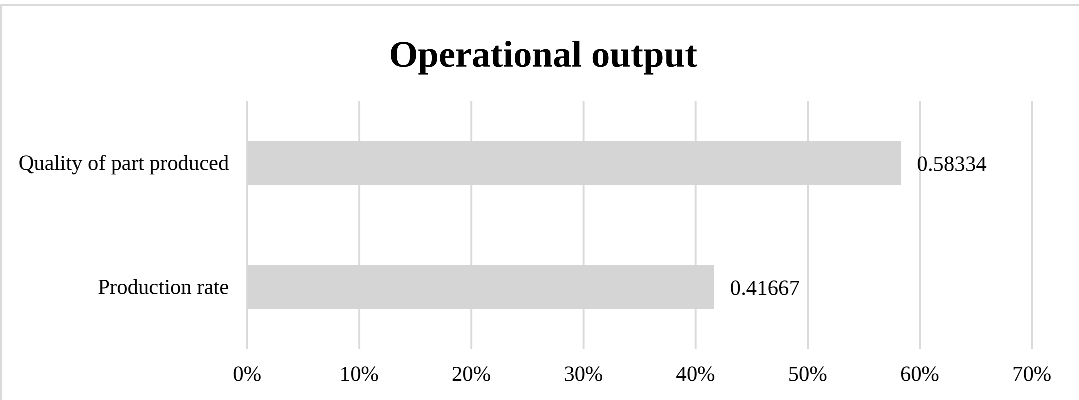


Figure 4.35 Case study 4 : AHP chart of operational output main criterion

Figure 4.35 presents the AHP result from the perspective of operational output cluster. Following to case study 4 (steels product), weights of two sub-criteria yielded are quite close by 58.33% for quality of part produced and 41.67% for production rate. Nevertheless, the quality of part produced are more focused compared to the rate of production.

Table 4.8 Case study 4 : Ranking of semi-skilled worker selection criteria

Main criteria	Global Ranking	Sub-criteria	Global Ranking
(1) Operational output	34.62%	Quality of part produced	20.20%
(2) Personal characteristics	21.42%	Production rate	14.43%
(3) Skill	17.20%	Willingness	8.20%
(4) Experience	15.28%	Health	8.06%
(5) Competency	11.48%	Year of experience	6.44%
		Maintaining standards/ following protocol	5.87%
		Operational familiarity	5.63%
		Qualifications/job title	5.00%
		Training level	4.81%
		Age/seniority	3.81%
		Working knowledge	3.20%
		Task preparation and prioritization	2.74%
		Operation and control	2.57%
		Working in teams/cooperation	2.49%
		Communication	1.94%
		Educational background	1.67%
		Active learning	1.59%
		Appearance	1.35%

Table 4.6 presents the overall priorities and rankings of five main criteria and eighteen sub-criteria derived from semi-skilled worker selection practice in steel products manufacturing companies (case study 4). In the viewpoint of clusters, it is evident that "operational output" main criterion yield the maximum importance weight by 34.62% compared to the other four main criteria which include personal characteristics, skill, experience, and competency. The second ranking criterion, personal characteristics achieves 13% less than the operational output (by 21.42%). For skill and experience, it is found to have similar weights by 17.20% and 15.28% respectively. The lowest ranking based on case study 4 is "competency" main criterion with 11.48%. However, weights achieved by the last three clusters are not obviously different.

Accordingly, the top two rankings of sub-criteria are quality of part produced by 20.20% and production rate 14.43%. In whilst, willingness and health criteria similarly yield 8.20% (ranking 3) and 8.06% (ranking 4) importance weights. The criteria which yield from 4.00% to 6.00% include year of experience 6.44%, maintaining standards/ following protocol 5.87%, operational familiarity 5.63%, qualifications/job title 5.00%, and training level 4.81% respectively. Moreover, five criteria consequently achieve weights between 2.00% to 4.00% which consists of age/seniority, working knowledge, task preparation and prioritization, operation and control, working in teams/cooperation. The last four criteria which yield the lowest ranking from 1.00% to 2.00% includes communication, educational background, active learning, and appearance. However, the ranking of AHP results yielded in steel products case study above has no exact pattern of clusters since all sub-criteria are crossly ranked.

4.1.2 Recruitment outsourcing providers

- Case study 5: Department of Employment (Thailand)

Department of Employment (DOE) is the organization that highly supports labor recruitment in industries with labor market situations and trends. It primarily works as a labor market information center to facilitate both parties of manufacturing industries and employees. Matching working people with the most suitable job functions following to their knowledge and aptitudes, which respond to the firm’s requirements. Shortly, DOE performs as a middleman who plays a significant role in connecting two mentioned parties and provides benefits in term of human resource management. This is not only expediting domestic labor market from employee’s viewpoint but also various industries which highly drive the overall economics forward.

The main functions of DOE are as follows (DOE, Ministry of Labor):

1) Proceeding all legal matters according to the Recruitment and Job Seekers Protection Act, the Working of Alien Act, and other relevant laws.

2) Analyzing labor market situation, forecasting the trends of labor market demand and supply, and being the labor market information center.

3) Developing employment service system, measures, and recruitment procedures, as well as preparing and coordinating the Department’s action plan to

comply with the policies and strategies of the Ministry of Labor and specifying occupational and industrial standards.

4) Providing vocational guidance, career counseling, and aptitude tests to the general public.

5) Performing all duties as prescribed by laws or assigned by the Ministry or the Cabinet.

Based on the semi-skill worker selection practices of all four labor-intensive case studies, there are two main ways in recruiting the operational workers in general. Firstly "self-recruitment", a company would process the recruitment following to its hiring process by seeking a pool of works itself. This is a common practice of many manufacturing firms, however it is found that a number of organizations recruit the operational worker from outsourcing party or recruitment companies. As the alternative recruitment method "outsourcing recruitment", services provided by DOE is one efficient way to seek for pool of workers with required qualifications.

From the investigation of the case study 5, the hierarchical structure of all derived worker selection criteria based on the perspective of labor specialists (DOE, Ministry of Labor) is illustrated in Figure 4.36.

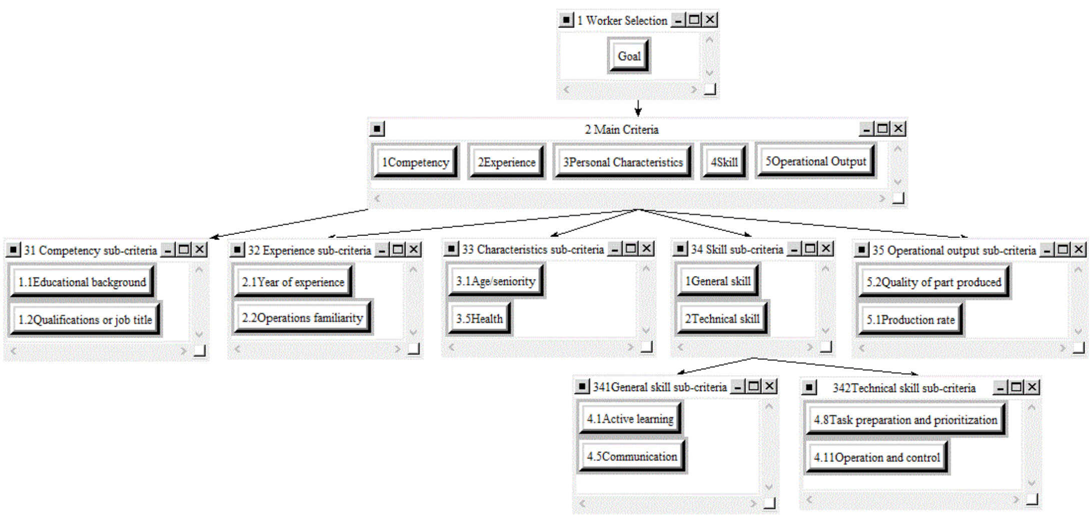


Figure 4.36 Case study 5 : Hierarchical structure of selection criteria

According to the important role of DOE above-mentioned, selection criteria derived from recruitment outsourcing providers generate the different perspectives which creates values in this research. It is obviously seen from Figure 4.36 that less criteria are considered in case study 5 compared to four case studies from industry viewpoints.

Five main criteria are similarly discussed, competency, experience, personal characteristics, skill, and operational output. In competency cluster, only two criteria are considered includes educational background and qualifications or job title. However, training level and working licenses criteria are not discussed since the semi-skilled workers are only required with basic qualifications and skills. The experience cluster consists of two sub-criteria, year of experience and operation familiarity. Only age/seniority and health are considered in the personal characteristics cluster. Similarly, the skill is categorized into general skills and technical skills. The general skills based on DOE case study include active learning and communication sub-criteria while the technical skills consist of task preparation and prioritization, and operation and control. The production rate and quality of part produced sub-criteria are investigated in operational output cluster.

Table 4.9 Case study 5 : Computational results of AHP

Main criteria	Cluster priority	Consistency Ratio (CR)	Sub-criteria	Local weight	Global priority
Competency	0.04706	-*	Educational background	0.29166	1.37%
			Qualifications or job title	0.70835	3.33%
Experience	0.12071	-*	Year of experience	0.62501	7.54%
			Operational familiarity	0.37500	4.53%
Personal characteristics	0.15088	-*	Age/seniority	0.29999	4.53%
			Health	0.70001	10.56%
Skill	0.35040	-*	*General skills*	*0.14600*	
			Active learning	0.50000	7.30%
			Communication	0.50000	7.30%
		-*	*Technical skills*	*0.20440*	
			Task preparation and prioritization	0.47917	9.79%
			Operation and control	0.52084	10.65%
Operational output	0.33096	-*	Production rate	0.41667	13.79%
			Quality of part produced	0.58334	19.31%

*The Consistency Ratio (CR) is possible to obtain with more than or equal to three factors (n≥3).

Table 4.9 presents the importance weights of both clusters and nodes obtained from AHP model, based on the perspective of outsourcing recruitment providers (DOE). Accordingly, CR value in this case study is not applicable since all clusters consist of two sub-criteria. However, weights and priorities of each single sub-criteria are illustrated in Figure 4.37 – 4.43 categorized by clusters.

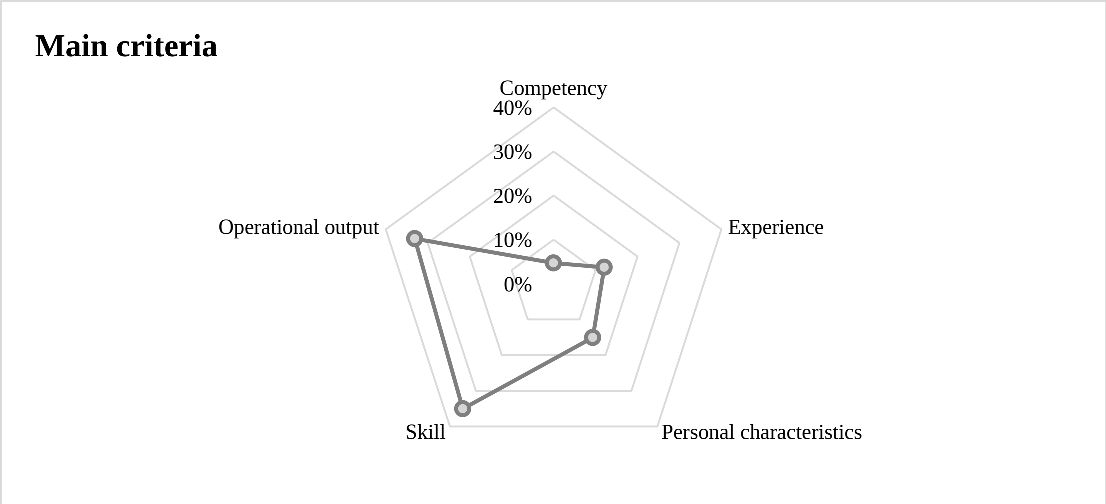


Figure 4.37 Case study 5 : Main criteria priority matrix

Five main clusters are discussed in Figure 4.37, it is seen that operational output and skill criteria are outstanding in range between 30 – 40%. The skill cluster yields the highest ranking by 35.04% while operational output cluster achieved the second ranking by 33.10%, approximately 2% less from the first ranking. The personal characteristics and experience are in range between 10 – 20% with weights of 15.09% and 12.07% respectively. It is evident that the competency cluster yields the lowest ranking by less than 10% (4.71%).

With respect to the DOE perspective, it is evident that skill criterion is considered as the most important factor in recruiting semi-skilled worker. However, the operational output tends to be another significant factor which closely yields as the skill criterion.

Figure 4.38 presents the AHP result obtained from competency cluster, two sub-criteria are investigated. The chart reveals that "qualifications or job title" obviously yield the first ranking by 70.84% while educational background is 40% less by 29.17% importance weight.

Accordingly, the educational background is slightly considered in selecting semi-skilled worker practice compared to the qualifications or job title which indicates more in an individual qualifications and job functions achieved by a worker.

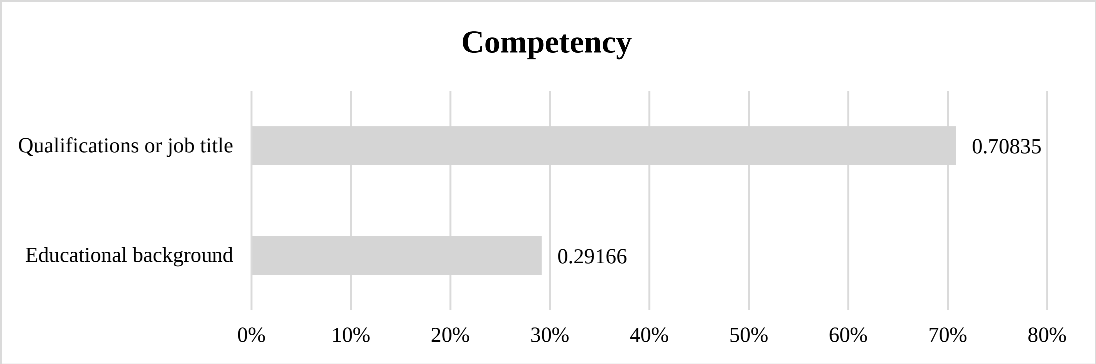


Figure 4.38 Case study 5 : AHP chart of competency main criterion

In the experience cluster shown in Figure 4.39, operational familiarity and year of experience are discussed. It is evident that “year of experience” criterion outstandingly yield the higher priority compared to the operational familiarity by 62.50% and 37.50% respectively. A number of manufacturing companies focus more on long-term experience in any related filed achieved by a single employee while the operational familiarity is secondly considered since it also indicates how professional a worker is, in a specific capability.

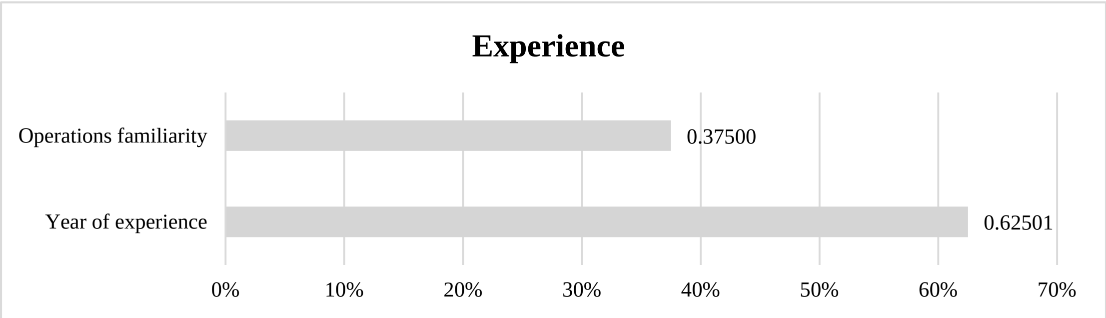


Figure 4.39 Case study 5 : AHP chart of experience main criterion

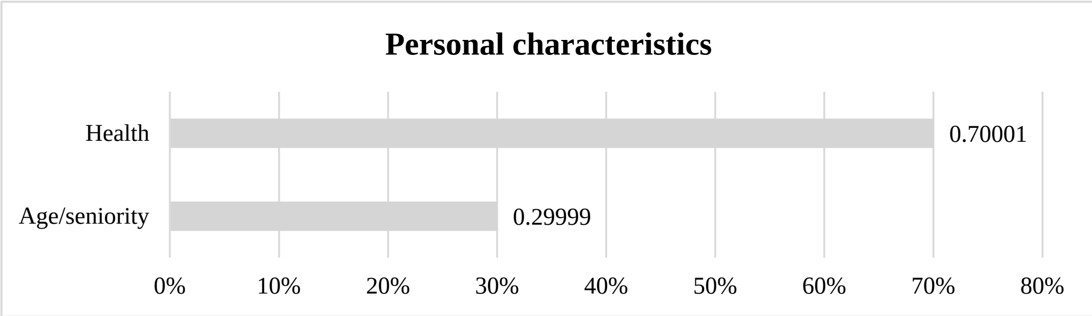


Figure 4.40 Case study 5 : AHP chart of personal characteristics main criterion

Two sub-criteria are investigated in personal characteristics cluster, health and age/seniority. Based on the labor specialist viewpoints, “health” is highly yield by 70.00% as the first ranking whereas the lower ranking of 30.00% is achieved by age/seniority criterion.

On the other hand, general skills and technical skills are categorized in the skill cluster. Figure 4.41 indicates that both criteria similarly yield in priorities, however the technical skills achieve 17% higher (58.33%) while the general skills obtain 41.67% respectively.

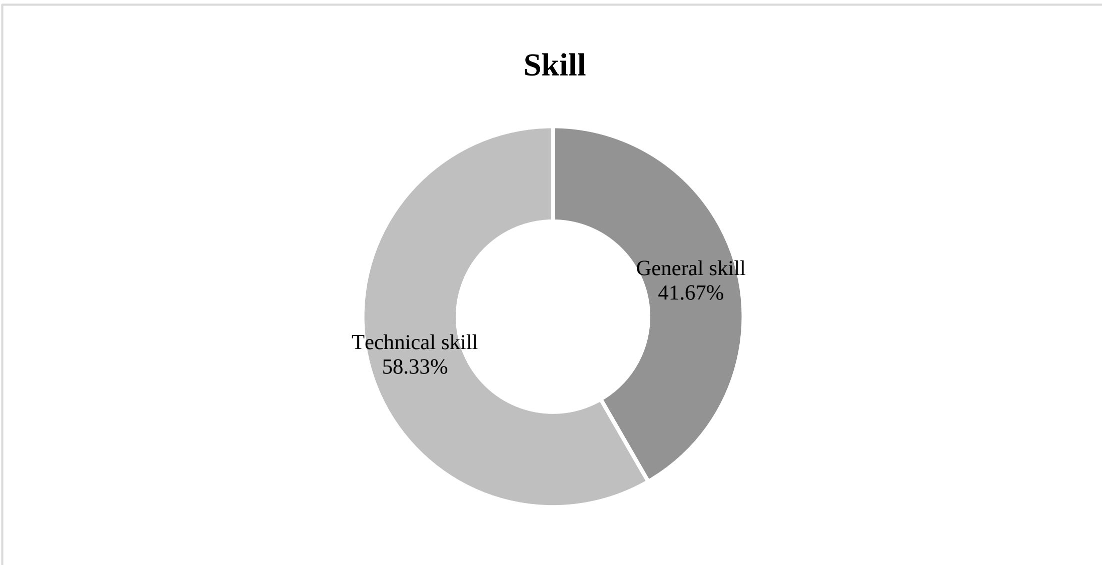


Figure 4.41 Case study 5 : AHP chart of skill main criterion

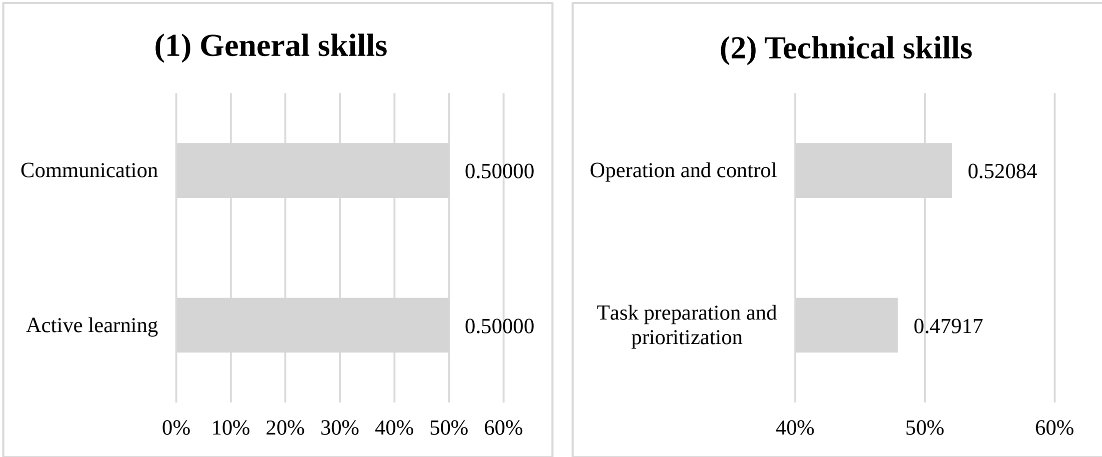


Figure 4.42 Case study 5 : AHP chart of skill sub-criteria

It is clearly seen that communication and active learning sub-criteria yield exactly the same priorities in general skills cluster, or 50% and 50% (see Figure 4.42). Similarly to the technical skills cluster, 52.08% yielded by operation and control sub-criteria as the higher ranking and 47.92% yielded by task preparation and prioritization as the lower ranking.

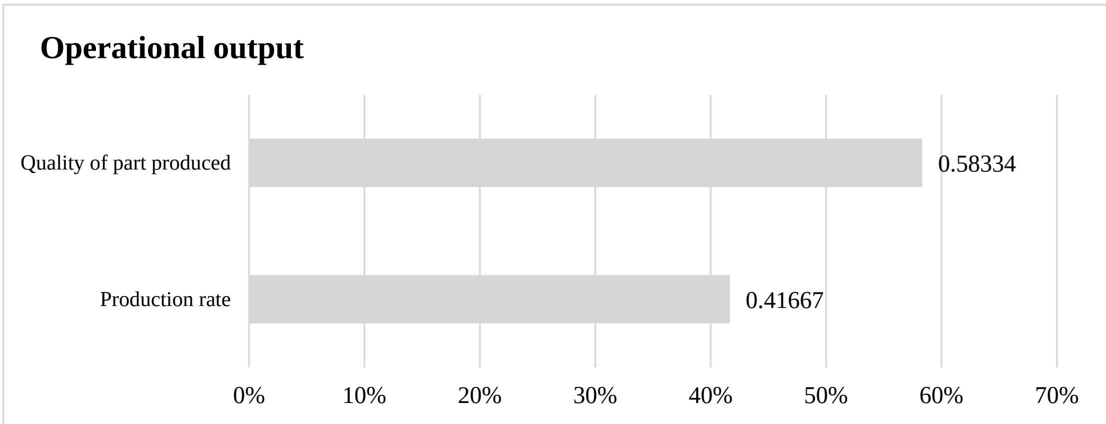


Figure 4.43 Case study 5 : AHP chart of operational output criterion

Figure 4.43 illustrates the AHP result obtained from the operational output cluster, it is found that quality of part produced achieves 58.33% importance weight while the production rate criterion yields 41.67% respectively. According to the production rate factor or quantity of the work-in-process/finished product produced in a certain amount of time, it commonly plays a great role in all manufacturing companies as mass production is mostly operates. However, the quality of production significantly achieves higher weights and tends to be a critical factor in measuring an individual worker performance which leads to the overall manufacturing output in term of investment.

Table 4.10 Case study 5 : Ranking of semi-skilled worker selection criteria

Main criteria	Global Ranking	Sub-criteria	Global Ranking
(1) Skill	35.04%	Quality of part produced	19.31%
(2) Operational output	33.10%	Production rate	13.79%
(3) Personal characteristics	15.09%	Operation and control	10.65%
(4) Experience	12.07%	Health	10.56%
(5) Competency	4.71%	Task preparation and prioritization	9.79%
		Year of experience	7.54%
		Active learning	7.30%
		Communication	7.30%
		Operations familiarity	4.53%
		Age/seniority	4.53%
		Qualifications or job title	3.33%
		Educational background	1.37%

The overall AHP rankings and priorities of semi-skilled worker selection criteria obtained from case study 5 (DOE) are summarized in Table 4.10.

Following to the cluster point of view, “skill” cluster achieves the highest ranking by 35.04%. However, the second ranking has been drawn to the operational output cluster which closely yields the first ranking by 33.20%. As a recruitment outsourcing providers, it is found that skill and operational output factors are corresponding with significant AHP weights.

The personal characteristics cluster yields the third ranking with 18% less than the operational output cluster (15.09%), following by the experience cluster which achieves 12.07%. And the lowest ranking with only 4.71% is the competency cluster. Convincingly, the skill and operational output are the outstanding main criteria in semi-skilled worker selection practice in the context of labor-intensive industry.

In the perspective of sub-criteria, “quality of part produced” criterion obviously yield the top ranking by 19.31% and production rate as the second ranking by 13.79%. Accordingly, operation and control from skill cluster and health from the personal characteristics cluster similarly yield the importance weights of 10.65% and 10.56% respectively. In whilst, the rest of sub-criteria obtained less than 10% global priorities, task preparation and prioritization 9.79%, year of experience 7.54%, active learning 7.30%, communication 7.30%, operations familiarity 4.53%, age/seniority 4.53%, qualifications or job title 3.33%, and educational background 1.37% as the lowest ranking criterion. Accordingly, the two lowest ranking criteria are qualifications or job title and educational background from the competency cluster which achieves the lowest ranking cluster compared to the other four main criteria.

Conclusively, a number of semi-skilled worker selection criteria obtained from case study 5 as the recruitment outsourcing providers are less considered compared to the other four case studies from manufacturing perspectives in various industries. Moreover, most of the criteria discussed tend to be the basic requirements of employee’s qualifications which are not obviously specific in a single context.

4.1.3 Case studies analysis

The overall computational results of semi-skilled worker selection criteria in labor-intensive industry obtained from AHP model are discussed in this section.

The objecitves of this research primarily focus on worker selection practices in various manufacturing environments with respect to labor-intensive perspective. Five different case studies are investigated, i.e. 1) food products, 2) textiles/wearing apparel products, 3) plastic products, 4) steel products, and 5) recruitment outsourcing providers (DOE). The importance weights and priorities derived from AHP model are presented in Table 4.11 and 4.12, categorized by case studies.

Table 4.11 AHP Importance weights of main criteria

Main criteria	Case study					Average
	1	2	3	4	5	
	Food	Textile	Plastic	Steel	Outsource	
(1) Competency	4.19%	15.50%	5.51%	11.48%	4.71%	8.2767%
(2) Experience	10.14%	30.23%	33.53%	15.28%	12.07%	20.2512%
(3) Personal characteristics	17.06%	3.38%	6.64%	21.42%	15.09%	12.7187%
(4) Skill	21.32%	13.29%	14.41%	17.20%	35.04%	20.2511%
(5) Operational output	47.29%	37.59%	39.91%	34.62%	33.10%	38.5024%

The AHP importance weights shown in Table 4.11 by the *average column* indicates that “operational output” criterion of production rate and quality of part produced yields the highest weight as the first priority of semi-skilled worker selection practice with 38.50% following to all case studies in labor-intensive industry. Meanwhile experience and skill criteria similarly achieve the percentages which experience criterion slightly yields more in the fourth decimal level (20.2512%). Accordingly, personal characteristics takes 12.72% as the forth ranking that is approximately 7% less than experience and skill criteria. The lowest ranking criterion has been drawn to competency cluster which plays less important role in semi-skilled selection practice including the sub-criteria of educational background, qualifications or job title, training level, and working license.

Following to the case studies discussion, it is found that textile ranks the highest weight for competency criterion by 15.50% while food ranks the lowest weight (4.19%). In the viewpoint of experience cluster, plastic case study provides the maximum weight by 33.53% while food case study oppositely provides the lowest (10.14%). It is also found that three case studies of 1, 4 and 5 similarly weight by less than 16% for the experience cluster whereas textile and plastic (case study 2 and 3) provide more than 30%. Similarly, the case study of steel products ranks the highest weight (21.42%) for personal characteristics cluster compared to the other four case studies while textile ranks the lowest by 3.38%. The percentage provided for personal characteristics cluster could be conclude into two groups, the first group includes case study 1, 4 and 5 which provide weights more than 15% while the second group of case study 2 and 3 (textile and plastic products) provide less than 7%. For the skill cluster, it is evident that the case study of outsourcing providers give the maximum weights with 35.04% meanwhile textile pays less attention in the skill criteria by 13.29% weighting the lowest.

As the top ranking of all case studies, the operational output cluster obviously achieves the maximum weight by food products (case study 1) with 47.29%, and the minimum yield from outsourcing providers (case study 5) by 33.10%. Within this cluster, it is found that all case studies provide weights more than 30% which is clearly high compared to other four clusters.

Table 4.12 Rankings of main criteria

Main criteria	Case study					
	1	2	3	4	5	**Overall Ranking**
	Food	Textile	Plastic	Steel	Outsource	
(1) Competency	5	3	5	5	5	**5**
(2) Experience	4	2	2	4	4	**2**
(3) Personal characteristics	3	5	4	2	3	**4**
(4) Skill	2	4	3	3	1	**3**
(5) Operational output	1	1	1	1	2	**1**

From Table 4.12, all rankings of main criteria categorized by case studies are presented. It is found that four from five case studies rank the "competency" as the lowest priority including case study 1, 3, 4, and 5 whereas case study 2 (textiles/ wearing apparel) ranks competency criterion as the third priority. Obviously, four case studies yield "operational output" cluster as the first ranking which include food products, textiles/wearing apparel products, plastic products, and steel products. However, case study 5 of recruitment outsourcing providers (DOE) ranks the operational output as the second priority. This could be concluded that operational output is the most important factor which highly impacts the overall manufacturing performance based on labor-intensive industry viewpoints. Moreover, three case studies yield "experience" criterion as the fourth ranking includes food products, steel products and recruitment outsourcing providers while textiles/wearing apparel and plastic products yield experience as the second ranking.

Figure 4.44 presents the overview result obtained from AHP model. Following to the chart below, five dimensions on the axis represents five different case studies, i.e. food, textile, steel, plastic, and outsource. Lines appeared in the chart indicates data obtained from those case studies, categorized by a single main criterion (cluster). It is evident that the area of operational output criterion achieves the maximum weight for all case studies except outsource. However, this is entirely seen that operational output yields the largest area with more than 30% weight. Skill and experience criteria look quite similar by varying from 10 - 40%. The personal characteristics and competency criteria are obviously achieved low weights, where competency obtained the smallest area which is less than 20% as the lowest priority.

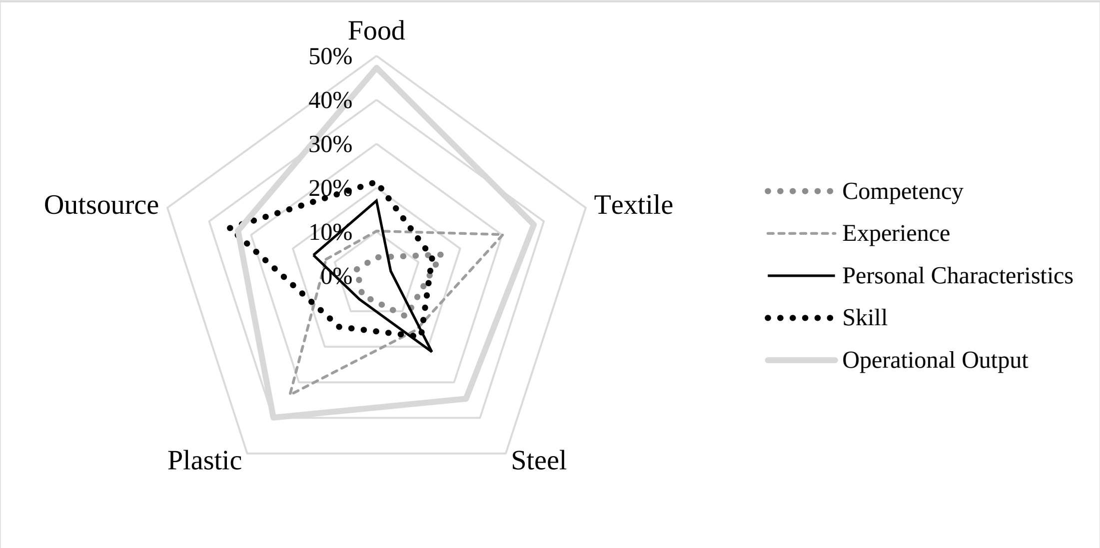


Figure 4.44 AHP results of clusters by case studies

It is obviously seen that “operational output” cluster yields the maximum weight with range varies from 30 – 50%, shown in Figure 4.45. This figure presents AHP results with five dimensions of selection main criteria and lines of different case studies to see the overall selection criteria in various manufacturing perspectives. Food is obviously obtained the highest weight seen from its line which is the nearest to operational output cluster. Plastic and textile are found to be close to each other, similarly to outsource and steel cases.

Experience and skill clusters widely vary from 10 – 40% however it is evident to be the secondary criteria obtained from AHP model. In experience viewpoint, textile and plastic are clearly seen with similar weights as well as the case studies of food, steel and outsource. On the other hand, steel ranks experience cluster with a higher weight compared to food and outsource but definitely lower than textile and plastic. On the other hand, the case studies of food and outsource provide the similar weights for personal characteristics cluster while steel gives the maximum weight. Accordingly, it is found that personal characteristics are slightly focused with less than 10% weights from textile and plastic case studies.

Following to the skill cluster, outsource obviously provide the maximum weight by 30 – 40%, whereas the other four case studies provide 10 – 20% only. Moreover, it is evident that all five case studies weight the competency cluster by less than 20% which could be significantly concluded that “competency” is not an important semi-skilled worker criterion in labor-intensive manufacturing with respect to five areas of cases.

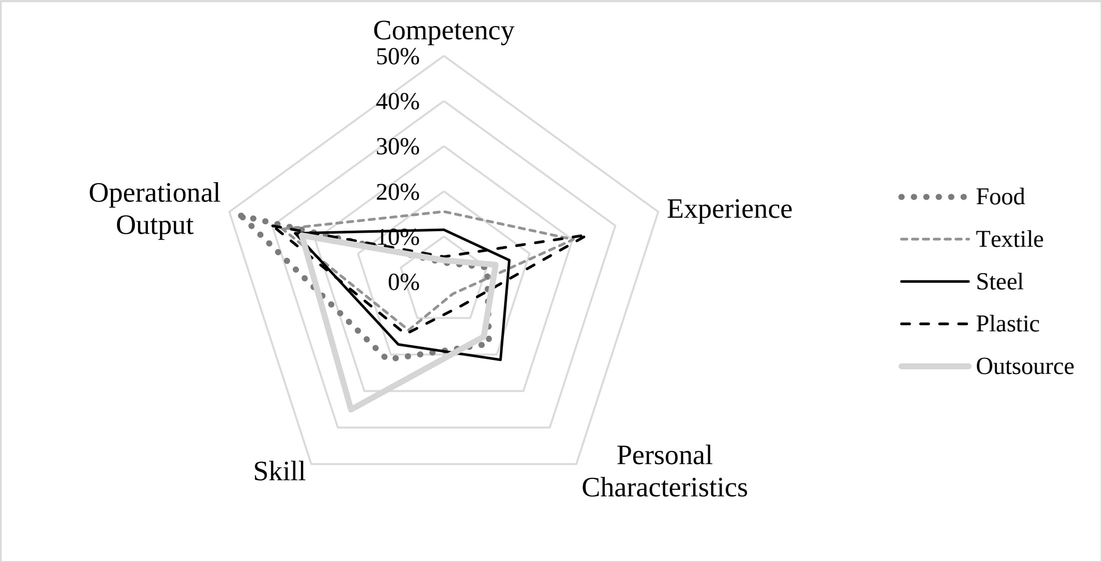


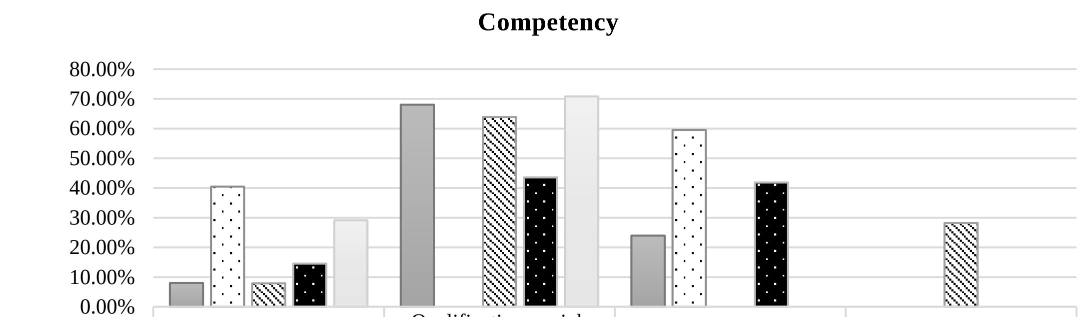
Figure 4.45 AHP results of case studies by clusters

The overall importance weights of semi-skilled worker selection main criteria obtained from five case studies are presented in Figure 4.45 (obtained from Table 4.11). The results are entirely concluded with respect to the similarities as follows.

- Case study 2 and 3 (textiles/wearing apparel and plastic products) provide the similar weights in four aspects, include experience, personal characteristics, skill, and operational output. In whilst, the competency cluster makes a small 10% difference which is higher provided by case study 2.

- Case study 1 and 4 (food and steel products) provide different weights for five aspects but all in the same ranks, see Table 4.12. However from Table 4.11, it is found that steel focuses more in personal characteristics, experience, and competency, compared to food since it provides the higher weights compared to food. Meanwhile, food concerns more in operational output and skill factors.

- Case study 5 (recruitment outsourcing providers) is outstandingly different from the other four case studies in skill aspect. This could be concluded that skill plays an important role in selection practice with respect to recruitment providers' perspective. However, the weights provided are not only similar to food products (case study 1) in experience and personal characteristics aspects but also steel products (case study 4) with respect to the operational output criteria.

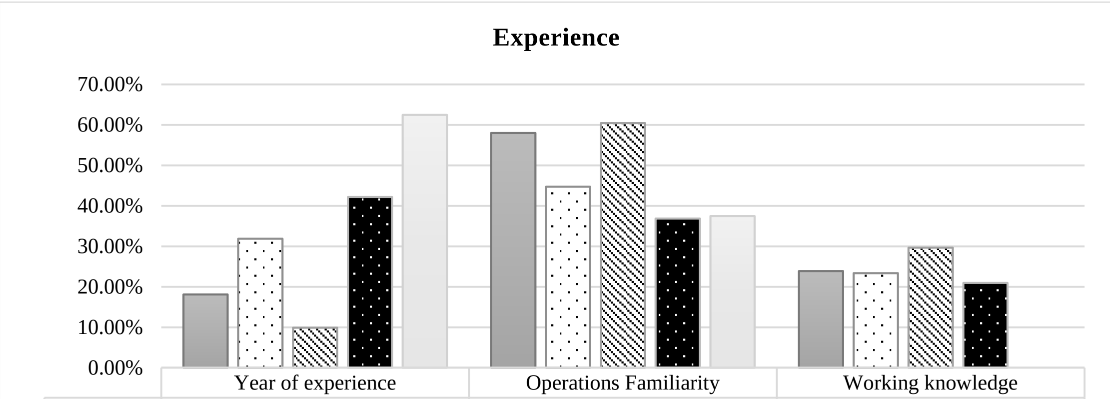


	Educational background	Qualifications or job title	Training level	Working Licenses
Food	8.00%	68.03%	23.97%	0.00%
Textile	40.48%	0.00%	59.52%	0.00%
Plastic	7.92%	63.87%	0.00%	28.22%
Steel	14.55%	43.58%	41.88%	0.00%
Outsource	29.17%	70.83%	0.00%	0.00%

Figure 4.46 AHP results of competency cluster by case studies

Figure 4.46 - 4.52 present a comparison of importance weights obtained from AHP models of five different case studies. The following worker selection sub-criteria within clusters of competency, experience, personal characteristics, general skills, and technical skills are separately discussed with respect to an individual case study context since the sub-criteria of those clusters are differently considered with respect to different policies implemented in selection practices. However, each single sub-criterion under skill and operational output clusters are investigated through all five case studies.

In competency cluster shown in Figure 4.46, the working licenses sub-criterion is only considered by plastic products. Educational background criterion is similarly weighted by food, steel, and plastics products with less than 20% importance weights whereas recruitment outsourcing providers and food products provide 30 – 40% respectively. It is evident in qualifications or job title criterion that achieves the similar weights by 40 – 70% from 100% as total. However, this criterion is not taken into account for case study 2 (textiles/wearing apparel products). Similarly to training level criterion, it is not considered in case study 3 and 5 (plastic product and outsource) respectively.

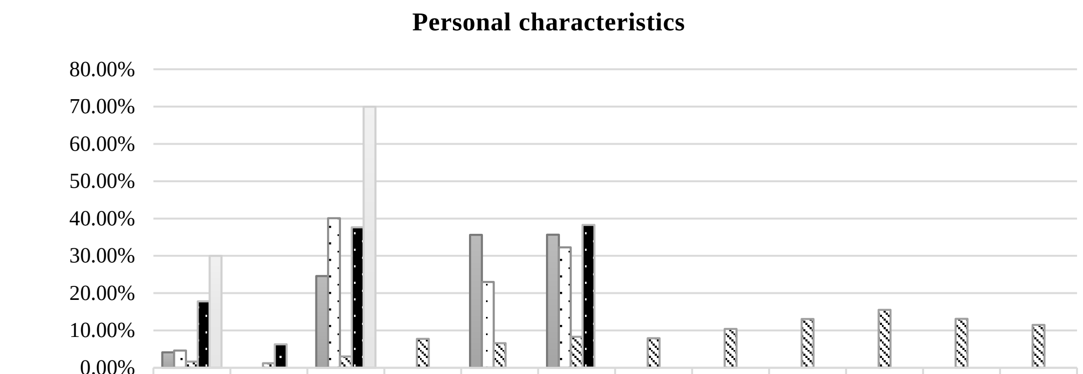


	Year of experience	Operations Familiarity	Working knowledge
Food	18.12%	58.00%	23.87%
Textile	31.88%	44.74%	23.38%
Plastic	9.88%	60.47%	29.65%
Steel	42.19%	36.84%	20.97%
Outsource	62.50%	37.50%	0.00%

Figure 4.47 AHP results of experience cluster by case studies

Following to the experience cluster illustrated in Figure 4.47, working knowledge criterion is similarly weight by 20 – 30% from four case studies (1 – 4) while it is neglected in case study 5. For operational familiarity criterion, more than 50% importance weights are provided by case study 1 and 3. This could be concluded that year of experience is significantly considered in selecting the semi-skilled worker by all case studies even though weights are varied in a big range (9 – 63%).

Twelve sub-criteria are discussed in the personal characteristics cluster (see Figure 4.48). Nevertheless, seven criteria include loyalty and honesty, adaptation of change, social perceptiveness, leadership, attendance, negotiation/persuasion, and service orientation are only discussed in case study 3 (plastic products).

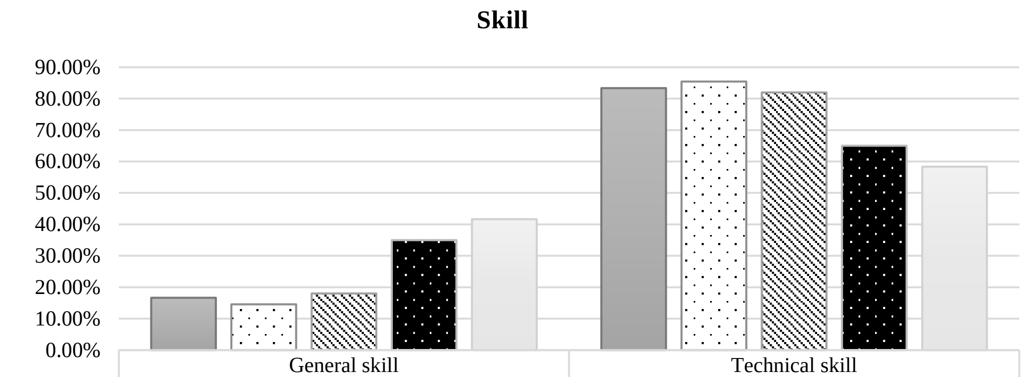


	Age/seniority	Appearance	Health	Loyalty and honesty	Time punctuality	Willingness	Adaptation of change	Social perceptiveness	Leadership	Attendance	Negotiation/persuasion	Service orientation
Food	4.13%	0.00%	24.57%	0.00%	35.64%	35.66%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Textile	4.61%	0.00%	40.09%	0.00%	23.01%	32.29%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Plastic	1.63%	1.23%	3.01%	7.76%	6.57%	8.30%	7.91%	10.41%	13.09%	15.50%	13.11%	11.48%
Steel	17.78%	6.30%	37.64%	0.00%	0.00%	38.29%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Outsource	30.00%	0.00%	70.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%

Figure 4.48 AHP results of personal characteristics cluster by case studies

In whilst, the chart reveals that appearance is only considered in plastic and steel products (case study 3 and 4) as an important selection criteria within personal characteristics cluster. Regarding to the operations nature of steel products, appearance tends to be a criterion that significantly impacts worker selection decisions. On the other hand, age/seniority and health are both discussed in all five case studies with wide range of weights. Time punctuality is neglected in steel and outsource case studies, similarly to willingness criterion which is not considered by outsource.

Figure 4.49 illustrates AHP results obtained from skill cluster with five different case studies. It is obviously seen that technical skills play an important role in worker selection practice by more than 50% importance weights provided from all case studies. Accordingly, the general skills are slightly focused in the case studies of food, textile, and plastic products (1, 2, and 3) with less than 20% while case studies of steel and outsource (4 and 5) weight the general skills criterion by more than 30%.



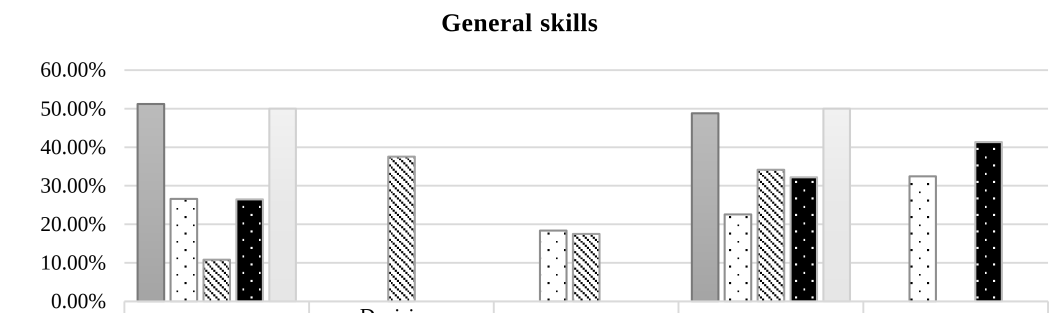
	General skill	Technical skill
Food	16.67%	83.33%
Textile	14.58%	85.42%
Plastic	18.06%	81.94%
Steel	35.00%	65.00%
Outsource	41.67%	58.33%

Figure 4.49 AHP results of skill cluster by case studies

In general skills cluster (see Figure 4.50), it is evident that five case studies commonly consider active learning and communication criteria. Case study 1 and 5 (food and outsource) provides the similar weights to active learning by 50% while textile and steel provide 26% approximately, and 10.82% by plastic products. Similarly in communication criterion, case study 1 and 5 provides weights which are close to 50% whereas case studies of plastic and steel products maintain around 30%, and 20% by textile.

Accordingly, decision-making/trouble shooting criterion is only considered in case study 3 (plastic products) by 37.54% compared to the other three sub-criteria.

Moreover, situation awareness criterion is only investigated in two case studies, textile and plastic products with less than 20% weights while working licenses criterion is similarly only focused by case study 2 and 3 (textile and steel products).

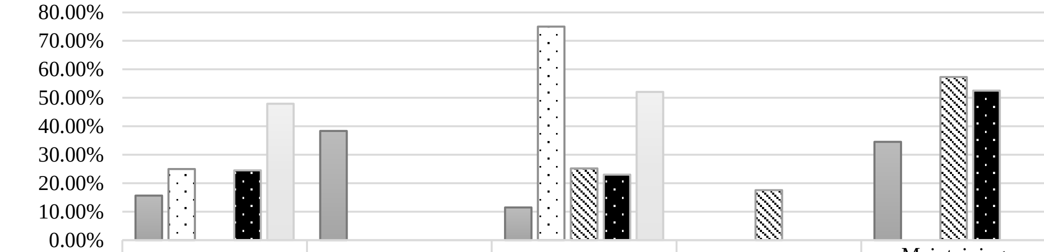


	Active learning	Decision-making/troubleshooting	Situation awareness	Communication	Working in teams/cooperation
Food	51.19%	0.00%	0.00%	48.81%	0.00%
Textile	26.61%	0.00%	18.37%	22.58%	32.44%
Plastic	10.82%	37.54%	17.51%	34.13%	0.00%
Steel	26.46%	0.00%	0.00%	32.21%	41.34%
Outsource	50.00%	0.00%	0.00%	50.00%	0.00%

Figure 4.50 AHP results of general skills cluster by case studies

On the other hand of technical skills viewpoint (shown in Figure 4.51), it is found that two sub-criteria are only considered by one case study. The equipment selection criterion is particularly focused in case study 1 of food products with 38.35% while operation monitoring factor is only weighted by plastic products (case study 3) by 17.54%. Moreover, it is found that four case studies except plastic products consider task preparation and prioritization criteria which the case study of recruitment outsourcing providers provide nearly 50% weight compared with operation and control criteria, while case study 1, 2, and 4 provide less than 30% priorities.

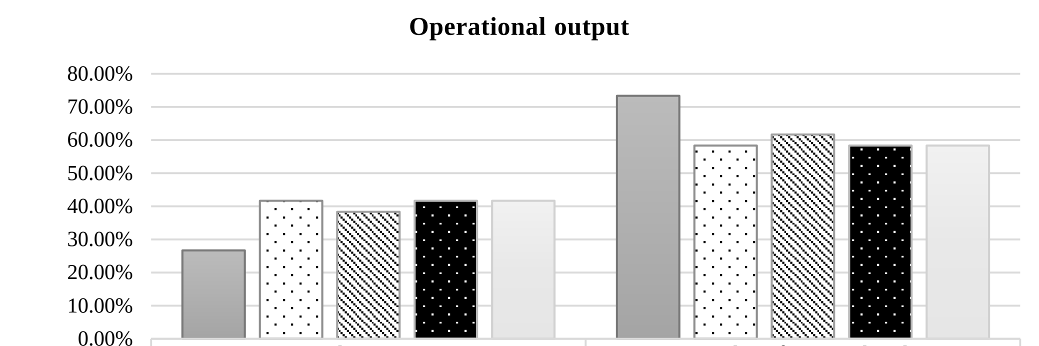
In operation and control criteria, textiles/wearing apparel products (case study 2) provides 75% compared to task preparation and prioritization. Also, case study 5 provides the similar weights by 52.08% and 47.92% for operation and control and task preparation and prioritization criteria respectively. However, the other three case studies of 1, 3, and 4 rank the operation and control criterion with less than 30% compared to the other criteria within their individual technical skills cluster. Regarding to the factor of maintain standards/following protocol, it is found that plastic and steel products yield more than 50% importance weights considered with other factors. However, case study 5 gives less than 40% for maintain standards/following protocol criterion.



	Task preparation and prioritization	Equipment selection	Operation and control	Operation monitoring	Maintaining standards/following protocol
Food	15.65%	38.35%	11.47%	0.00%	34.53%
Textile	25.00%	0.00%	75.00%	0.00%	0.00%
Plastic	0.00%	0.00%	25.17%	17.54%	57.28%
Steel	24.51%	0.00%	22.99%	0.00%	52.50%
Outsource	47.92%	0.00%	52.08%	0.00%	0.00%

Figure 4.51 AHP results of technical skills cluster by case studies

Figure 4.52 presents AHP results obtained from the operational output cluster. Both criteria of production rate and quality of part produced play an important role in semi-skilled worker selection policy, taken into account by all five case studies. The chart reveals that the overall importance weights are similarly given, higher in quality of part produced by more than 50% and more than 70% as the maximum (case study 1 of food products) while lower in production rate or less than 50%.



	Production rate	Quality of part produced
Food	26.67%	73.33%
Textile	41.67%	58.33%
Plastic	38.33%	61.67%
Steel	41.67%	58.33%
Outsource	41.67%	58.33%

Figure 4.52 AHP results of operational output cluster by case studies

Table 4.13 – 4.15 presents the overall summary of semi-skilled worker selection criteria based on five case studies of food products, textiles/wearing apparel products, plastic products, steel products, and recruitment outsourcing providers.

Following to Table 4.13, it is evident that five sub-criteria (given below) are neglected in selection policies with respect to the different manufacturing contexts of aforementioned case studies;

Personal characteristics cluster

- Culture
- Determination of goal

Skill cluster

1) General skills cluster

- Analytical thinking
- Basic computer skill

2) Technical skills cluster

- Equipment installation

Accordingly, these criteria are terminated from AHP models which result importance weights (Table 4.14) and priorities (Table 4.15 – 4.16) obtained by a single case study presented in Table 4.14. From Table 4.13, it is found that all five case studies are commonly considered nine criteria in the semi-skilled worker selection policies, namely (1) educational background, (2) year of experience, (3) age/seniority, (4) health, (5) active learning, (6) communication, (7) operation and control, (8) production rate, and (9) quality of part produced.

With respect to labor-intensive manufacturing based on five case studies (10 samples), it could be concluded that nine common criteria play an important role in their selection practice of semi-skilled worker which highly impacts the firms' achievements especially the production performance whereas the criteria of culture, determination of goal, analytical thinking, basic computer and equipment installation skills are not considered as the influencing factors in selecting the semi-skilled workers.

Table 4.13 Summary of semi-skilled worker selection criteria by case studies

Case study		1	2	3	4	5
		Food	Textile	Plastic	Steel	Outsource
Cluster 1: Competency						
(1)	Educational background	✓	✓	✓	✓	✓
(2)	Qualifications or job title	✓	-	✓	✓	✓
(3)	Training level	✓	✓	-	✓	-
(4)	Working Licenses	-	-	✓	-	-
Cluster 2: Experience						
(1)	Year of experience	✓	✓	✓	✓	✓
(2)	Operations Familiarity	✓	✓	✓	✓	✓
(3)	Working knowledge	✓	✓	✓	✓	-
Cluster 3: Personal characteristics						
(1)	Age/seniority	✓	✓	✓	✓	✓
(2)	Appearance	-	-	✓	✓	-
(3)	Culture	-	-	-	-	-
(4)	Determination of goal	-	-	-	-	-
(5)	Health	✓	✓	✓	✓	✓
(6)	Loyalty and honesty	-	-	✓	-	-
(7)	Time punctuality	✓	✓	✓	-	-
(8)	Willingness	✓	✓	✓	✓	-
(9)	Adaptation of change	-	-	✓	-	-
(10)	Social perceptiveness	-	-	✓	-	-
(11)	Leadership	-	-	✓	-	-
(12)	Attendance	-	-	✓	-	-
(13)	Negotiation/persuasion	-	-	✓	-	-

Table 4.13 Summary of semi-skilled worker selection criteria by case studies (cont.)

Case study		1	2	3	4	5
		Food	Textile	Plastic	Steel	Outsource
(14)	Service orientation	-	-	✓	-	-
Cluster 4: Skill						
1) General skills						
(1)	Active learning	✓	✓	✓	✓	✓
(2)	Decision-making/troubleshooting	-	-	✓	-	-
(3)	Analytical thinking	-	-	-	-	-
(4)	Situation awareness	-	✓	✓	-	-
(5)	Communication	✓	✓	✓	✓	✓
(6)	Basic computer skill	-	-	-	-	-
(7)	Working in teams/cooperation	-	✓	-	✓	-
2) Technical skills						
(1)	Task preparation and prioritization	✓	✓	-	✓	✓
(2)	Equipment selection	✓	-	-	-	-
(3)	Equipment installation	-	-	-	-	-
(4)	Operation and control	✓	✓	✓	✓	✓
(5)	Operation monitoring	-	-	✓	-	-
(6)	Maintaining standards/following protocol	✓	-	✓	✓	-
Cluster 5: Operational output						
(1)	Production rate	✓	✓	✓	✓	✓
(2)	Quality of part produced	✓	✓	✓	✓	✓

Table 4.14 Summary of local importance weights obtained from AHP model

Case study		1	2	3	4	5
		Food	Textile	Plastic	Steel	Outsource
Cluster 1: Competency						
(1)	Educational background	8.00%	40.48%	7.92%	14.55%	29.17%
(2)	Qualifications or job title	68.03%	-	63.87%	43.58%	70.83%
(3)	Training level	23.97%	59.52%	-	41.88%	-
(4)	Working Licenses	-	-	28.22%	-	-
Cluster 2: Experience						
(1)	Year of experience	18.12%	31.88%	9.88%	42.19%	62.50%

Table 4.14 Summary of local importance weights obtained from AHP model (cont.)

Case study		1 Food	2 Textile	3 Plastic	4 Steel	5 Outsource
(2)	Operations Familiarity	58.00%	44.74%	60.47%	36.84%	37.50%
(3)	Working knowledge	23.87%	23.38%	29.65%	20.97%	-
Cluster 3: Personal characteristics						
(1)	Age/seniority	4.13%	4.61%	1.63%	17.78%	30.00%
(2)	Appearance	-	-	1.23%	6.30%	-
(3)	Health	24.57%	40.09%	3.01%	37.64%	70.00%
(4)	Loyalty and honesty	-	-	7.76%	-	-
(5)	Time punctuality	35.64%	23.01%	6.57%	-	-
(6)	Willingness	35.66%	32.29%	8.30%	38.29%	-
(7)	Adaptation of change	-	-	7.91%	-	-
(8)	Social perceptiveness	-	-	10.41%	-	-
(9)	Leadership	-	-	13.09%	-	-
(10)	Attendance	-	-	15.50%	-	-
(11)	Negotiation/persuasion	-	-	13.11%	-	-
(12)	Service orientation	-	-	11.48%	-	-
Cluster 4: Skill						
1) General skills						
(1)	Active learning	51.19%	26.61%	10.82%	26.46%	50.00%
(2)	Decision-making/troubleshooting	-	-	37.54%	-	-
(3)	Situation awareness	-	18.37%	17.51%	-	-
(4)	Communication	48.81%	22.58%	34.13%	32.21%	50.00%
(5)	Working in teams/cooperation	-	32.44%	-	41.34%	-
2) Technical skills						
(1)	Task preparation and prioritization	15.65%	25.00%	-	24.51%	47.92%
(2)	Equipment selection	38.35%	-	-	-	-
(3)	Operation and control	11.47%	75.00%	25.17%	22.99%	52.08%
(4)	Operation monitoring	-	-	17.54%	-	-
(5)	Maintaining standards/following protocol	34.53%	-	57.28%	52.50%	-
Cluster 5: Operational output						
(1)	Production rate	26.67%	41.67%	38.33%	41.67%	41.67%
(2)	Quality of part produced	73.33%	58.33%	61.67%	58.33%	58.33%

Table 4.15 Local rankings and priorities of semi-skilled worker selection criteria from AHP model

Case study		1	2	3	4	5
		Food	Textile	Plastic	Steel	Outsource
Cluster 1: Competency						
(1)	Educational background	3	2	3	3	2
(2)	Qualifications or job title	1	-	1	1	1
(3)	Training level	2	1	-	2	-
(4)	Working Licenses	-	-	2	-	-
Cluster 2: Experience						
(1)	Year of experience	3	2	3	1	1
(2)	Operations familiarity	1	1	1	2	2
(3)	Working knowledge	2	3	2	3	-
Cluster 3: Personal characteristics						
(1)	Age/seniority	4	4	11	3	2
(2)	Appearance	-	-	12	4	-
(3)	Health	3	1	10	2	1
(4)	Loyalty and honesty	-	-	8	-	-
(5)	Time punctuality	2	3	9	-	-
(6)	Willingness	1	2	6	1	-
(7)	Adaptation of change	-	-	7	-	-
(8)	Social perceptiveness	-	-	5	-	-
(9)	Leadership	-	-	3	-	-
(10)	Attendance	-	-	1	-	-
(11)	Negotiation/persuasion	-	-	2	-	-
(12)	Service orientation	-	-	4	-	-
Cluster 4: Skill						
1) General skills						
(1)	Active learning	1	2	4	3	1*
(2)	Decision-making/troubleshooting	-	-	1	-	-
(3)	Situation awareness	-	4	3	-	-
(4)	Communication	2	3	2	2	1*
(5)	Working in teams/cooperation	-	1	-	1	-
2) Technical skills						
(1)	Task preparation and prioritization	3	2	-	2	2
(2)	Equipment selection	1	-	-	-	-
(3)	Operation and control	4	1	2	3	1
(4)	Operation monitoring	-	-	3	-	-

Table 4.15 Local rankings and priorities of semi-skilled worker selection criteria from AHP model (cont.)

Case study		1	2	3	4	5
		Food	Textile	Plastic	Steel	Outsource
(5)	Maintaining standards/following protocol	2	-	1	1	-
Cluster 5: Operational output						
(1)	Production rate	2	2	2	2	2
(2)	Quality of part produced	1	1	1	1	1

The final rankings and priorities of semi-skilled worker selection criteria obtained from AHP model are presented in Table 4.15, the first ranking criterion under each cluster is also discussed with respect to its selection policy.

In competency cluster, qualifications or job title criterion yields the first priority in case studies of food products, plastics products, and recruitment outsourcing providers while case studies of textiles/wearing apparel and steel products yield training level as the top ranking criterion. Operations familiarity achieves the highest ranking in experience cluster by three case studies, i.e. food, textiles/wearing apparel, and plastic products. However, the case studies of steel products and recruitment outsourcing providers obviously yield the year of experience criterion as the first ranking. The first ranking criterion in personal characteristics cluster is not obviously yielded by five case studies, nevertheless food and steel products consider “willingness” as the most important criterion whereas “health” yields the first priority in textiles/wearing apparel products and recruitment outsourcing providers. Moreover, it is found that the case study of plastic products is significantly isolated in providing the maximum weight to attendance criterion. On the other hand of skill cluster, active learning achieves the first ranking criterion in general skills category with respect to food products and recruitment outsourcing providers case studies. Similarly, textiles/wearing apparel and steel products provide the highest priority to working in teams/cooperation criterion whereas plastic products case study firstly considers decision-making/troubleshooting criterion. For technical skills category, operation and control yields the first ranking criterion in case studies of textiles/wearing apparel products and recruitment outsourcing providers while plastic and steel products consider maintaining standards/following protocol as the most important criterion. However, it is found that food products case study yields equipment selection criterion as the highest priority. Obviously, the “quality of part produced” criterion under operational output cluster yield the first priority with respect to all five case studies while production rate achieve the second ranking respectively.

Table 4.16 presents the overall global rankings and priorities of semi-skilled worker selection criteria obtained from AHP model with respect to five different case studies of labor-intensive manufacturing.

Table 4.16 Global rankings and priorities of semi-skilled worker selection criteria from AHP model

Case study		1	2	3	4	5
		Food	Textile	Plastic	Steel	Outsource
Cluster 1: Competency						
(1)	Educational background	18	8	23	16	12
(2)	Qualifications or job title	9	-	6	8	11
(3)	Training level	16	5	-	9	-
(4)	Working Licenses	-	-	10	-	-
Cluster 2: Experience						
(1)	Year of experience	13	4	7	5	6
(2)	Operations familiarity	7	3	2	7	9
(3)	Working knowledge	11	7	4	11	-
Cluster 3: Personal characteristics						
(1)	Age/seniority	17	17	26	10	10
(2)	Appearance	-	-	27	18	-
(3)	Health	8	10	25	4	4
(4)	Loyalty and honesty	-	-	20	-	-
(5)	Time punctuality	6	12	22	-	-
(6)	Willingness	5	11	18	3	-
(7)	Adaptation of change	-	-	19	-	-
(8)	Social perceptiveness	-	-	17	-	-
(9)	Leadership	-	-	15	-	-
(10)	Attendance	-	-	11	-	-
(11)	Negotiation/persuasion	-	-	14	-	-
(12)	Service orientation	-	-	16	-	-
Cluster 4: Skill						
1) General skills						
(1)	Active learning	14	14	24	17	7

Table 4.16 Global rankings and priorities of semi-skilled worker selection criteria from AHP model (cont.)

Case study		1	2	3	4	5
		Food	Textile	Plastic	Steel	Outsource
(2)	Decision-making/troubleshooting	-	-	12	-	-
(3)	Situation awareness	-	16	21	-	-
(4)	Communication	15	15	13	15	8
(5)	Working in teams/cooperation	-	13	-	14	-
2) Technical skills						
(1)	Task preparation and prioritization	10	9	-	12	5
(2)	Equipment selection	3	-	-	-	-
(3)	Operation and control	12	6	8	13	3
(4)	Operation monitoring	-	-	9	-	-
(5)	Maintaining standards/following protocol	4	-	5	6	-
Cluster 5: Operational output						
(1)	Production rate	2	2	3	2	2
(2)	Quality of part produced	1	1	1	1	1

The overall results show that 31 criteria (as total) are considered in the semi-skilled worker selection practice from four case studies where case study 3 of plastic products considers 26 criteria (highest), case study 1 with 18 criteria, case study 2 with 17 criteria, case study 4 with 16 criteria, and case study 5 with 12 criteria (lowest). Accordingly, this could be concluded that the semi-skilled workers in plastic products are required to have more qualifications compared to other case studies regarding to its production nature which machines are a part and the qualified labors are important. As the responsibilities of outsourcing service providers (DOE), it is reasonable that they consider less criteria by only 12 from 31 since the pre-selected semi-skilled workers would be recruited again by a company and the semi-skilled worker in labor-intensive factories are not required to have the high qualities based on their perspecives.

4.14 Worker selection policies obtained from case studies

According to the previous sections of case studies analysis, five semi-skilled worker selection polices are obtained as follow.

Table 4.17 Semi-skilled worker selection policies

Selection Policy	Industry Type	Overall Performance of an Alternative *n* (OWC$_{Wn}$)	W_{ijk} Value
Policy 1	Food	$\sum_{i=1}^{5}\sum_{j=1}^{n}\sum_{k=0}^{m}(W_{ijk} \times R_{ijk})$	Table 4.18
Policy 2	Textiles/wearing apparel	$\sum_{i=1}^{5}\sum_{j=1}^{n}\sum_{k=0}^{m}(W_{ijk} \times R_{ijk})$	Table 4.19
Policy 3	Plastic	$\sum_{i=1}^{5}\sum_{j=1}^{n}\sum_{k=0}^{m}(W_{ijk} \times R_{ijk})$	Table 4.20
Policy 4	Steel	$\sum_{i=1}^{5}\sum_{j=1}^{n}\sum_{k=0}^{m}(W_{ijk} \times R_{ijk})$	Table 4.21
Policy 5	Recruitment outsourcing providers	$\sum_{i=1}^{5}\sum_{j=1}^{n}\sum_{k=0}^{m}(W_{ijk} \times R_{ijk})$	Table 4.22

Table 4.17 presents five different semi-skilled worker selection policies reagarding to labor-intensive manufacturings and recruitment outsourcing providers. Accordingly, W_{ijk} values used to calculate the overall performance of an alternative *n* by the equation of $\sum_{i=1}^{5}\sum_{j=1}^{n}\sum_{k=0}^{m}(W_{ijk} \times R_{ijk})$ vary through each policy (see Table 4.18 – 4.22).

Semi-skilled worker selection policies with criteria weights (W_{global}) including considered factors and non-considered factors are presented in the following Table 4.18 – 4.22.

Table 4.18 Semi-skilled worker selection policy 1

Policy	Industry Type	Considered Factors	W_{global}	Non-considered Factors
Policy 1	Food	**Cluster 1**		
		• Educational background	0.34%	• Working licenses
		• Qualifications or job title	2.85%	
		• Training level	1.00%	
		Cluster 2		
		• Year of experience	1.84%	
		• Operations familiarity	5.88%	
		• Working knowledge	2.42%	
		Cluster 3		
		• Age/seniority	0.70%	• Appearance
		• Health	4.19%	• Culture
		• Time punctuality	6.08%	• Determination of goal
		• Willingness	6.08%	• Loyalty and honesty
				• Adaptation of change
				• Social perceptiveness
				• Leadership
				• Attendance
				• Negotiation/persuasion
				• Service orientation
		Cluster 4		
		• Active learning	1.82%	• Decision-making/ troubleshooting
		• Communication	1.73%	• Analytical thinking
		• Task preparation and prioritization	2.78%	• Situation awareness
		• Equipment selection	6.81%	• Basic computer skill
		• Operation and control	2.04%	• Working in teams/ cooperation
		• Maintaining standards/ following protocol	6.14%	• Equipment installation
				• Operation monitoring
		Cluster 5		
		• Production rate	12.61%	
		• Quality of part produced	34.68%	

Table 4.19 Semi-skilled worker selection policy 2

Policy	Industry Type	Considered Factors	W_{global}	Non-considered Factors
Policy 2	Textiles/wearing apparel	**Cluster 1**		
		• Educational background	6.27%	• Qualifications or job title
		• Training level	9.23%	• Working licenses
		Cluster 2		
		• Year of experience	9.64%	
		• Operations familiarity	13.53%	
		• Working knowledge	7.07%	
		Cluster 3		
		• Age/seniority	0.16%	• Appearance
		• Health	1.36%	• Culture
		• Time punctuality	0.78%	• Determination of goal
		• Willingness	1.09%	• Loyalty and honesty
				• Adaptation of change

Table 4.19 Semi-skilled worker selection policy 2 (continued)

Policy	Industry Type	Considered Factors	W_{global}	Non-considered Factors
				• Social perceptiveness • Leadership • Attendance • Negotiation/persuasion • Service orientation
		Cluster 4		
		• Active learning	0.52%	• Decision-making/ troubleshooting
		• Situation awareness	0.36%	• Analytical thinking
		• Communication	0.44%	• Basic computer skill
		• Working in teams/ cooperation	0.63%	• Equipment selection
		• Task preparation and prioritization	2.84%	• Equipment installation • Operation monitoring
		• Operation and control	8.51%	• Maintaining standards/ following protocol
		Cluster 5		
		• Production rate	15.66%	
		Quality of part produced	21.93%	

Table 4.20 Semi-skilled worker selection policy 3

Policy	Industry Type	Considered Factors	W_{global}	Non-considered Factors
Policy 3	Plastic	**Cluster 1**		
		• Educational background	0.44%	• Training level
		• Qualifications or job title	3.52%	
		• Working licenses	1.55%	
		Cluster 2		
		• Year of experience	3.31%	
		• Operations familiarity	20.28%	
		• Working knowledge	9.94%	
		Cluster 3		
		• Age/seniority	0.11%	• Culture
		• Appearance	0.08%	• Determination of goal
		• Health	0.20%	
		• Time punctuality	0.52%	
		• Willingness	0.44%	
		• Loyalty and honesty	0.55%	
		• Adaptation of change	0.52%	
		• Social perceptiveness	0.69%	
		• Leadership	0.87%	
		• Attendance	1.03%	
		• Negotiation/persuasion	0.87%	
		• Service orientation	0.76%	
		Cluster 4		
		• Active learning	0.28%	• Analytical thinking
		• Decision-making/ troubleshooting	0.98%	• Basic computer skill • Working in teams/ cooperation

Table 4.20 Semi-skilled worker selection policy 3 (cont.)

Policy	Industry Type	Considered Factors	W_{global}	Non-considered Factors
		• Situation awareness	0.46%	• Task preparation and prioritization
		• Communication	0.89%	• Equipment selection
		• Operation and control	2.97%	• Equipment installation
		• Operation monitoring	2.07%	
		• Maintaining standards/ following protocol	6.76%	
		Cluster 5		
		• Production rate	15.30%	
		• Quality of part produced	24.61%	

Table 4.21 Semi-skilled worker selection policy 4

Policy	Industry Type	Considered Factors	W_{global}	Non-considered Factors
Policy 4	Steel	**Cluster 1**		
		• Educational background	1.67%	• Working licenses
		• Qualifications or job title	5.00%	
		• Training level	4.81%	
		Cluster 2		
		• Year of experience	6.44%	
		• Operations familiarity	5.63%	
		• Working knowledge	3.20%	
		Cluster 3		
		• Age/seniority	3.81%	• Culture
		• Appearance	1.35%	• Determination of goal
		• Health	8.06%	• Loyalty and honesty
		• Willingness	8.20%	• Time punctualit
				• Adaptation of change
				• Social perceptiveness
				• Leadership
				• Attendance
				• Negotiation/persuasion
				• Service orientation
		Cluster 4		
		• Active learning	1.59%	• Decision-making/ troubleshooting
		• Communication	1.94%	• Analytical thinking
		• Working in teams/ cooperation	2.49%	• Situation awareness
		• Task preparation and prioritization	2.74%	• Basic computer skill
		• Operation and control	2.57%	• Equipment selection
		• Maintaining standards/ following protocol	5.87%	• Equipment installation
				• Operation monitoring
		Cluster 5		
		• Production rate	14.43%	
		• Quality of part produced	20.20%	

Table 4.22 Semi-skilled worker selection policy 5

Policy	Industry Type	Considered Factors	W_{global}	Non-considered Factors
Policy 5	Outsoucing recruitment	**Cluster 1** • Educational background • Qualifications or job title	 1.37% 3.33%	 • Training level • Working Licenses
		Cluster 2 • Year of experience • Operations Familiarity	 7.54% 4.53%	 • Working knowledge
		Cluster 3 • Age/seniority • Health	 4.53% 10.56%	 • Appearance • Culture • Determination of goal • Loyalty and honesty • Time punctuality • Willingness • Adaptation of change • Social perceptiveness • Leadership • Attendance • Negotiation/persuasion • Service orientation
		Cluster 4 • Active learning • Communication • Task preparation and prioritization • Operation and control	 7.30% 7.30% 9.79% 10.65%	 • Decision-making/ troubleshooting • Analytical thinking • Situation awareness • Basic computer skill • Working in teams/ cooperation • Equipment selection • Equipment installation • Operation monitoring • Maintaining standards/ following protocol
		Cluster 5 • Production rate • Quality of part produced	 13.79% 19.31%	

Each of a selection policy significantly represents the production natures of a specific labor-intensive industry including a recruitment outsourcing provider which consider selection critria in the different perspectives. The considered factors play an important role in the organization's selection process regarding to its production system while the non-considered factors slightly impact the overall output, therefore, they are neglected in the assessment of worker's performance. However, it is evident that a number of semi-skilled worker selection criteria is commonly considered among five case studies with respect to labor-intensive perspective. The practical implementation of these selection policies could be applied and launched in a company by following the policy which complies to its manufacturing conditions.

Conclusively, semi-skilled worker selection criteria considered in labor-intensive industry significantly varies to the differences in production natures of each case study. Accordingly, workers with particular characteristics are required to achieve the operation gains and it causes different selection policies include the important selection criteria implemented by each case study.

4.2 Semi-skilled worker selection and grouping model based on manufacturing practices and previous studies

Based on four different case studies in labor-intensive industry, i.e. the manufacturing of (1) food products, (2) textiles/wearing apparel products, (3) plastic products, and (4) steel products, it is found that the selection and grouping practices of operational semi-skilled worker in their operations preliminarily maintain the similar procedures as shown in Figure 4.53.

Figure 4.53 presents the selection and grouping processes investigated from four cases. It is mainly carried out into two stages of selection decisions, (1) preliminary selection, and (2) final selection with respect to different selection policies. The diagram starts from searching for pool of workers by various methods of vacancies announcement. The applicants would be preliminarily selected in pre-screen and interview processes, in this phase the selection criteria of three main aspects of competency, experience, and personal characteristics are considered. The applicants who comply the organization’s selection policies are selected and processed the next recruitment stages. It is also evident that “probation” process is an important process of worker selection practice based on four manufacturing case studies of labor-intensive context. Since job training is provided in probation phase, worker performance of operating skills and output aspects could be conducted as it highly impacts to the production gains and companies’ achievements. Hence, skill and operational output criteria are focused to make the final selection decision. Finally, overall worker capability based on five aspects are individually obtained and selected workers are categorized into groups that is in accordance with their overall performance.

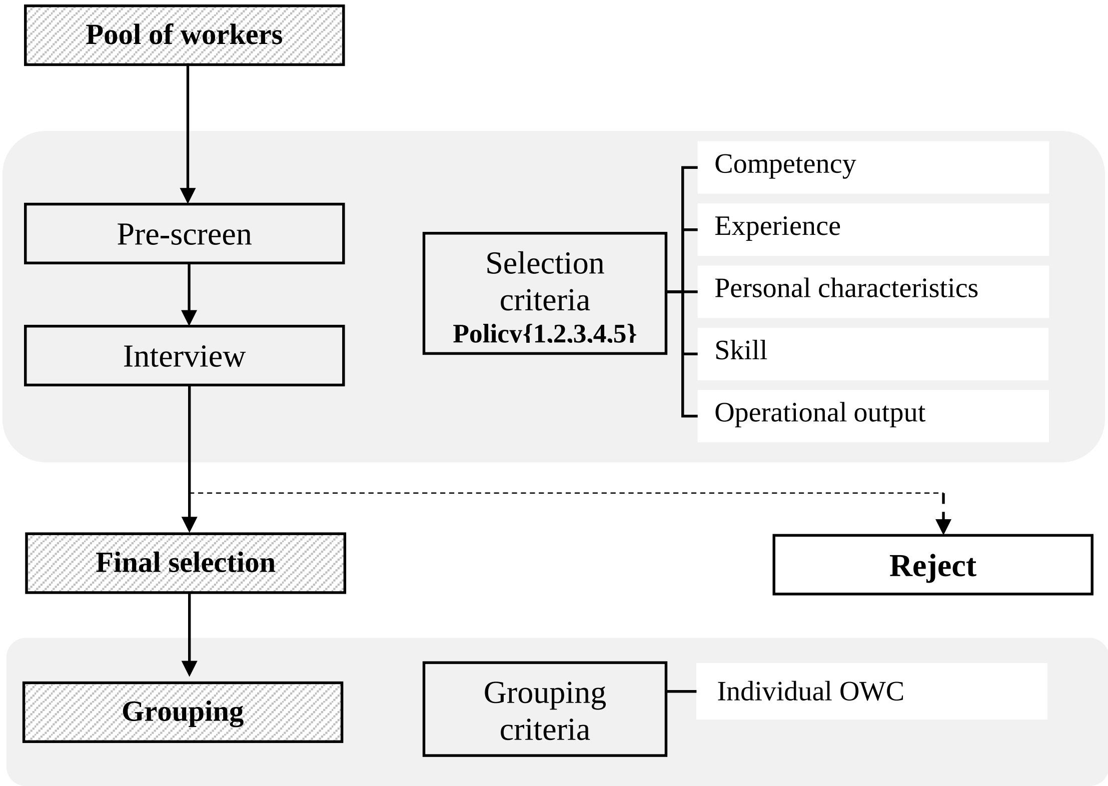


Figure 4.53 Selection and grouping procedures based on labor-intensive industry

Accordingly, assigning worker to task (allocation phase) should be conducted after selection and grouping phases regarding to workfoce decisions (Nembhard and Bentefouet, 2014). However, the allocation problem of semi-skilled worker with respect to labor-intensive industry is not investigated in this research. Since a number of the existing literature has hardly focused on worker assigment problem and various approaches are obtained. Additionally, it is obviously seen that before worker assignment decision has been made, worker selection and grouping processes should be prior determined with respect to the valid criteria of workforce or human-related factors. This study mainly contributes the important semi-skilled worker selection criteria and practice obtained from the real case studies of labor-intensive manufacturing as an important basis of all workforce decisions in determining the qualified worker resource.

Moreover, the integrated approach of workforce decisions including selection, grouping, and allocation is a potential extension of the future research.

Though, it is evident that all four case studies of labor-intensive manufacturing generally conduct the similar procedures of semi-skilled worker selection and grouping practices. Nevertheless, the important selection criteria is found to be varied following to its unique production system (as discussed in Section 4.1.1) among food products, textiles/wearing apparel products, plastic products, and steel products.

On the other hand, semi-skilled worker selection and grouping practices based on recruitment outsourcing providers (case study 5) are significantly different from four afore-mentioned case studies. Since DOE works as a third-party service provider in facilitating human resource management activities for any business firms, the particular recruitment process is obtained in Figure 4.54. It is seen that the organization plays an important role in connecting an individual worker and business firm to match worker resource with required qualifications in various aspects, i.e. competency, experience, personal characteristics, skill, and productivity.

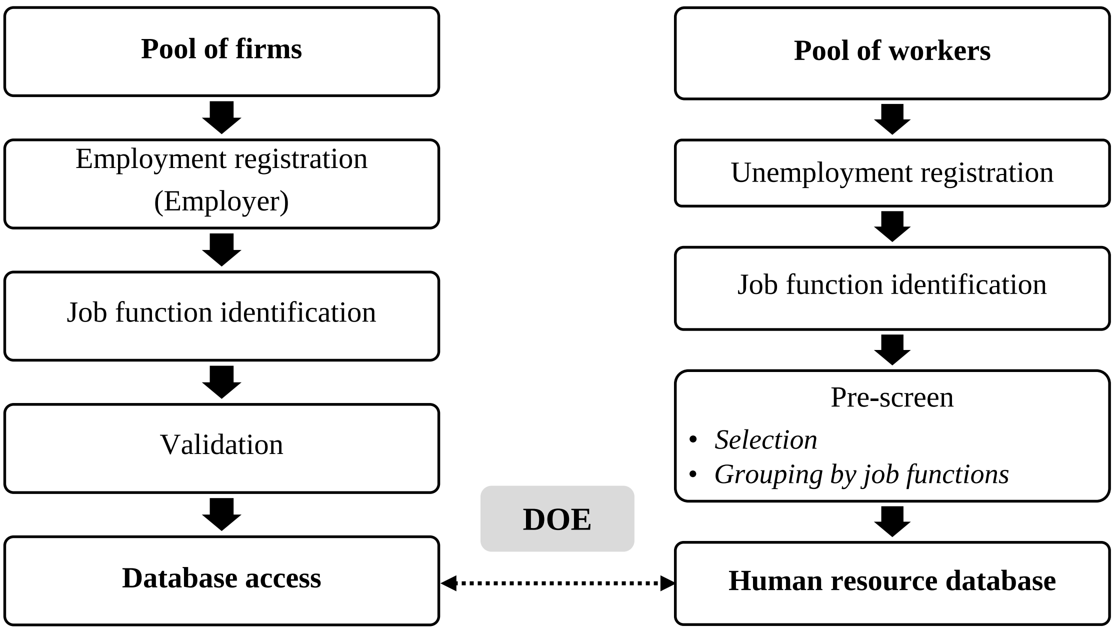


Figure 4.54 Recruitment procedures based on DOE (case study 5)

Figure 4.54 illustrates the recruitment process obtained from outsourcing provider practices (DOE). As the third-party, sections of employee and firms are separately discussed.

In a role of employee, the registration of unemployment is first processed which specific documents are required. The employee needs to identify job function that he/she wants to work for in accordance with his/her experience and skills. Accordingly, DOE would run the pre-screen phase by considering employee from documents and employment legal purpose. It is found that the selection criteria generally include working experience, age/seniority, health, and communication. The preliminary selected employee is grouped into various job functions and recorded to human resource database.

Similarly to the business firms or employers, registrations are needed and related documents which comply with employment legal are required. Basic information of company and job functions are also identified. Then, DOE would validate a single business firm in its employer's database. As soon as the business firm is validated into DOE system, the access of worker resource database is active. With this process, DOE connects two sections of workers and business firms together. Human resource database allows business firms or employers to investigate profiles of a single employee. This significantly benefits the manufacturing firms to select a qualified worker with required experience and skills. However, a firm would continue its own recruitment process after all (see Figure 4.54). Furthermore, DOE reveals that most of the manufacturing companies maintained in its employer database are textiles/wearing apparel industry with respect to 60%, whereas industries of food, steel, and plastics are less. The recruiting service provided by DOE is evidently beneficial to labor-intensive industry for recruting the semi-skilled workers, since a pool of worker resource is obtained in DOE database which eases the firms to efficiently process the human resource activities.

4.3 Numerical example

An individual <u>*overall worker capability*</u> equals to the equation given in the following;

$$Overall\ Worker\ Capability\ (OWC) = \sum_{i=1}^{5}\sum_{j=1}^{n}\sum_{k=0}^{m}(W_{ijk} \times R_{ijk})$$

Where i is main criteria *i* (*i* = 1,…,5), *j* is sub-criteria *j* (*j* = 1,2,…,*n)*, and *k* is the second level sub-criteria *k* (*k* = 1,2,…,*m)*. If *k* = 0 (one level sub-criteria) then, W_{ij} is the importance weight of sub-criterion *j* under main criterion *i*. Similarly, R_{ij} is raw score of sub-criterion *j* under main criterion *i* achieved by a worker. If *k* > 0 (two levels sub-criteria) then, W_{ijk} is the importance weight of the second level sub-criterion *k* under sub-criterion *j* of main criterion *i*. Similarly, R_{ijk} is raw score of the second level sub-criterion *k* of sub-criterion *j* under main criterion *i* achieved by a worker.

It is noted that the overall worker capability as per equation above, is for the performance evaluation of an individual worker. Traditionally, *raw score (R)* on each criterion of a worker is assessed by a production manager or any related sector who is in charge of an organization. However, the raw score of each worker is assumed in this study, to demonstrate the preliminary results of worker selection and grouping practice with weights and priorities obtained from AHP model. The total number of alternative workers are defined as 20 (20 workers) and a case study of textiles/wearing apparel is investigated as a numerical example.

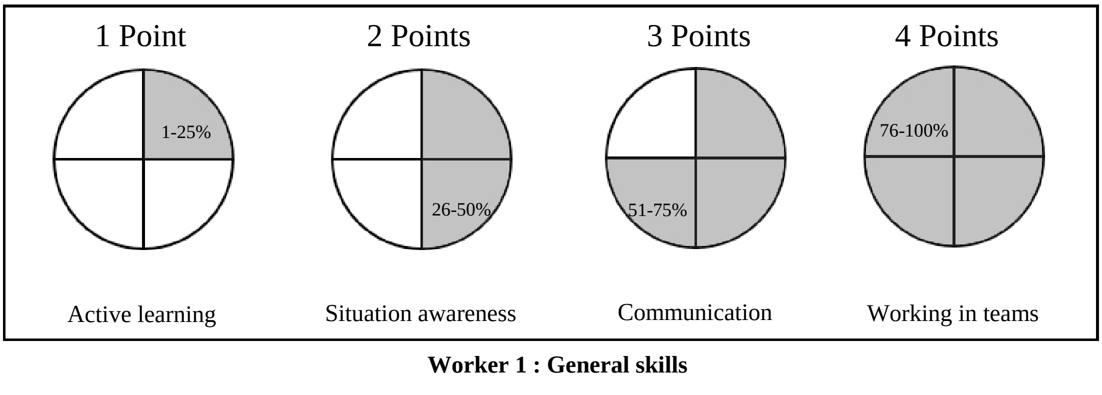


Figure 4.55 An individual performance measurement based on case study

Table 4.25 presents an individual OWC of semi-skilled worker *using OWC equation* with raw scores (*R*) and AHP weights (*W*) of each selection criterion based on textiles/wearing apparel products (Table 4.23 – 4.24). Five aspects of selection criteria include competency, experience, personal characteristics, skill, and operational output are investigated. However, the number of sub-criteria considered in each aspect is based on case study 2 which various criteria should be discussed in accordance with the production system for the real application.

Table 4.23 Raw score (*R* value) of 20 alternatives with 1 - 4 points

Alternative (Worker)	Competency		Experience			Personal characteristics				Skill						Operational output	
										General skill				Technical skill			
	Educational background	Training level	Year of experience	Operations Familiarity	Working knowledge	Age/seniority	Health	Time punctuality	Willingness	Active learning	Situation awareness	Communication	Working in teams/ cooperation	Task preparation and prioritization	Operation and control	Production rate	Quality of part produced
W1	2	1	4	2	2	3	4	2	4	4	4	3	4	4	2	2	3
W2	2	4	2	3	3	4	4	2	1	3	2	2	4	4	2	2	4
W3	1	3	1	1	4	2	1	2	2	3	2	1	1	1	2	1	1
W4	4	2	3	3	2	1	2	1	3	1	3	3	4	4	2	4	2
W5	4	2	1	3	1	2	3	4	1	4	2	3	4	3	4	1	1
W6	2	1	2	2	1	1	2	1	1	3	4	4	1	1	4	1	2
W7	4	2	2	1	3	4	2	3	3	1	4	3	1	4	4	2	3
W8	2	4	1	4	4	4	2	4	2	4	2	3	1	4	2	1	2
W9	1	1	4	1	3	2	2	4	1	2	4	3	1	1	4	3	3
W10	3	3	3	3	4	3	3	4	4	2	3	4	3	3	4	1	3
W11	1	3	4	1	2	1	1	4	1	3	1	1	2	2	1	3	2
W12	2	1	4	4	2	2	1	3	2	4	3	4	3	3	2	2	1
W13	1	2	1	4	4	4	4	3	1	2	4	4	2	2	4	2	1
W14	3	1	3	3	1	3	1	4	4	3	2	4	1	1	4	2	2
W15	4	4	3	1	4	2	3	2	4	3	3	1	3	4	4	4	4
W16	1	3	1	4	3	2	1	3	2	2	4	4	2	2	3	4	3
W17	4	2	2	2	4	3	3	1	4	2	3	1	3	2	3	1	3
W18	1	4	4	3	4	2	3	1	3	2	4	2	1	4	3	3	2
W19	1	4	3	3	2	1	4	3	3	2	1	2	2	2	4	2	1
W20	3	2	2	2	1	1	2	2	3	4	4	4	1	4	2	2	3

Table 4.24 AHP weights (*W* value)

Main criteria	Cluster priority	Sub-criteria	Local weight	Global priority (*W*)
Competency	0.15503	Educational background	0.40476	**0.063**
		Training level	0.59524	**0.092**
Experience	0.30234	Year of experience	0.31880	**0.096**
		Operational familiarity	0.44737	**0.135**
		Working knowledge	0.23384	**0.071**
Personal characteristics	0.03384	Age/seniority	0.04611	**0.002**
		Health	0.40090	**0.014**
		Time punctuality	0.23005	**0.008**
		Willingness	0.32295	**0.011**
Skill	0.13286	*General skills*	*0.14583*	
		Active learning	0.26615	**0.005**
		Situation awareness	0.18370	**0.004**
		Communication	0.22577	**0.004**
		Working in teams/ cooperation	0.32438	**0.006**
		Technical skills	*0.85418*	
		Task preparation and prioritization	0.25000	**0.028**
		Operation and control	0.75000	**0.085**
Operational output	0.37595	Production rate	0.41667	**0.157**
		Quality of part produced	0.58334	**0.219**

A computational example of OWC value of alternative 1 (W1) is presented as follows.

From the OWC equation;

$$OWC = \sum_{i=1}^{5}\sum_{j=1}^{n}\sum_{k=0}^{m}\left(W_{ijk} \times R_{ijk}\right)$$

$$\begin{aligned} OWC_{w1} = {} & (W_{11} \times R_{11}) + (W_{12} \times R_{12}) + (W_{21} \times R_{21}) + (W_{22} \times R_{22}) \\ & + (W_{23} \times R_{23}) + (W_{31} \times R_{31}) + (W_{32} \times R_{32}) + (W_{33} \times R_{33}) \\ & + (W_{34} \times R_{34}) + (W_{411} \times R_{411}) + (W_{412} \times R_{412}) + (W_{413} \times R_{413}) \\ & + (W_{414} \times R_{414}) + (W_{421} \times R_{421}) + (W_{422} \times R_{422}) + (W_{51} \times R_{51}) \\ & + (W_{52} \times R_{52}) \end{aligned}$$

$$OWC_{w1} = (0.063 \times 2) + (0.092 \times 1) + (0.096 \times 4) + (0.135 \times 2) + (0.071 \times 2) + (0.002 \times 3) + (0.014 \times 4) + (0.008 \times 2) + (0.011 \times 4) + (0.005 \times 4) + (0.004 \times 4) + (0.004 \times 3) + (0.006 \times 4) + (0.028 \times 4) + (0.085 \times 2) + (0.157 \times 2) + (0.219 \times 3)$$

$$OWC_{w1} = 0.125 + 0.092 + 0.386 + 0.271 + 0.141 + 0.005 + 0.054 + 0.016 + 0.044 + 0.021 + 0.014 + 0.013 + 0.025 + 0.113 + 0.170 + 0.313 + 0.658$$

$$OWC_{w1} = 2.461$$

It is noted that R values in this example are assumed following to Table 4.23 with criteria weights obatined from AHP based on textiles/wearing apparel case study (see Table 4.24). The weights (W) used in OWC equation are global priority or in another case, the local weights could be used which R values must be multiplied by criteria local weights and cluster priority respectively.

The computational result of OWP_{w1} of 2.461 means that worker 1 as alternative 1 obtains the overall worker capability 2.461 from 4 points or 61.54%. Table 4.25 presents the overall computational resutls of ten alteratives (workers) with respect to five main selection criteria, the figures in the table are obtained from $W_{ijk} \times R_{ijk}$ whereas OWC column represents the summation of points achieved by all criteria or $\sum_{i=1}^{5}\sum_{j=1}^{n}\sum_{k=0}^{m}(W_{ijk} \times R_{ijk})$. Accordingly, the percentage (%) column presents the overall performance of ten alternatives in percentage form.

Table 4.25 Computational results of an individual OWC

Alternative (Worker)	Competency		Experience			Personal characteristics			Skill						Operational output		OWC	%
	0.155		*0.302*			*0.034*			*0.133*						*0.376*			
									General skill *0.146*				Technical skill *0.854*					
	Educational background	Training level	Year of experience	Operations Familiarity	Working knowledge	Age/seniority	Health	Time punctuality	Willingness	Active learning	Situation awareness	Communication	Working in teams/ cooperation	Task preparation and prioritization	Operation and control	Production rate	Quality of part produced		
	0.405	*0.595*	*0.319*	*0.447*	*0.234*	*0.046*	*0.401*	*0.230*	*0.323*	*0.266*	*0.184*	*0.226*	*0.324*	*0.250*	*0.750*	*0.417*	*0.583*		
W1	0.125	0.092	0.386	0.271	0.141	0.005	0.054	0.016	0.044	0.021	0.014	0.013	0.025	0.113	0.170	0.313	0.658	**2.461**	**61.54%**
W2	0.125	0.369	0.193	0.406	0.212	0.006	0.054	0.016	0.011	0.015	0.007	0.009	0.025	0.113	0.170	0.313	0.877	**2.923**	**73.07%**
W3	0.063	0.277	0.096	0.135	0.283	0.003	0.014	0.016	0.022	0.015	0.007	0.004	0.006	0.028	0.170	0.157	0.219	**1.516**	**37.90%**
W4	0.251	0.185	0.289	0.406	0.141	0.002	0.027	0.008	0.033	0.005	0.011	0.013	0.025	0.113	0.170	0.627	0.439	**2.744**	**68.60%**
W5	0.251	0.185	0.096	0.406	0.071	0.003	0.041	0.031	0.011	0.021	0.007	0.013	0.025	0.085	0.340	0.157	0.219	**1.962**	**49.04%**
W6	0.125	0.092	0.193	0.271	0.071	0.002	0.027	0.008	0.011	0.015	0.014	0.017	0.006	0.028	0.340	0.157	0.439	**1.817**	**45.42%**
W7	0.251	0.185	0.193	0.135	0.212	0.006	0.027	0.023	0.033	0.005	0.014	0.013	0.006	0.113	0.340	0.313	0.658	**2.529**	**63.23%**
W8	0.125	0.369	0.096	0.541	0.283	0.006	0.027	0.031	0.022	0.021	0.007	0.013	0.006	0.113	0.170	0.157	0.439	**2.427**	**60.68%**
W9	0.063	0.092	0.386	0.135	0.212	0.003	0.027	0.031	0.011	0.010	0.014	0.013	0.006	0.028	0.340	0.470	0.658	**2.501**	**62.52%**
W10	0.188	0.277	0.289	0.406	0.283	0.005	0.041	0.031	0.044	0.010	0.011	0.017	0.019	0.085	0.340	0.157	0.658	**2.860**	**71.51%**
W11	0.063	0.277	0.386	0.135	0.141	0.002	0.014	0.031	0.011	0.015	0.004	0.004	0.013	0.057	0.085	0.470	0.439	**2.145**	**53.63%**
W12	0.125	0.092	0.386	0.541	0.141	0.003	0.014	0.023	0.022	0.021	0.011	0.017	0.019	0.085	0.170	0.313	0.219	**2.203**	**55.08%**
W13	0.063	0.185	0.096	0.541	0.283	0.006	0.054	0.023	0.011	0.010	0.014	0.017	0.013	0.057	0.340	0.313	0.219	**2.247**	**56.17%**
W14	0.188	0.092	0.289	0.406	0.071	0.005	0.014	0.031	0.044	0.015	0.007	0.017	0.006	0.028	0.340	0.313	0.439	**2.306**	**57.66%**
W15	0.251	0.369	0.289	0.135	0.283	0.003	0.041	0.016	0.044	0.015	0.011	0.004	0.019	0.113	0.340	0.627	0.877	**3.437**	**85.94%**
W16	0.063	0.277	0.096	0.541	0.212	0.003	0.014	0.023	0.022	0.010	0.014	0.017	0.013	0.057	0.255	0.627	0.658	**2.902**	**72.55%**
W17	0.251	0.185	0.193	0.271	0.283	0.005	0.041	0.008	0.044	0.010	0.011	0.004	0.019	0.057	0.255	0.157	0.658	**2.449**	**61.23%**
W18	0.063	0.369	0.386	0.406	0.283	0.003	0.041	0.008	0.033	0.010	0.014	0.009	0.006	0.113	0.255	0.470	0.439	**2.907**	**72.68%**
W19	0.063	0.369	0.289	0.406	0.141	0.002	0.054	0.023	0.033	0.010	0.004	0.009	0.013	0.057	0.340	0.313	0.219	**2.345**	**58.63%**
W20	0.188	0.185	0.193	0.271	0.071	0.002	0.027	0.016	0.033	0.021	0.014	0.017	0.006	0.113	0.170	0.313	0.658	**2.297**	**57.43%**

In order to group the semi-skilled workers, R values achieved by 20 alternatives (workers) are ranked with respect to the cluster priorities of five aspects i.e. competency, experience, personal characteristics, skill, and operational output including OWC values. Table 4.26 – 4.27 presents the overall rankings of ten alternatives by main selection criteria.

From Table 4.26, it is evident that W15 yields the highest OWC by 3.437 which also draws the top rankings in competency 4.000, skill 3.788, and operational output 4.000 respectively. However, W15 achieves level 3 in experience criteria (see Table 4.26).

Table 4.26 The overall rankings of workers by main selection criteria

Competency		**Experience**		**Personal characteristics**		**Skill**		**Operational output**		**OWC**	
15	4.000	**18**	3.553	**10**	3.553	**15**	3.788	**15**	4.000	**15**	3.437
2	3.190	**12**	3.532	**1**	3.494	**7**	3.709	**16**	3.417	**2**	2.923
8	3.190	**10**	3.234	**19**	3.309	**5**	3.700	**2**	3.167	**18**	2.907
10	3.000	**8**	3.044	**15**	3.047	**10**	3.635	**9**	3.000	**16**	2.902
4	2.810	**13**	3.044	**17**	2.863	**13**	3.401	**4**	2.833	**10**	2.860
5	2.810	**16**	2.810	**13**	2.801	**19**	3.254	**1**	2.583	**4**	2.744
7	2.810	**4**	2.766	**14**	2.751	**6**	3.179	**7**	2.583	**7**	2.529
17	2.810	**19**	2.766	**7**	2.645	**14**	3.125	**20**	2.583	**9**	2.501
18	2.786	**2**	2.681	**2**	2.571	**9**	3.107	**11**	2.417	**1**	2.461
19	2.786	**1**	2.638	**8**	2.552	**18**	3.074	**18**	2.417	**17**	2.449
20	2.405	**14**	2.532	**5**	2.538	**16**	2.760	**10**	2.167	**8**	2.427
3	2.190	**17**	2.468	**18**	2.494	**1**	2.686	**17**	2.167	**19**	2.345
11	2.190	**9**	2.424	**20**	2.277	**17**	2.682	**14**	2.000	**14**	2.306
16	2.190	**15**	2.339	**9**	2.137	**20**	2.577	**6**	1.583	**20**	2.297
14	1.810	**11**	2.190	**4**	2.047	**2**	2.561	**8**	1.583	**13**	2.247
13	1.595	**5**	1.895	**12**	1.829	**4**	2.543	**12**	1.417	**12**	2.203
1	1.405	**7**	1.786	**16**	1.829	**8**	2.490	**13**	1.417	**11**	2.145
6	1.405	**6**	1.766	**11**	1.690	**12**	2.431	**19**	1.417	**5**	1.962
12	1.405	**20**	1.766	**3**	1.599	**3**	1.745	**3**	1.000	**6**	1.817
9	1.000	**3**	1.702	**6**	1.401	**11**	1.338	**5**	1.000	**3**	1.516

Table 4.27 Rankings and performance levels of alternatives (workers)

Competency		Experience		Personal characteristics		Skill		Operational output		OWC	
15	4	**18**	4	**10**	4	**15**	4	**15**	4	**15**	4
2	4	**12**	4	**1**	4	**7**	4	**16**	4	**2**	3
8	4	**10**	4	**19**	4	**5**	4	**2**	4	**18**	3
10	3	**8**	4	**15**	4	**10**	4	**9**	3	**16**	3
\4	3	**13**	4	**17**	3	**13**	4	**4**	3	**10**	3
5	3	**16**	3	**13**	3	**19**	4	**1**	3	**4**	3
7	3	**4**	3	**14**	3	**6**	4	**7**	3	**7**	3
17	3	**19**	3	**7**	3	**14**	4	**20**	3	**9**	3
18	3	**2**	3	**2**	3	**9**	4	**11**	3	**1**	3
19	3	**1**	3	**8**	3	**18**	4	**18**	3	**17**	3
20	3	**14**	3	**5**	3	**16**	3	**10**	3	**8**	3
3	3	**17**	3	**18**	3	**1**	3	**17**	3	**19**	3
11	3	**9**	3	**20**	3	**17**	3	**14**	2	**14**	3
16	3	**15**	3	**9**	3	**20**	3	**6**	2	**20**	3
14	2	**11**	3	**4**	3	**2**	3	**8**	2	**13**	3
13	2	**5**	2	**12**	2	**4**	3	**12**	2	**12**	3
1	2	**7**	2	**16**	2	**8**	3	**13**	2	**11**	3
6	2	**6**	2	**11**	2	**12**	3	**19**	2	**5**	2
12	2	**20**	2	**3**	2	**3**	2	**3**	1	**6**	2
9	1	**3**	2	**6**	2	**11**	2	**5**	1	**3**	2

At this point, Table 4.26 – 4.27 represents the performance of alternatives (workers) in all five aspects including OWC. This significantly support the decisions regarding workforce management to the related departments, i.e. human resource management and production. The information leads to a better management on semi-skilled workers in grouping and allocating them to the right tasks.

In Table 4.27, it is extended from Table 4.26 which worker performance levels is presented based on textiles/wearing apparel case study and previous studies. The semi-skilled workers in its production system are categorized into four groups based on a single overall performance.

- Group 1 – Poor performance
- Group 2 – Satisfied performance
- Group 3 – Average performance
- Group 4 – High performance

With distinct groups of workers based on their overall performance, managers could efficiently make the decisions on worker assignment problems to appropriately allocate a semi-skilled worker into tasks in accordance with his/her abilities with respect to five performance aspects including the group of poor performance worker which a relevant training course should be provided.

Figure 4.56 – 4.61 illustrate the groups of semi-skilled workers in each performance aspect. Figures in the tables represent alternatives (workers).

Group 1 Poor	**Group 2** Satisfied	**Group 3** Average	**Group 4** High
-	**5**	**2**	**15**
	6	**18**	
	3	**16**	
		10	
		4	
		7	
		9	
		1	
		17	
		8	
		19	
		14	
		20	
		13	
		12	
		11	

Figure 4.56 Groups of semi-skilled workers by OWC

Group 1 Poor	**Group 2** Satisfied	**Group 3** Average	**Group 4** High
9	**14**	**10**	**15**
	13	**4**	**2**
	1	**5**	**8**
	6	**7**	
	12	**17**	
		18	
		19	
		20	
		3	
		11	
		16	

Figure 4.57 Groups of semi-skilled workers by competency aspect

Group 1 Poor	Group 2 Satisfied	Group 3 Average	Group 4 High
-	**5**	**16**	**18**
	7	**4**	**12**
	6	**19**	**10**
	20	**2**	**8**
	3	**1**	**13**
		14	
		17	
		9	
		15	
		11	

Figure 4.58 Groups of semi-skilled workers by experience aspect

Group 1 Poor	Group 2 Satisfied	Group 3 Average	Group 4 High
-	**12**	**17**	**10**
	16	**13**	**1**
	11	**14**	**19**
	3	**7**	**15**
	6	**2**	
		8	
		5	
		18	
		20	
		9	
		4	

Figure 4.59 Groups of semi-skilled workers by personal characteristics aspect

Group 1 Poor	Group 2 Satisfied	Group 3 Average	Group 4 High
-	**3**	**16**	**15**
	11	**1**	**7**
		17	**5**
		20	**10**
		2	**13**
		4	**19**
		8	**6**
		12	**14**
			9
			18

Figure 4.60 Groups of semi-skilled workers by skill aspect

Group 1	**Group 2**	**Group 3**	**Group 4**
Poor	Satisfied	Average	High
3	**14**	**9**	**15**
5	**6**	**4**	**16**
	8	**1**	**2**
	12	**7**	
	13	**20**	
	19	**11**	
		18	
		10	
		17	

Figure 4.61 Groups of semi-skilled workers by operational output aspect

Accordingly, in order to see the overall perfomance of the semi-skilled workers in all aspects, the radar chart in Figure 4.62 is examined.

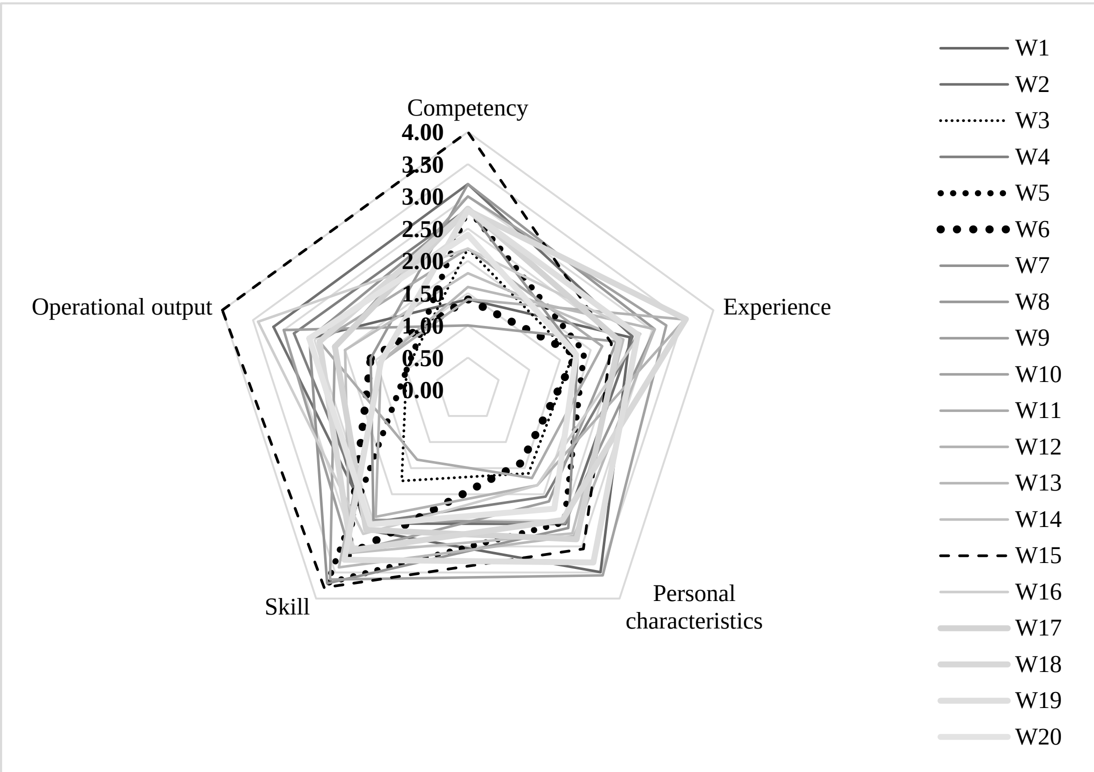


Figure 4.62 An example of radar chart with worker performance in five criteria

Figure 4.62 presents the radar chart of an individual worker performance regarding to five main selection criteria, competency, experience, personal characteristics, skill, and operational output. Twenty lines in the chart examined performance scores of each worker obtained from AHP model. Three distinct groups of semi-skilled workers are shown based on OWC, the dot lines refer to Group 2 (W3, W5 and W6) and Group 4 (W15) whereas the normal grey lines present workers in Group 3 with satisfied performance. With this chart, it is easily seen the overall worker capability which facilitates worker management decisions in various aspects.

Conclusively, the overall worker capability (OWC) achieved by a single semi-skilled worker including rankings and performance levels shown in Table 4.26 – 4.27 and Figure 4.56 – 4.62 significantly support the final decisions on worker assignment problem as the next worker management phase. Moreover, weights and priorities obtained from the model effectively benefit the overall human resource management scheme with respect to an individual worker performance which plays an important role in driving the organization to achieve its business’s goals. Regarding to labor-intensive industry, strengths and weaknesses of the primary production resource as workers are acknowledge, and this has led to improve semi-skilled workers with further training programs related to their important performance aspects to maximized the company’s productivity gains.

CHAPTER V
DISCUSSION AND CONCLUSION

This chapter provides contribution conducted from this research with respect to its objectives. The comparison of semi-skilled worker selection and grouping in labor-intensive industry between the proposed study and others is discussed including the important criteria, tool and methodology used in both academic and practical perspectives. Through the discussion and conclusion, research limitations and future research are also described.

5.1 Discussion

5.1.1 The comparison of research methodology and results between the proposed study and others

Important selection criteria

With respect to the existing literature related to worker selection in labor-intensive industry, Rani et al. (2014) proposed a study of operator performance evaluation using a case study of SME food manufacturing companies. To measure operator performance in various aspects, all criteria involved is conducted through previous literature and consensuses from management of a case study company. However, the study only considers criteria through a viewpoint of food industry with less complex research model. It is also found that main criteria and sub-criteria conducted in the study are inadequate, especially personal characteristics and skill aspects are not focused as they highly effect the production performance in labor-intensive manufacturing context. On the other hand, a few studies investigate worker selection problem in various contexts, e.g. electronics, automobile, and telecommunication. It is obviously seen that the number of importance selection criteria is less considered since workers are not the main resource in their production systems.

Afshari et al. (2010) investigates a personnel selection problem in which only seven human-related factors are discussed. In whilst, operator performance evaluation approach of Şen and Çınar (2010) hardly focus on a single worker's capability of machine operating. Nembhard and Bentefouet (2014) similarly conducts the selection policies based on a case study of an automobile company, however only individual learning and forgetting characteristics are considered. Accordingly, the importance selection criteria proposed in the existing studies are still inadequate to represent the worker selection model with respect to labor-intensive industry. With this study, worker selection criteria based on human-related factor is primarily highlighted with five performance aspects, i.e. competency, experience, personal characteristics, skill, and operational output, as discussed in Chapter III and IV.

On the other hand, Consoli and Rentocchini (2015) recently proposed an empirical study of multi-industry labor force skills which primarily focused on identifying skills of specific categories of practical know-how and classification of industry groups based on skills contents. It is obviously found that the scope of their study has been slightly different compared to the proposed study which a taxonomy of labor skills is mainly concerned whereas worker selection and grouping approaches are not included. However, the study of Consoli and Rentocchini (2015) greatly supports the validation of selection criteria in worker selection process approach proposed in this research, and ensures that the selected important criteria is a crucial driver of industry evolution based on the recent database and information.

Research tools

Multiple criteria decision making (MCDM) methods have been widely used in personnel selection problem as potential tools to judge different alternatives (choice, strategy, policy) on various criteria and find possible selection of the best alternative. However, various approaches of MCDM are studied including AHP, FAHP, ELECTRE, PROMETHEE II, TOPSIS, and VIKOR. It is found that most of the related studies applied AHP and FAHP as MCDM methods in their research methodologies to solve worker performance evaluation/selection problem. A study of Rani et al. (2014) reveals that AHP is identified as the suitable method in operator performance evaluation for food production with respect to labor-intensive context. Accordingly, AHP is applied in this research to investigate weights and priorities of the importance selection criteria conducted from previous studies and manufacturing practices.

Case studies

As manufacturing practices are mainly focused in this study, four case studies with different labor-intensive manufacturing contexts are investigated to food products, textiles/wearing apparel products, plastic products, steel products. Furthermore, a case study from recruitment outsourcing providers is also conducted with a significant role in managing labor resource for manufacturing industries and services. In AHP model of the proposed study, ten decision makers are investigated which includes two decision makers from each case study in order to conduct various practical perspectives from those worker resource experts. However, a number of the existing studies conduct a single industry as case study which only one to three experts are investigated. Accordingly, a single case study is inadequate to represent worker selection in general since it could not effectively response to various production conditions by a specific viewpoint and contributes less benefit for real applications.

Applications

Regarding to the results obtained in this study, categorized by types of manufacturing or case studies. It is obviously seen that the overall semi-skilled worker selection and grouping practices are not distinctly different especially the primary recruitment processes (as discussed in Chapter IV) remain similar whereas there is a small difference in selection criteria considered, with respect to each production natures that requires different characteristics/qualities of a single semi-skilled worker. Accordingly, the important selection criteria based on human-related factors are included in this study. The labor-intensive industry is highlighted. Semi-skilled worker selection and grouping model from Chapter IV could be significantly applied in a real company using criteria and weights/priorities conducted from manufacturing experts, including the entire recruitment process from a pool of workers until grouping process. On the other hand, the existing literature mostly concludes their studies with the theoretical model which is complicated to apply in real settings. It is moreover found that those studies hardly focus on academic standpoints while practical conditions and applications tend to be neglected.

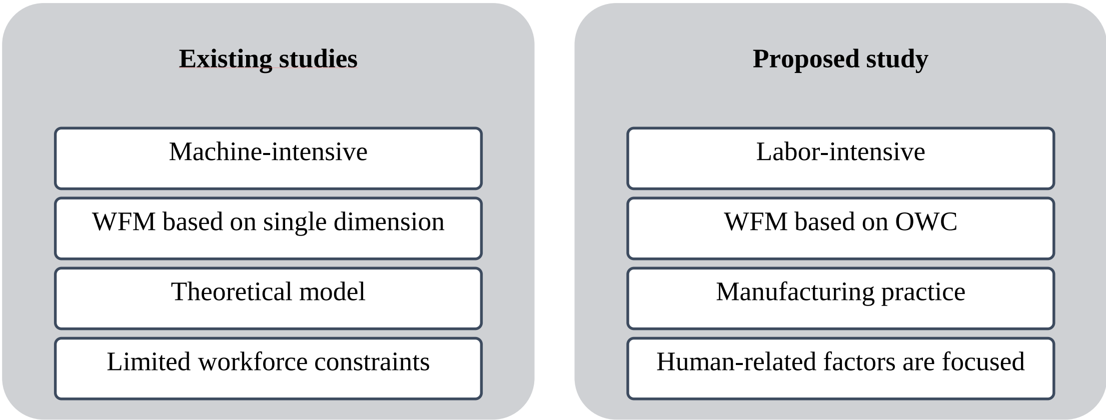


Figure 5.1 Existing studies and proposed study

Figure 5.1 presents the overview of existing studies and proposed study as discussed in Chapter III. This research studies a WFM of semi-skilled worker selection and grouping based on labor-intensive industry perspective whereas a number of previous studies focus much more in machine-intensive industry. Regarding to workforce management (WFM), various performance aspects as overall worker capability (OWC) of a single worker, i.e. competency, experience, personal characteristics, skill, and operational output are highlighted while it is found that most of literatures only consider a single performance aspect with complex theoretical methodology. The entire AHP model proposed in this study is primarily based on human-related factors since worker resource plays an important role in production performance of labor-intensive manufacturing including the important selection criteria. As well as the real application of the proposed methodology is needed to be applicable and comply with manufacturing settings.

5.2 Conclusion

This research presents semi-skilled worker selection and grouping in the context of labor-intensive industry with different perspectives of both academic and real manufacturing practice. Accordingly, the important criteria and practical method used in worker selection process including preliminary approach in grouping phase, similarities and differences among case studies are discussed. Analytical Hierarchy

Process (AHP) is applied as multiple criteria decision making methods in providing weights and priorities of the important selection criteria conducted from previous studies and manufacturing practices, the human-related factors are highlighted in five main performance aspects including (1) competency, (2) experience, (3) personal characteristics, (4) skill, and (5) operational output. Five different case studies of both manufacturing companies including food products, textiles/wearing apparel products, plastic products, steel products and recruitment outsourcing provider are investigated with ten selected experts to provide judgements matrix for all criteria in the AHP model.

As the result, it is found that each case study considers different selection criteria of semi-skilled worker with a significance regarding to its operational characteristics and production environment. However, the overall flows of selection and grouping process tends to be similar with respect to labor-intensive context as illustrated in Figure 4.53, Section 4.13, Chapter IV.

5.2.1 The advantage of semi-skilled worker selection and grouping in labor-intensive industry

Academic perspective

- According to worker allocation problem, selection and grouping as pre-phases would significantly support the final decision makings in assigning workers to tasks in operations with respect to his/her individual performance. In addition, this pre-phases also support the entire integrated WFM model in selection, grouping, and allocation. With respect to studies related to labor-intensive industry, human-related factors are mainly considered as the important constraints in any theoretical models which make the models more realistic.

- AHP is an effective method widely used to deal with multiple constraints in making decisions. It is applicable in various scenarios in which transforming verbal judgements into numeric matrix and provide importance weights. The AHP model of semi-skilled worker selection in this study could be beneficial in a personnel selection problem of future studies.

Manufacturing perspective

- Semi-skilled worker selection and grouping model proposed in this study highly benefits in supporting the company's human resource recruitment process with respect to weights and priorities of the important selection criteria including the entire flow from selecting a pool of workers, performance evaluation, selection, and grouping with respect to performance variabilities in various aspects.

- The effective model with accurate judgments on selection criteria accordingly results the valid selection of worker resource with qualified performance that helps to increase the productivity gains.

- OWC allows the management of a company to acknowledge an individual performance of worker including strengths and weaknesses based on five aspects of competency, experience, personal characteristics, skill, and operational output. In term of Human Resource Management, this facilitates the decisions on worker's wage raise including a long term plan on human resource such as future training programs in achieving the business's goal. Moreover, an acknowledgement of worker performance helps production managers in assigning operations to a single worker in accordance with his/her capabilities. A holistic view of overall worker capability also supports the management team in defining strengths and weakness of the production systems.

5.3 Limitation and recommendation for future research

5.3.1 Research limitation

The semi-skilled worker selection and grouping model in this study are limited to labor-intensive industry since human-related factors and workforce management (WFM) play a great role in effecting the overall performance in labor-intensive production. However, it is applicable in other manufacturing context. Weighting judgement based on an individual preference of a decision maker is partial applied from AHP approach, whereas the complex alternatives are not studied as well as the relations among five clusters (competency, experience, personal characteristics, skill, and operational output).

5.3.2 Recommendation for future research

Different approaches can be applied and compared with the proposed study with respect to the practical constraints and applicable in real manufacturing settings. Regarding to the holistic workforce management (WFM), the selection and grouping model as pre-phases in this study can be extended by improving an integrated WFM with multiple phases including selection, grouping, and allocation. Additionally, the measurement method of worker selection/grouping models tend to be neglected in existing studies. The related key performance index should be advised to validate the model, and the outstanding benefits are conducted.

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APPENDICES

APPENDIX A
SEMI-SKILLED WORKER CRITERIA DEFINITIONS

ขีดความสามารถทางอาชีพ		
1.1	วุฒิทางการศึกษา	ระดับทางการศึกษา เช่น มัธยมศึกษา, อนุปริญญา, ปวช., ปวส., ปริญญาตรี เป็นต้น
1.2	ประวัติการทำงาน/ตำแหน่งงาน	ประวัติการทำงาน และตำแหน่งงานที่เคยได้รับมอบหมาย
1.3	การฝึกอบรม	ประวัติการฝึกอบรม หรือประกาศนียบัตรที่ได้ผ่านการเข้าฝึกอบรมต่าง ๆ ซึ่งมีความเกี่ยวข้องกับตำแหน่งงาน
1.4	ใบอนุญาตการทำงานเฉพาะทาง	ใบผ่านงานหรือใบอนุญาตการทำงานเฉพาะทางที่เกี่ยวข้อง
ประสบการณ์ทางอาชีพ		
2.1	ประสบการณ์การทำงาน	ประสบการณ์การทำงานในสาขาที่เกี่ยวข้อง
2.2	ความเชี่ยวชาญในการปฏิบัติงาน	การสั่งสมความเชี่ยวชาญในงานอาชีพ และสามารถประยุกต์ใช้ความรู้ความสามารถให้เกิดประสิทธิภาพในการปฏิบัติงานที่ได้รับมอบหมาย
2.3	ความรู้ที่เกี่ยวข้องในการปฏิบัติงาน	มีความรู้เฉพาะด้านที่เกี่ยวข้องกับตำแหน่งงาน หรือเคยปฏิบัติงานในสาขาที่เกี่ยวข้อง
ลักษณะส่วนบุคคล		
3.1	อายุ/วัยวุฒิ	ช่วงอายุที่รับพนักงานเข้าทำงานตามกฎระเบียบขององค์กร
3.2	รูปลักษณ์ภายนอก	ลักษณะทางกายภาพ เช่น ส่วนสูง น้ำหนัก เป็นต้น
3.3	วัฒนธรรมโดยทั่วไป	พฤติกรรม และการแสดงออกทางวัฒนธรรมโดยทั่วไป
3.4	เป้าหมายในการทำงาน	วัตถุประสงค์ และการตั้งเป้าหมายในการทำงานระยะยาว
3.5	สุขภาพ	ประวัติความเจ็บป่วย และสุขภาพเบื้องต้น
3.6	ความซื่อสัตย์และจงรักภักดีต่อองค์กร	คุณลักษณะทางบวกด้านคุณธรรม ความจริงใจ ตรงไปตรงมา ในหน้าที่ที่ได้รับมอบหมาย และความจงรักภักดีที่มีต่อองค์กร
3.7	ความตรงต่อเวลา	การรักษาเวลา และถือกำหนดเวลาในการปฏิบัติงานที่ได้รับมอบหมาย
3.8	ความสมัครใจในการทำงาน	ความกระตือรือร้น และปฏิบัติงานที่ได้รับมอบหมายด้วยความเต็มใจ

ลักษณะส่วนบุคคล (ต่อ)		
3.9	ความยืดหยุ่นในการเปลี่ยนแปลงตามสภาพแวดล้อม/สถานการณ์	การปรับตัว และเปลี่ยนแปลงได้ตามสถานการณ์ที่เกิดขึ้นระหว่างปฏิบัติงานและสภาพแวดล้อมในการทำงาน เพื่อนร่วมงาน และองค์กร
3.10	ความเข้าใจทางสังคมและเพื่อนร่วมงาน	ทัศนคติในทางบวกต่อเพื่อนร่วมงาน และสังคมการทำงาน
3.11	ภาวะความเป็นผู้นำ	พฤติกรรมในการกำกับกิจกรรมของกลุ่มเพื่อนร่วมงานไปสู่เป้าหมายร่วมกัน
3.12	การมีส่วนร่วมในองค์กร	การเข้าเป็นส่วนหนึ่งของกิจกรรมหรือกฎระเบียบต่าง ๆ ขององค์กรและปฏิบัติตามด้วยความเต็มใจ
3.13	ความสามารถในการเจรจาต่อรอง/โน้มน้าว	ทักษะในการเจรจาต่อรองหรือโน้มน้าวบุคคลอื่น ให้เกิดผลประโยชน์สูงสุดต่องานที่รับผิดชอบ และต่อองค์กร
3.14	การบริการหรือตอบสนองต่อความต้องการของเพื่อนร่วมงาน	การประพฤติปฏิบัติตนต่อเพื่อนร่วมงานในทางบวก เช่น การให้ความช่วยเหลือซึ่งกันและกัน มีน้ำใจต่อกัน เป็นต้น
ทักษะด้านการปฏิบัติงาน		
(1) ทักษะพื้นฐาน		ทักษะพื้นฐานในการทำงานโดยทั่วไป ซึ่งสามารถประยุกต์ใช้ได้หลายสาขาอาชีพ ไม่จำกัดประเภทอุตสาหกรรม
4.1	ความสามารถในการเรียนรู้	ความเร็วในการเรียนรู้สิ่งใหม่ ๆ เช่น การปฏิบัติงานในตำแหน่งอื่นโดยการใช้ทักษะที่แตกต่างจากเดิม
4.2	ความสามารถในการตัดสินใจหรือแก้ปัญหาเบื้องต้น	สามารถตัดสินใจแก้ปัญหาในการปฏิบัติงานเบื้องต้นได้
4.3	การคิดเชิงวิเคราะห์	ความสามารถในการจำแนกแจกแจงองค์ประกอบต่าง ๆ ของงานที่ปฏิบัติและหาความสัมพันธ์เชิงเหตุผลระหว่างองค์ประกอบเหล่านั้นเพื่อค้นหาสาเหตุที่แท้จริงของสิ่งที่เกิดขึ้น
4.4	การรับรู้สถานการณ์ต่าง ๆ	ทักษะในการรับรู้ต่อสิ่งแวดล้อมและสถานการณ์ต่าง ๆ ที่เกิดขึ้นหรือเปลี่ยนแปลงไป
4.5	ความสามารถด้านการสื่อสาร	ความสามารถในการสื่อสารทั้ง 4 ทักษะ ได้แก่ การพูด การฟัง การอ่าน และการเขียน หรือทักษะที่จำเป็นต่อการปฏิบัติงานในตำแหน่งที่ได้รับมอบหมาย
4.6	ความรู้พื้นฐานทางคอมพิวเตอร์	สามารถใช้โปรแกรมคอมพิวเตอร์พื้นฐานได้ เช่น Microsoft Word
4.7	การประสานงานและทำงานร่วมกันเป็นกลุ่ม	ทักษะในการประสานงาน และทำงานร่วมกับเพื่อนร่วมงานคนอื่น ๆ เพื่อบรรลุวัตถุประสงค์ในการปฏิบัติงาน

ทักษะด้านการปฏิบัติงาน (ต่อ)		
(2) ทักษะเชิงปฏิบัติ		ทักษะเฉพาะทางหรือความเชี่ยวชาญด้านการปฏิบัติงานในอุตสาหกรรมประเภทใดประเภทหนึ่ง
4.8	การเตรียมและจัดเรียงลำดับการผลิต	ความสามารถในการวางแผนเตรียมการผลิตตามลำดับกระบวนการที่กำหนด เช่น การเตรียมวัตถุดิบการผลิต การเตรียมเครื่องจักรและอุปกรณ์ที่ใช้ในการผลิต เป็นต้น
4.9	การเลือกใช้อุปกรณ์และเครื่องจักรในการผลิตอย่างเหมาะสม	การเลือกใช้อุปกรณ์หรือเครื่องจักรการผลิตที่ถูกต้อง และเหมาะสมกับกระบวนการผลิตที่ได้รับมอบหมาย ภายใต้นโยบายด้านความปลอดภัยขององค์กร
4.10	การติดตั้งอุปกรณ์และเครื่องจักรที่ใช้ในการผลิต	สามารถติดตั้งหรือตั้งค่าอุปกรณ์และเครื่องจักรที่ใช้ในการผลิตระดับเบื้องต้น
4.11	ความสามารถในการปฏิบัติงานและการควบคุมการผลิต	ทักษะการปฏิบัติงานในกระบวนการผลิตเพื่อตอบสนองเป้าหมายที่กำหนดโดยฝ่ายการผลิต เช่น เป้าหมายการผลิตเป็นจำนวนชิ้นต่อวัน รวมถึงสามารถควบคุมการผลิตในส่วนที่ตนรับผิดชอบได้
4.12	การติดตามกระบวนการผลิต	การติดตามกระบวนการผลิตของชิ้นงานที่ตนผลิตอย่างต่อเนื่องจนจบกระบวนการ
4.13	การรักษามาตรฐานและปฏิบัติตามขั้นตอนการผลิต	การคำนึงถึงมาตรฐานการผลิต เช่น คุณภาพชิ้นงานที่ผลิตจะต้องตรงตามมาตรฐานที่กำหนดโดยองค์กร และปฏิบัติตามกฎระเบียบการผลิตอย่างเคร่งครัด
ผลการปฏิบัติงาน		
5.1	อัตราการผลิต (จำนวนหน่วยที่ผลิตต่อหนึ่งหน่วยเวลา)	การวัดผลการปฏิบัติงานด้วยอัตราการผลิตด้วยจำนวนหน่วยที่ผลิตได้ต่อหนึ่งหน่วยเวลา เช่น จำนวนชิ้นที่ผลิตได้ต่อหนึ่งชั่วโมง เป็นต้น เพื่อเปรียบเทียบกับเป้าหมายที่กำหนด
5.2	คุณภาพของหน่วยการผลิตเปรียบเทียบกับค่ามาตรฐานขององค์กร	การวัดผลการปฏิบัติงานด้วยคุณภาพของหน่วยการผลิตเทียบกับค่ามาตรฐานที่กำหนดไว้

APPENDIX B
QUESTIONNAIRE

แบบสอบถาม

เรื่อง การเลือกและการจัดกลุ่มแรงงานกึ่งใช้ฝีมือ (Semi-skilled) ในอุตสาหกรรมประเภทใช้แรงงาน

<u>คำชี้แจง</u>

1. แบบสอบถามฉบับนี้มีวัตถุประสงค์เพื่อศึกษาข้อมูลแนวทางปฏิบัติ เกณฑ์พิจารณาในการเลือก และการจัดกลุ่มพนักงานกึ่งใช้ฝีมือ (Semi-skilled) ซึ่งปฏิบัติงานภายใต้ฝ่ายการผลิตในอุตสาหกรรมประเภทใช้แรงงาน สำหรับใช้ในงานวิจัยของนักศึกษาระดับปริญญาโทคณะวิศวกรรมศาสตร์ สาขาวิศวกรรมอุตสาหการ บัณฑิตวิทยาลัย มหาวิทยาลัยมหิดล โดยแบบสอบถามประกอบไปด้วยคำถามทั้งหมด 2 ชุด มีรายละเอียดของคำถามดังต่อไปนี้

ชุดที่ 1 ข้อมูลทั่วไปในการเลือก และการจัดกลุ่มพนักงานประเภทกึ่งใช้ฝีมือ (Semi-skilled) จากกรณีศึกษาของกลุ่มบริษัทตัวอย่างในอุตสาหกรรมประเภทใช้แรงงาน หน้า 156 – 158

ตอนที่ 1 ข้อมูลทั่วไปของผู้ตอบแบบสอบถามและประเภทขององค์กร

ตอนที่ 2 คำจำกัดความของ “พนักงานกึ่งใช้ฝีมือ (Semi-skilled)”

ตอนที่ 3 การเลือก และประเมินพนักงานกึ่งใช้ฝีมือ

ตอนที่ 4 การจัดกลุ่มพนักงานกึ่งใช้ฝีมือ

ชุดที่ 2 เกณฑ์การเลือกพนักงานกึ่งใช้ฝีมือ (Semi-skilled) ในอุตสาหกรรมประเภทใช้แรงงาน หน้า 159 – 171

ตอนที่ 1 เกณฑ์การเลือกพนักงานกึ่งใช้ฝีมือ (Semi-skilled)

เกณฑ์การเลือกถูกแบ่งออกเป็น 5 เกณฑ์หลัก โดยแต่ละเกณฑ์หลักประกอบด้วยเกณฑ์ย่อย ตามรายละเอียดดังต่อไปนี้

เกณฑ์หลักที่ 1 ขีดความสามารถทางอาชีพ แบ่งเป็น 4 เกณฑ์ย่อย

เกณฑ์หลักที่ 2 ประสบการณ์ทางอาชีพ แบ่งเป็น 3 เกณฑ์ย่อย

เกณฑ์หลักที่ 3 ลักษณะส่วนบุคคล แบ่งเป็น 14 เกณฑ์ย่อย

เกณฑ์หลักที่ 4 ทักษะด้านการปฏิบัติงาน แบ่งเป็น 13 เกณฑ์ย่อย

เกณฑ์หลักที่ 5 ผลการปฏิบัติงาน แบ่งเป็น 2 เกณฑ์ย่อย

ตอนที่ 2 การให้น้ำหนักเกณฑ์การเลือกพนักงานกึ่งใช้ฝีมือ (Semi-skilled) ด้วยกระบวนการวิเคราะห์ตามลำดับชั้น (Analytic Hierarchy Process: AHP)

การเปรียบเทียบเกณฑ์การเลือกพนักงานกึ่งใช้ฝีมือ (Semi-skilled) ประกอบด้วย 6 ส่วน ดังนี้

ส่วนที่ 1 การเปรียบเทียบเกณฑ์หลัก

ส่วนที่ 2 การเปรียบเทียบเกณฑ์ย่อยขีดความสามารถทางอาชีพ

ส่วนที่ 3 การเปรียบเทียบเกณฑ์ย่อยประสบการณ์ทางอาชีพ

ส่วนที่ 4 การเปรียบเทียบเกณฑ์ย่อยลักษณะส่วนบุคคล

ส่วนที่ 5 การเปรียบเทียบเกณฑ์ย่อยทักษะด้านการปฏิบัติงาน

ส่วนที่ 5.1 การเปรียบเทียบเกณฑ์ย่อยทักษะพื้นฐาน

ส่วนที่ 5.2 การเปรียบเทียบเกณฑ์ย่อยทักษะเชิงปฏิบัติ

ส่วนที่ 6 การเปรียบเทียบเกณฑ์ย่อยผลการปฏิบัติงาน

ภาคผนวก ความหมายและคำจำกัดความของเกณฑ์การเลือกพนักงานกึ่งใช้ฝีมือ (Semi-skilled) **หน้า 151 – 153**

2. โปรดตอบคำถามทุกข้อตาม***<u>ข้อเท็จจริง</u>***ที่ได้จากมุมมองในเชิงปฏิบัติของอุตสาหกรรมการผลิต เพื่อความสมบูรณ์และถูกต้องในการประมวลผลงานวิจัย และสามารถนำไปประยุกต์ใช้ในกระบวนการคัดเลือกและจัดกลุ่มพนักงานกึ่งใช้ฝีมือ (Semi-skilled) ของอุตสาหกรรมประเภทใช้แรงงานได้อย่างมีประสิทธิภาพ

ชุดที่ 1

ข้อมูลทั่วไปในการเลือกและการจัดกลุ่มพนักงานประเภทกึ่งใช้ฝีมือ (Semi-skilled) จากกรณีศึกษาของกลุ่มบริษัทตัวอย่างในอุตสาหกรรมประเภทใช้แรงงาน

ตอนที่ 1 ข้อมูลทั่วไปของผู้ตอบแบบสอบถามและประเภทขององค์กร

คำถามที่ 1.1 ตำแหน่ง

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คำถามที่ 1.2 ประเภทของอุตสาหกรรม

☐ การผลิตผลิตภัณฑ์อาหารและเครื่องดื่ม

☐ การผลิตสิ่งทอ/การผลิตเครื่องแต่งกาย รวมทั้งการตกแต่งและย้อมสีขนสัตว์/การฟอก และตกแต่งหนังฟอก รวมทั้งการผลิตกระเป๋าเดินทาง กระเป๋าถือ อานม้า เครื่องเทียมลาก และรองเท้า

☐ การผลิตผลิตภัณฑ์ยางและพลาสติก

☐ การผลิตผลิตภัณฑ์ที่ทำจากโลหะประดิษฐ์

☐ อื่นๆ : โปรดระบุ____

คำถามที่ 1.3 ขนาดอุตสาหกรรม

☐ อุตสาหกรรมขนาดใหญ่	☐ อุตสาหกรรมขนาดกลาง	☐ อุตสาหกรรมขนาดย่อม
(มีการจ้างงานมากกว่า 200 คน)	(มีการจ้างงาน 51 - 200 คน)	(มีการจ้างงานไม่เกิน 50 คน)

*อ้างอิงจาก การแบ่งขนาดอุตสาหกรรมตามวิสาหกิจขนาดกลางและขนาดย่อม (SMEs) และอุตสาหกรรมการผลิตไทย

คำถามที่ 1.4 บุคลากรฝ่ายใดในองค์กรที่มีหน้าที่ดำเนินการเลือกและการจัดกลุ่มพนักงานฝ่ายการผลิต (กรุณาระบุตำแหน่ง/แผนกงานโดยสังเขป)

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ตอนที่ 2 คำจำกัดความของ “พนักงานกึ่งใช้ฝีมือ (Semi-skilled)”

คำถามที่ 2.1 กรุณาให้ความหมายของ “**พนักงาน**” ประเภทต่าง ๆ ดังต่อไปนี้ ตามคำจำกัดความขององค์กร

- **พนักงานฝีมือ (Skilled)** หมายถึง พนักงานที่มีความรู้ทางทฤษฎีและปฏิบัติ ซึ่งมีความชำนาญในงานอาชีพเฉพาะทางจากการฝึกอบรมขั้นสูงหรือมีระดับทางการศึกษา และสามารถตัดสินใจรวมถึงแก้ไขปัญหาที่เกิดขึ้นในการทำงานด้วยตนเองได้ พนักงานฝีมือโดยทั่วไปจะเรียนรู้และฝึกปฏิบัติงานในระยะยาวตั้งแต่ 6 เดือน ถึง 1 ปีขึ้นไป

  ☐ เห็นด้วย

  ☐ ไม่เห็นด้วย (กรุณาระบุโดยสังเขป)____________________________________

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- **พนักงานกึ่งใช้ฝีมือ (Semi-skilled)** หมายถึง พนักงานที่มีความรู้ทางทฤษฎีและปฏิบัติที่มีความชำนาญเพียงบางส่วนของงานอาชีพ โดยไม่จำเป็นต้องได้รับการฝึกอบรมทางวิชาชีพขั้นสูงรวมถึงระดับทางการศึกษา ในมุมมองของอุตสาหกรรมการผลิต พนักงานกึ่งใช้ฝีมือมีบทบาทสำคัญต่อการสร้างความ

ยืดหยุ่นในระบบการผลิต เนื่องจากพนักงานสามารถทำงานได้หลายประเภท (Multiple tasks) และสามารถหมุนเวียนหมุนเวียนเปลี่ยนงานได้ (Job rotation) งานกึ่งใช้ฝีมือโดยทั่วไปพนักงานสามารถเรียนรู้การฝึกปฏิบัติงานได้ด้วยระยะเวลาปานกลางตั้งแต่ 3 ถึง 6 เดือน

☐ เห็นด้วย

☐ ไม่เห็นด้วย (กรุณาระบุโดยสังเขป) ______________________________

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- **พนักงานไร้ฝีมือ (Unskilled)** หมายถึง พนักงานที่ทำงานโดยใช้กำลังกาย ไม่จำเป็นต้องใช้ความรู้ความชำนาญ เพียงได้รับคำแนะนำบ้างเล็กน้อยก็สามารถทำงานได้ โดยทั่วไปพนักงานจะใช้เวลาเรียนรู้งานในระยะสั้นหรือภายใน 1 เดือนโดยประมาณ

☐ เห็นด้วย

☐ ไม่เห็นด้วย (โปรดระบุโดยสังเขป) ______________________________

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คำถามที่ 2.2 พนักงานที่ปฏิบัติงานภายใต้ฝ่ายการผลิตในองค์กรของท่าน มีคุณลักษณะดังต่อไปนี้หรือไม่

1) ได้รับการฝึกอบรมในขณะปฏิบัติงาน (On the job training)

☐ ใช่ ☐ ไม่ใช่

2) มีทักษะการทำงานหลายประเภท (Multiple tasks) และสามารถหมุนเวียนเปลี่ยนงาน (Job rotation) ได้

☐ ใช่ ☐ ไม่ใช่

3) ใช้ระยะเวลาในการเรียนรู้งานระดับปานกลาง ตั้งแต่ 3 ถึง 6 เดือน โดยประมาณ

☐ ใช่ ☐ ไม่ใช่

ตอนที่ 3 การเลือกและประเมินพนักงานกึ่งใช้ฝีมือ (Worker Recruitment)

คำถามที่ 3.1 โปรดอธิบาย***วิธีการเลือก*** และ***ประเมิน***ความสามารถของพนักงานกึ่งใช้ฝีมือ (Semi-skilled) ที่ปฏิบัติงานภายใต้ฝ่ายการผลิต *พร้อมวาด Flow Chart ขั้นตอนการรับพนักงานเข้าทำงานในฝ่ายผลิต* โดยสังเขป

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คำถามที่ 3.2 **องค์กรมีเกณฑ์ในการเลือกและประเมินพนักงานกึ่งใช้ฝีมือ (Semi-skilled) หรือไม่**

1) กรณีที่ไม่มีเกณฑ์ เนื่องจาก____

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<u>หมายเหตุ</u> กรุณา**ข้าม**คำถามชุดที่ 2

2) กรณีที่มีเกณฑ์ โปรดระบุเกณฑ์หลักที่ใช้ในการพิจารณาเลือกพนักงานกึ่งใช้ฝีมือ (Semi-skilled) โดยเรียงลำดับความสำคัญจากมากไปน้อย

1	
2	
3	
4	
5	

ตอนที่ 4 การจัดกลุ่มพนักงานกึ่งใช้ฝีมือ

คำถามที่ 4.1 ในองค์กรมีการจัดกลุ่มพนักงานกึ่งใช้ฝีมือหรือไม่

☐ ใช่ ☐ ไม่ใช่

<u>หมายเหตุ</u> **กรณีที่ตอบ "ใช่"** กรุณาตอบคำถามที่ 4.2 ถึง 4.4

คำถามที่ 4.2 องค์กรใช้เกณฑ์ใดในการจัดกลุ่มพนักงาน

☐ ประสิทธิภาพของพนักงาน (Performance)

แบ่งออกเป็น 4 ระดับ ได้แก่ ระดับสูง ระดับปานกลาง ระดับที่พึงพอใจ และระดับต่ำ

☐ ประเภท/ลักษณะของงาน (Job description)

☐ เกณฑ์อื่น ๆ (โปรดระบุ) ____

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คำถามที่ 4.3 องค์กรมีวิธีการในการจัดกลุ่มพนักงานโดยใช้เกณฑ์ตามคำถามที่ 4.2 อย่างไร

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คำถามที่ 4.4 ตามระเบียบปฏิบัติในการเลือกและจัดกลุ่มพนักงานกึ่งใช้ฝีมือขององค์กร ข้อใดถูกต้อง

☐ <u>**เลือก**</u>พนักงาน<u>**ก่อน**</u> แล้วจึงจัดกลุ่มพนักงานตามเกณฑ์ที่กำหนด

☐ <u>**จัดกลุ่ม**</u>พนักงาน<u>**ก่อน**</u> แล้วจึงเลือกพนักงานตามเกณฑ์ที่กำหนด

☐ อื่น ๆ (โปรดระบุ) ____

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ชุดที่ 2

เกณฑ์การเลือกพนักงานกึ่งใช้ฝีมือ (Semi-skilled) ในอุตสาหกรรมประเภทใช้แรงงาน

ตอนที่ 1 เกณฑ์การเลือกพนักงานกึ่งใช้ฝีมือ (Semi-skilled)

<u>คำชี้แจง</u> ให้พิจารณาเกณฑ์การเลือกพนักงานย่อยในแต่ละเกณฑ์หลัก สำหรับช่อง “พิจารณา” กรณีที่องค์กรใช้เกณฑ์ดังกล่าว กรุณาทำเครื่องหมาย ✓ ในช่องคำตอบ (ใช่) และกรณีที่องค์กรไม่ได้ใช้เกณฑ์นั้นๆ ให้ทำเครื่องหมาย ✓ ในช่องคำตอบ (ไม่ใช่) ในส่วนของช่อง “ระดับความสำคัญ” ให้ตอบเฉพาะในกรณีที่องค์กร**<u>เลือกใช้เกณฑ์พิจารณาเท่านั้น</u>** โดยระดับความสำคัญจะประกอบด้วย 5 ระดับ เรียงลำดับจาก*มากที่สุด* (5) ไปจนถึง*น้อยที่สุด* (1) ตามแบบมาตรวัดของลิเคิร์ท (Likert Scale)

เกณฑ์หลัก	เกณฑ์ย่อย	พิจารณา		ระดับความสำคัญ				
		ใช่	ไม่ใช่	5 มากที่สุด	4 มาก	3 ปานกลาง	2 น้อย	1 น้อยที่สุด
1. ขีดความสามารถทางอาชีพ	1.1 วุฒิทางการศึกษา							
	1.2 ประวัติการทำงาน/ตำแหน่งงาน							
	1.3 การฝึกอบรม							
	1.4 ใบอนุญาตการทำงานเฉพาะทาง							
2. ประสบการณ์ทางอาชีพ	2.1 ประสบการณ์การทำงาน							
	2.2 ความเชี่ยวชาญในการปฏิบัติงาน							
	2.3 ความรู้ที่เกี่ยวข้องในการปฏิบัติงาน							
3. ลักษณะส่วนบุคคล	3.1 อายุ/วัยวุฒิ							
	3.2 รูปลักษณ์ภายนอก							
	3.3 วัฒนธรรมโดยทั่วไป							
	3.4 เป้าหมายในการทำงาน							
	3.5 สุขภาพ							
	3.6 ความซื่อสัตย์และจงรักภักดีต่อองค์กร							
	3.7 ความตรงต่อเวลา							
	3.8 ความสมัครใจในการทำงาน							
	3.9 ความยืดหยุ่นในการเปลี่ยนแปลงตามสภาพแวดล้อม/สถานการณ์							
	3.10 ความเข้าใจทางสังคมและเพื่อนร่วมงาน							

เกณฑ์หลัก	เกณฑ์ย่อย	พิจารณา		ระดับความสำคัญ				
		ใช่	ไม่ใช่	5 มากที่สุด	4 มาก	3 ปานกลาง	2 น้อย	1 น้อยที่สุด
3. **ลักษณะส่วนบุคคล** (ต่อ)	3.11 ภาวะความเป็นผู้นำ							
	3.12 การมีส่วนร่วมในองค์กร							
	3.13 ความสามารถในการเจรจาต่อรอง/โน้มน้าว							
	3.14 การบริการหรือตอบสนองต่อความต้องการของเพื่อนร่วมงาน							
4. **ทักษะด้านการปฏิบัติงาน**								
(1) ทักษะพื้นฐาน	4.1 ความสามารถในการเรียนรู้							
	4.2 ความสามารถในการตัดสินใจหรือแก้ปัญหาเบื้องต้น							
	4.3 การคิดเชิงวิเคราะห์							
	4.4 การรับรู้สถานการณ์ต่าง ๆ							
	4.5 ความสามารถด้านการสื่อสาร							
	4.6 ความรู้พื้นฐานทางคอมพิวเตอร์							
	4.7 การประสานงานและทำงานร่วมกันเป็นกลุ่ม							
(2) ทักษะเชิงปฏิบัติ	4.8 การเตรียมและจัดเรียงลำดับการผลิต							
	4.9 การเลือกใช้อุปกรณ์และเครื่องจักรในการผลิตอย่างเหมาะสม							
	4.10 การติดตั้งอุปกรณ์และเครื่องจักรที่ใช้ในการผลิต							
	4.11 ความสามารถในการปฏิบัติงานและการควบคุมการผลิต							
	4.12 การติดตามกระบวนการผลิต							
	4.13 การรักษามาตรฐานและปฏิบัติตามขั้นตอนการผลิต							
5. **ผลการปฏิบัติงาน**	5.1 อัตราการผลิต (จำนวนหน่วยที่ผลิตต่อหนึ่งหน่วยเวลา)							
	5.2 คุณภาพของหน่วยการผลิตเปรียบเทียบกับค่ามาตรฐานขององค์กร							

ตอนที่ 2 การให้น้ำหนักเกณฑ์การเลือกพนักงานกึ่งใช้ฝีมือ (Semi-skilled) ด้วยกระบวนการวิเคราะห์ตามลำดับชั้น (Analytic Hierarchy Process: AHP)

คำชี้แจง ในการให้น้ำหนักเกณฑ์การเลือกพนักงานกึ่งใช้ฝีมือ (Semi-skilled) นั้น เกณฑ์แต่ละเกณฑ์จะถูกนำมาเปรียบเทียบระดับความสำคัญเป็นคู่ (Pairwise Comparison) โดยให้คะแนนตั้งแต่ระดับ 1 ถึง 9 ตามความหมายดังแสดงในตารางต่อไปนี้

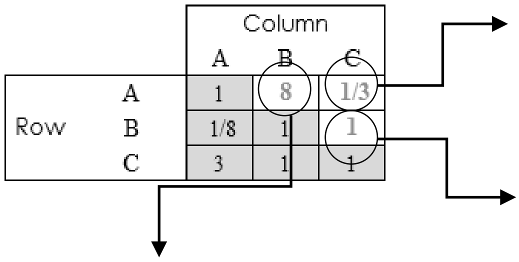
ค่าความสำคัญ	นิยาม	คำอธิบาย
1	มีความสำคัญเท่ากัน	ทั้ง 2 เกณฑ์ส่งผลกระทบต่อวัตถุประสงค์เท่า ๆ กัน
3	มีความสำคัญมากกว่าพอประมาณ	ประสบการณ์ และการวินิจฉัยแสดงถึงความพึงพอใจในเกณฑ์หนึ่งมากกว่าอีกเกณฑ์หนึ่งปานกลาง
5	มีความสำคัญมากกว่าอย่างเด่นชัด	ประสบการณ์ และการวินิจฉัยแสดงถึงความพึงพอใจในเกณฑ์หนึ่งมากกว่าอีกเกณฑ์หนึ่งมาก
7	มีความสำคัญมากกว่าอย่างเด่นชัดมาก	เกณฑ์หนึ่งได้รับความพึงพอใจมากที่สุดเมื่อเปรียบเทียบกับอีกเกณฑ์หนึ่ง ในทางปฏิบัติเกณฑ์นั้นมีอิทธิผลเหนือกว่าอย่างเห็นได้ชัด
9	มีความสำคัญมากกว่าอย่างยิ่ง	มีหลักฐานยืนยันความพึงพอใจในเกณฑ์หนึ่งมากกว่าอีกเกณฑ์หนึ่ง
2, 4, 6, 8	เป็นค่าความสำคัญระหว่างกลางของค่าที่กล่าวไว้ข้างต้น	กรณีที่ผู้ให้น้ำหนักคะแนนต้องการวินิจฉัยในลักษณะที่ก้ำกึ่งกันและไม่สามารถอธิบายด้วยคำพูดที่เหมาะสมได้

ตัวอย่างการให้น้ำหนักคะแนน

ในตัวอย่างประกอบไปด้วยการตอบคำถามใน 2 ลักษณะ ได้แก่ (1) รูปแบบเมตริกซ์ และ (2) รูปแบบสเกล ทั้งนี้ แบบสอบถามจะใช้ลักษณะคำถามใน**รูปแบบสเกล**เท่านั้น เนื่องจากการให้น้ำหนักคะแนนในรูปแบบสเกลนั้นไม่ซับซ้อน และสามารถทำความเข้าใจได้โดยง่าย

(1) รูปแบบเมตริกซ์

จากตารางประกอบไปด้วยเกณฑ์ทั้งหมด 3 เกณฑ์ (A, B, C) ผู้ตอบแบบสอบถามจะต้องเปรียบเทียบเกณฑ์ดังกล่าวเป็นคู่ ๆ ได้แก่ A และ B, A และ C ตามด้วย B และ C โดยให้น้ำหนักคะแนนตามตารางความสำคัญจาก 1 ถึง 9 ในช่องบริเวณสีขาว และยึดเกณฑ์ด้านซ้ายของตารางเป็นเกณฑ์เปรียบเทียบ ส่วนช่องบริเวณสีเทาให้เว้นไว้ เนื่องจากเป็นคะแนนในทางกลับกัน เช่น A และ B มีน้ำหนักคะแนน 8 เมื่อเทียบเกณฑ์ A เป็นตัวตั้ง ซึ่งหมายความว่าเกณฑ์ A สำคัญกว่าเกณฑ์ B ด้วยน้ำหนักคะแนน 8 แต่หากเทียบ B และ A โดยใช้เกณฑ์ B เป็นตัวตั้ง ค่าน้ำหนักจะเท่ากับ 1/8 หมายความว่า B สำคัญน้อยกว่า A ด้วยน้ำหนักคะแนน 8 เป็นต้น



เกณฑ์ A มีความ*สำคัญน้อยกว่า***เกณฑ์ C** ด้วยน้ำหนักคะแนน 1/3 หรืออีกนัยหนึ่ง เกณฑ์ C มีความสำคัญมากกว่าเกณฑ์ A ด้วยน้ำหนักคะแนน 3

เกณฑ์ B มีความ*สำคัญเท่ากับ***เกณฑ์ C**

เกณฑ์ A มีความ*สำคัญมากกว่า***เกณฑ์ B** ด้วยน้ำหนักคะแนน 8 หรืออีกนัยหนึ่ง เกณฑ์ B มีความสำคัญน้อยกว่าเกณฑ์ A ด้วยน้ำหนักคะแนน 8

(2) รูปแบบสเกล

การให้น้ำหนักคะแนนเกณฑ์ในรูปแบบสเกลจะเป็นการเปรียบเทียบทีละคู่ โดยตาราง 1 ตารางเท่ากับการเปรียบเทียบเกณฑ์ 1 คู่ เช่นตารางที่แสดงด้านล่าง ประกอบไปด้วยการเปรียบเทียบเกณฑ์คู่ที่ 1 คือ A และ B ส่วนเกณฑ์คู่ที่ 2 คือ A และ C ตามด้วยเกณฑ์คู่ที่ 3 คือ B และ C ตารางแต่ละตารางจะมีตัวเลขซึ่งแสดงน้ำหนักคะแนนตั้งแต่ระดับ 1 ถึง 9 โดยน้ำหนักแต่ละค่ามีความหมายต่างกันตามระดับความสำคัญของเกณฑ์นั้น ๆ น้ำหนักคะแนนชุดฝั่งซ้ายแสดงถึงระดับความสำคัญของเกณฑ์ฝั่งซ้ายซึ่งมีความสำคัญมากกว่าเกณฑ์ฝั่งขวา ในทำนองเดียวกันน้ำหนักคะแนนชุดฝั่งขวาแสดงถึงระดับความสำคัญของเกณฑ์ฝั่งขวาซึ่งมีความสำคัญมากกว่าเกณฑ์ฝั่งซ้าย การให้น้ำหนักคะแนนในรูปแบบสเกลนี้ ผู้ตอบแบบสอบถามจะต้องวงตัวเลขตามระดับความสำคัญของเกณฑ์ในแต่ละคู่ตามที่แสดงในตัวอย่างด้านล่าง ซึ่งมีความหมายตามตัวอย่างในรูปแบบเมตริกซ์

	เกณฑ์ A มีความ*สำคัญมากกว่า* เกณฑ์ B								เท่ากัน	เกณฑ์ B มีความ*สำคัญมากกว่า* เกณฑ์ A								
A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	B

	เกณฑ์ A มีความ*สำคัญมากกว่า* เกณฑ์ C								เท่ากัน	เกณฑ์ C มีความ*สำคัญมากกว่า* เกณฑ์ A								
A	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C

	เกณฑ์ B มีความ*สำคัญมากกว่า* เกณฑ์ C								เท่ากัน	เกณฑ์ C มีความ*สำคัญมากกว่า* เกณฑ์ B								
B	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	C

คำชี้แจง กรุณาให้น้ำหนักเกณฑ์การเลือกพนักงานกึ่งใช้ฝีมือ โดยพิจารณาความสำคัญระหว่างเกณฑ์ด้านซ้ายมือและเกณฑ์ด้านขวามือเป็นคู่ ๆ และทำเครื่องหมายวงกลมตามระดับความสำคัญตั้งแต่ 1 – 9 ดังที่อธิบายข้างต้น

การเปรียบเทียบเกณฑ์การเลือกพนักงานกึ่งใช้ฝีมือ (Semi-skilled) ประกอบด้วย 6 ส่วน ดังนี้

ส่วนที่ 1 การเปรียบเทียบเกณฑ์หลัก

ส่วนที่ 2 การเปรียบเทียบเกณฑ์ย่อยขีดความสามารถทางอาชีพ

ส่วนที่ 3 การเปรียบเทียบเกณฑ์ย่อยประสบการณ์ทางอาชีพ

ส่วนที่ 4 การเปรียบเทียบเกณฑ์ย่อยลักษณะส่วนบุคคล

ส่วนที่ 5 การเปรียบเทียบเกณฑ์ย่อยทักษะด้านการปฏิบัติงาน

ส่วนที่ 5.1 การเปรียบเทียบเกณฑ์ย่อยทักษะพื้นฐาน

ส่วนที่ 5.2 การเปรียบเทียบเกณฑ์ย่อยทักษะเชิงปฏิบัติ

ส่วนที่ 6 การเปรียบเทียบเกณฑ์ย่อยผลการปฏิบัติงาน

หมายเหตุ : กรณีที่เกณฑ์ใดเกณฑ์หนึ่งในตารางตอนที่ 1 ไม่ได้ถูกนำมาพิจารณาในการเลือกพนักงานตามระเบียบปฏิบัติขององค์กร ขอให้ผู้ตอบแบบสอบถาม*ตัดเกณฑ์ดังกล่าวออก* และ<u>ไม่ต้องให้น้ำหนักเปรียบเทียบในส่วนนั้น</u>

ส่วนที่ 1 การเปรียบเทียบเกณฑ์หลัก

1)	ขีดความสามารถทางอาชีพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ประสบการณ์ทางอาชีพ
2)	ขีดความสามารถทางอาชีพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ลักษณะส่วนบุคคล
3)	ขีดความสามารถทางอาชีพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ทักษะด้านการปฏิบัติงาน
4)	ขีดความสามารถทางอาชีพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ผลการปฏิบัติงาน
5)	ประสบการณ์ทางอาชีพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ลักษณะส่วนบุคคล
6)	ประสบการณ์ทางอาชีพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ทักษะด้านการปฏิบัติงาน
7)	ประสบการณ์ทางอาชีพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ผลการปฏิบัติงาน
8)	ลักษณะส่วนบุคคล	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ทักษะด้านการปฏิบัติงาน
9)	ลักษณะส่วนบุคคล	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ผลการปฏิบัติงาน
10)	ทักษะด้านการปฏิบัติงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ผลการปฏิบัติงาน

ส่วนที่ 2 การเปรียบเทียบเกณฑ์ย่อย : ขีดความสามารถทางอาชีพ

1)	วุฒิทางการศึกษา	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ประวัติการทำงาน/ตำแหน่งงาน
2)	วุฒิทางการศึกษา	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การฝึกอบรม
3)	วุฒิทางการศึกษา	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ใบอนุญาตการทำงานเฉพาะทาง
4)	ประวัติการทำงาน/ตำแหน่งงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การฝึกอบรม
5)	ประวัติการทำงาน/ตำแหน่งงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ใบอนุญาตการทำงานเฉพาะทาง
6)	การฝึกอบรม	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ใบอนุญาตการทำงานเฉพาะทาง

ส่วนที่ 3 การเปรียบเทียบเกณฑ์ย่อย : ประสบการณ์ทางอาชีพ

1)	ประสบการณ์การทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความเชี่ยวชาญในการปฏิบัติงาน
2)	ประสบการณ์การทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความรู้ที่เกี่ยวข้องในการปฏิบัติงาน
3)	ความเชี่ยวชาญในการปฏิบัติงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความรู้ที่เกี่ยวข้องในการปฏิบัติงาน

ส่วนที่ 4 การเปรียบเทียบเกณฑ์ย่อย : ลักษณะส่วนบุคคล

1)	อายุ/วัยวุฒิ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	รูปลักษณ์ภายนอก
2)	อายุ/วัยวุฒิ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	วัฒนธรรมโดยทั่วไป
3)	อายุ/วัยวุฒิ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	เป้าหมายในการทำงาน
4)	อายุ/วัยวุฒิ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	สุขภาพ
5)	อายุ/วัยวุฒิ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความซื่อสัตย์และจงรักภักดีต่อองค์กร
6)	อายุ/วัยวุฒิ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความตรงต่อเวลา
7)	อายุ/วัยวุฒิ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสมัครใจในการทำงาน
8)	อายุ/วัยวุฒิ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความยืดหยุ่นในการเปลี่ยนแปลง ตามสภาพแวดล้อม/สถานการณ์
9)	อายุ/วัยวุฒิ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความเข้าใจทางสังคม และเพื่อนร่วมงาน
10)	อายุ/วัยวุฒิ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ภาวะความเป็นผู้นำ
11)	อายุ/วัยวุฒิ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การมีส่วนร่วมในองค์กร
12)	อายุ/วัยวุฒิ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสามารถในการเจรจาต่อรอง/โน้มน้าว
13)	อายุ/วัยวุฒิ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การบริการหรือตอบสนองต่อความต้องการของเพื่อนร่วมงาน
14)	รูปลักษณ์ภายนอก	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	วัฒนธรรมโดยทั่วไป
15)	รูปลักษณ์ภายนอก	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	เป้าหมายในการทำงาน
16)	รูปลักษณ์ภายนอก	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	สุขภาพ
17)	รูปลักษณ์ภายนอก	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความซื่อสัตย์และจงรักภักดีต่อองค์กร
18)	รูปลักษณ์ภายนอก	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความตรงต่อเวลา
19)	รูปลักษณ์ภายนอก	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสมัครใจในการทำงาน
20)	รูปลักษณ์ภายนอก	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความยืดหยุ่นในการเปลี่ยนแปลง ตามสภาพแวดล้อม/สถานการณ์

ส่วนที่ 4 การเปรียบเทียบเกณฑ์ย่อย : ลักษณะส่วนบุคคล (ต่อ)

21)	รูปลักษณ์ภายนอก	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความเข้าใจทางสังคมและเพื่อนร่วมงาน
22)	รูปลักษณ์ภายนอก	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ภาวะความเป็นผู้นำ
23)	รูปลักษณ์ภายนอก	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การมีส่วนร่วมในองค์กร
24)	รูปลักษณ์ภายนอก	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสามารถในการเจรจาต่อรอง/โน้มน้าว
25)	รูปลักษณ์ภายนอก	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การบริการหรือตอบสนองต่อความต้องการของเพื่อนร่วมงาน
26)	วัฒนธรรมโดยทั่วไป	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	เป้าหมายในการทำงาน
27)	วัฒนธรรมโดยทั่วไป	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	สุขภาพ
28)	วัฒนธรรมโดยทั่วไป	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความซื่อสัตย์และจงรักภักดีต่อองค์กร
29)	วัฒนธรรมโดยทั่วไป	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความตรงต่อเวลา
30)	วัฒนธรรมโดยทั่วไป	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสมัครใจในการทำงาน
31)	วัฒนธรรมโดยทั่วไป	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความยืดหยุ่นในการเปลี่ยนแปลงตามสภาพแวดล้อม/สถานการณ์
32)	วัฒนธรรมโดยทั่วไป	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความเข้าใจทางสังคมและเพื่อนร่วมงาน
33)	วัฒนธรรมโดยทั่วไป	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ภาวะความเป็นผู้นำ
34)	วัฒนธรรมโดยทั่วไป	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การมีส่วนร่วมในองค์กร
35)	วัฒนธรรมโดยทั่วไป	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสามารถในการเจรจาต่อรอง/โน้มน้าว
36)	วัฒนธรรมโดยทั่วไป	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การบริการหรือตอบสนองต่อความต้องการของเพื่อนร่วมงาน
37)	เป้าหมายในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	สุขภาพ
38)	เป้าหมายในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความซื่อสัตย์และจงรักภักดีต่อองค์กร
39)	เป้าหมายในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความตรงต่อเวลา
40)	เป้าหมายในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสมัครใจในการทำงาน

ส่วนที่ 4 การเปรียบเทียบเกณฑ์ย่อย : ลักษณะส่วนบุคคล (ต่อ)

41)	เป้าหมายในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความยืดหยุ่นในการเปลียนแปลงตามสภาพแวดล้อม/สถานการณ์
42)	เป้าหมายในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความเข้าใจทางสังคมและเพื่อนร่วมงาน
43)	เป้าหมายในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ภาวะความเป็นผู้นำ
44)	เป้าหมายในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การมีส่วนร่วมในองค์กร
45)	เป้าหมายในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสามารถในการเจรจาต่อรอง/โน้มน้าว
46)	เป้าหมายในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การบริการหรือตอบสนองต่อความต้องการของเพื่อนร่วมงาน
47)	สุขภาพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความซื่อสัตย์และจงรักภักดีต่อองค์กร
48)	สุขภาพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความตรงต่อเวลา
49)	สุขภาพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสมัครใจในการทำงาน
50)	สุขภาพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความยืดหยุ่นในการเปลี่ยนแปลงตามสภาพแวดล้อม/สถานการณ์
51)	สุขภาพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความเข้าใจทางสังคมและเพื่อนร่วมงาน
52)	สุขภาพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ภาวะความเป็นผู้นำ
53)	สุขภาพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การมีส่วนร่วมในองค์กร
54)	สุขภาพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสามารถในการเจรจาต่อรอง/โน้มน้าว
55)	สุขภาพ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การบริการหรือตอบสนองต่อความต้องการของเพื่อนร่วมงาน
56)	ความซื่อสัตย์และจงรักภักดีต่อองค์กร	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความตรงต่อเวลา
57)	ความซื่อสัตย์และจงรักภักดีต่อองค์กร	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสมัครใจในการทำงาน
58)	ความซื่อสัตย์และจงรักภักดีต่อองค์กร	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความยืดหยุ่นในการเปลี่ยนแปลงตามสภาพแวดล้อม/สถานการณ์
59)	ความซื่อสัตย์และจงรักภักดีต่อองค์กร	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความเข้าใจทางสังคมและเพื่อนร่วมงาน
60)	ความซื่อสัตย์และจงรักภักดีต่อองค์กร	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ภาวะความเป็นผู้นำ

ส่วนที่ 4 การเปรียบเทียบเกณฑ์ย่อย : ลักษณะส่วนบุคคล (ต่อ)

61)	ความซื่อสัตย์และจงรักภักดีต่อองค์กร	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การมีส่วนร่วมในองค์กร
62)	ความซื่อสัตย์และจงรักภักดีต่อองค์กร	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสามารถในการเจรจาต่อรอง/โน้มน้าว
63)	ความซื่อสัตย์และจงรักภักดีต่อองค์กร	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การบริการหรือตอบสนองต่อความต้องการของเพื่อนร่วมงาน
64)	ความตรงต่อเวลา	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสมัครใจในการทำงาน
65)	ความตรงต่อเวลา	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความยืดหยุ่นในการเปลี่ยนแปลงตามสภาพแวดล้อม/สถานการณ์
66)	ความตรงต่อเวลา	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความเข้าใจทางสังคมและเพื่อนร่วมงาน
67)	ความตรงต่อเวลา	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ภาวะความเป็นผู้นำ
68)	ความตรงต่อเวลา	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การมีส่วนร่วมในองค์กร
69)	ความตรงต่อเวลา	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสามารถในการเจรจาต่อรอง/โน้มน้าว
70)	ความตรงต่อเวลา	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การบริการหรือตอบสนองต่อความต้องการของเพื่อนร่วมงาน
71)	ความสมัครใจในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความยืดหยุ่นในการเปลี่ยนแปลงตามสภาพแวดล้อม/สถานการณ์
72)	ความสมัครใจในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความเข้าใจทางสังคมและเพื่อนร่วมงาน
73)	ความสมัครใจในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ภาวะความเป็นผู้นำ
74)	ความสมัครใจในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การมีส่วนร่วมในองค์กร
75)	ความสมัครใจในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสามารถในการเจรจาต่อรอง/โน้มน้าว
76)	ความสมัครใจในการทำงาน	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การบริการหรือตอบสนองต่อความต้องการของเพื่อนร่วมงาน
77)	ความยืดหยุ่นในการเปลี่ยนแปลงตามสภาพแวดล้อม/สถานการณ์	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความเข้าใจทางสังคมและเพื่อนร่วมงาน
78)	ความยืดหยุ่นในการเปลี่ยนแปลงตามสภาพแวดล้อม/สถานการณ์	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ภาวะความเป็นผู้นำ
79)	ความยืดหยุ่นในการเปลี่ยนแปลงตามสภาพแวดล้อม/สถานการณ์	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การมีส่วนร่วมในองค์กร
80)	ความยืดหยุ่นในการเปลี่ยนแปลงตามสภาพแวดล้อม/สถานการณ์	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสามารถในการเจรจาต่อรอง/โน้มน้าว

ส่วนที่ 4 การเปรียบเทียบเกณฑ์ย่อย : ลักษณะส่วนบุคคล (ต่อ)

81)	ความยืดหยุ่นในการเปลี่ยนแปลงตามสภาพแวดล้อม/สถานการณ์	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	การบริการหรือตอบสนองต่อความต้องการของเพื่อนร่วมงาน
82)	ความเข้าใจทางสังคมและเพื่อนร่วมงาน	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	ภาวะความเป็นผู้นำ
83)	ความเข้าใจทางสังคมและเพื่อนร่วมงาน	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	การมีส่วนร่วมในองค์กร
84)	ความเข้าใจทางสังคมและเพื่อนร่วมงาน	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	ความสามารถในการเจรจาต่อรอง/โน้มน้าว
85)	ความเข้าใจทางสังคมและเพื่อนร่วมงาน	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	การบริการหรือตอบสนองต่อความต้องการของเพื่อนร่วมงาน
86)	ภาวะความเป็นผู้นำ	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	การมีส่วนร่วมในองค์กร
87)	ภาวะความเป็นผู้นำ	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	ความสามารถในการเจรจาต่อรอง/โน้มน้าว
88)	ภาวะความเป็นผู้นำ	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	การบริการหรือตอบสนองต่อความต้องการของเพื่อนร่วมงาน
89)	การมีส่วนร่วมในองค์กร	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	ความสามารถในการเจรจาต่อรอง/โน้มน้าว
90)	การมีส่วนร่วมในองค์กร	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	การบริการหรือตอบสนองต่อความต้องการของเพื่อนร่วมงาน
91)	ความสามารถในการเจรจาต่อรอง/โน้มน้าว	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	การบริการหรือตอบสนองต่อความต้องการของเพื่อนร่วมงาน

ส่วนที่ 5 การเปรียบเทียบเกณฑ์ย่อย : ทักษะด้านการปฏิบัติงาน

1)	ทักษะพื้นฐาน	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	ทักษะเชิงปฏิบัติ

ส่วนที่ 5.1 การเปรียบเทียบเกณฑ์ย่อย : ทักษะพื้นฐาน

1)	ความสามารถในการเรียนรู้	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	ความสามารถในการตัดสินใจหรือแก้ปัญหาเบื้องต้น
2)	ความสามารถในการเรียนรู้	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	การคิดเชิงวิเคราะห์
3)	ความสามารถในการเรียนรู้	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	การรับรู้สถานการณ์ต่าง ๆ
4)	ความสามารถในการเรียนรู้	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	ความสามารถด้านการสื่อสาร
5)	ความสามารถในการเรียนรู้	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	ความรู้พื้นฐานทางคอมพิวเตอร์
6)	ความสามารถในการเรียนรู้	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	การประสานงานและทำงานร่วมกันเป็นกลุ่ม
7)	ความสามารถในการตัดสินใจหรือแก้ปัญหาเบื้องต้น	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	การคิดเชิงวิเคราะห์
8)	ความสามารถในการตัดสินใจหรือแก้ปัญหาเบื้องต้น	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	การรับรู้สถานการณ์ต่าง ๆ
9)	ความสามารถในการตัดสินใจหรือแก้ปัญหาเบื้องต้น	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	ความสามารถด้านการสื่อสาร
10)	ความสามารถในการตัดสินใจหรือแก้ปัญหาเบื้องต้น	9 8 7 6 5 4 3 2 1 2 3 4 5 6 7 8 9	ความรู้พื้นฐานทางคอมพิวเตอร์

ส่วนที่ 5.1 การเปรียบเทียบเกณฑ์ย่อย : ทักษะพื้นฐาน (ต่อ)

11)	ความสามารถในการตัดสินใจหรือแก้ปัญหาเบื้องต้น	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การประสานงานและทำงานร่วมกันเป็นกลุ่ม
12)	การคิดเชิงวิเคราะห์	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การรับรู้สถานการณ์ต่าง ๆ
13)	การคิดเชิงวิเคราะห์	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสามารถด้านการสื่อสาร
14)	การคิดเชิงวิเคราะห์	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความรู้พื้นฐานทางคอมพิวเตอร์
15)	การคิดเชิงวิเคราะห์	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การประสานงานและทำงานร่วมกันเป็นกลุ่ม
16)	การรับรู้สถานการณ์ต่าง ๆ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสามารถด้านการสื่อสาร
17)	การรับรู้สถานการณ์ต่าง ๆ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความรู้พื้นฐานทางคอมพิวเตอร์
18)	การรับรู้สถานการณ์ต่าง ๆ	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การประสานงานและทำงานร่วมกันเป็นกลุ่ม
19)	ความสามารถด้านการสื่อสาร	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความรู้พื้นฐานทางคอมพิวเตอร์
20)	ความสามารถด้านการสื่อสาร	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การประสานงานและทำงานร่วมกันเป็นกลุ่ม
21)	ความรู้พื้นฐานทางคอมพิวเตอร์	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การประสานงานและทำงานร่วมกันเป็นกลุ่ม

ส่วนที่ 5.2 การเปรียบเทียบเกณฑ์ย่อย : ทักษะเชิงปฏิบัติ

1)	การเตรียมและจัดเรียงลำดับการผลิต	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การเลือกใช้อุปกรณ์และเครื่องจักรในการผลิตอย่างเหมาะสม
2)	การเตรียมและจัดเรียงลำดับการผลิต	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การติดตั้งอุปกรณ์และเครื่องจักรที่ใช้ในการผลิต
3)	การเตรียมและจัดเรียงลำดับการผลิต	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสามารถในการปฏิบัติงานและการควบคุมการผลิต
4)	การเตรียมและจัดเรียงลำดับการผลิต	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การติดตามกระบวนการผลิต
5)	การเตรียมและจัดเรียงลำดับการผลิต	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การรักษามาตรฐานและปฏิบัติตามขั้นตอนการผลิต
6)	การเลือกใช้อุปกรณ์และเครื่องจักรในการผลิตอย่างเหมาะสม	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การติดตั้งอุปกรณ์และเครื่องจักรที่ใช้ในการผลิต
7)	การเลือกใช้อุปกรณ์และเครื่องจักรในการผลิตอย่างเหมาะสม	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสามารถในการปฏิบัติงานและการควบคุมการผลิต
8)	การเลือกใช้อุปกรณ์และเครื่องจักรในการผลิตอย่างเหมาะสม	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การติดตามกระบวนการผลิต
9)	การเลือกใช้อุปกรณ์และเครื่องจักรในการผลิตอย่างเหมาะสม	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การรักษามาตรฐานและปฏิบัติตามขั้นตอนการผลิต
10)	การติดตั้งอุปกรณ์และเครื่องจักรที่ใช้ในการผลิต	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	ความสามารถในการปฏิบัติงานและการควบคุมการผลิต
11)	การติดตั้งอุปกรณ์และเครื่องจักรที่ใช้ในการผลิต	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การติดตามกระบวนการผลิต
12)	การติดตั้งอุปกรณ์และเครื่องจักรที่ใช้ในการผลิต	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การรักษามาตรฐานและปฏิบัติตามขั้นตอนการผลิต

ส่วนที่ 5.2 การเปรียบเทียบเกณฑ์ย่อย : ทักษะเชิงปฏิบัติ (ต่อ)

13)	ความสามารถในการปฏิบัติงานและการควบคุมการผลิต	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การติดตามกระบวนการผลิต
14)	ความสามารถในการปฏิบัติงานและการควบคุมการผลิต	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การรักษามาตรฐานและปฏิบัติตามขั้นตอนการผลิต
15)	การติดตามกระบวนการผลิต	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	การรักษามาตรฐานและปฏิบัติตามขั้นตอนการผลิต

ส่วนที่ 6 การเปรียบเทียบเกณฑ์ย่อย : ผลการปฏิบัติงาน

1)	อัตราการผลิต (จำนวนหน่วยที่ผลิตต่อหนึ่งหน่วยเวลา)	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	คุณภาพของหน่วยการผลิตเปรียบเทียบกับค่ามาตรฐานขององค์กร

APPENDIX C
INTERNATIONAL CONFERENCE ON LOGISTICS AND TRANSPORT 2015 (ICLT) SUBMITTED PAPER

C.1 ACCEPTANCE LETTER

IUT LUMIERE LYON 2 — POUR FAIRE GRANDIR VOS COMPÉTENCES

ICLT 2015 — THE 7th INTERNATIONAL CONFERENCE ON LOGISTICS AND TRANSPORT 2015

UNIVERSITÉ LUMIÈRE LYON 2

September 17, 2015

Miss Teeraphattara Songsiri
Department of Industrial Engineering,
Faculty of Engineering, Mahidol University,
Nakhonpathom, 73170 Thailand

INVITATION
7th International Conference on Logistics and Transport (ICLT) 2015
Lyon, France 17th - 18th - 19th - 20th November 2015

Dear Miss Songsiri,

On behalf of the organizing committee I am inviting you to the 7th International Conference on Logistics and Transport (ICLT) 2015 which will be held in Lyon, France next November, 17-20, 2015.

The Centre for Logistics Research at Thammasat Business School, Thammasat University and Excellence Centre in Logistics and Supply Chain Management, Chiang Mai University and Université Lumière Lyon 2, are hosting the 2015 conference in Lyon II University Institute of technology (IUT). I and my colleagues, Prof.Dr. Gilles Neubert and Dr.Aicha Sekhari, are the local chair of the ICLT2015 conference. Assoc. Prof. Dr. Ruth Banomyong and Assoc. Prof. Dr. Apichat Sopadang are the general chairs of this conference.

Your active participation to this conference is vital for its success and we are eagerly waiting forward to meeting you in Lyon France on November 17th, 2015.

Best regards,

Prof. Yacine Ouzrout
Director of the IUT Lumière Lyon 2 and local chair of ICLT 2015 Conference

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C2. FULL PAPER

WORKER SELECTION WITH MULTIPLE SKILLS IN LABOR-INTENSIVE INDUSTRY

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Abstract
Purpose – In an environment of labor-intensive manufacturing, workforce plays an important role as a major resource that drives the entire system. An effective workforce management has become a great challenge for any worker-related activities within the organization. In addition, it is commonly agreed that worker skill has a strong impact on manufacturing performance. It is necessary to consider worker skill in the context of workforce management practice. A critical part of workforce management process is worker selection, as the most challenging goal of all organizations to achieve the effective methods of selecting workers with different competencies. The purpose of this paper is to determine the influencing worker selection criteria with its important weight, includes worker selection practice drawn from the real labor-intensive industry.
Design/methodology/approach – An analytical hierarchy process (AHP) is employed for the worker selection problem in this study. The worker selection criteria are weighed and prioritized in performance evaluation process. In the context of labor-intensive manufacturing, the selection criteria derived from previous studies and practical viewpoint is determined. Then the pair-wise comparisons are made on AHP basis using an in-depth interview to investigate a manufacturing expert. Finally, with respect to the important weights of each criterion worker performance evaluation and the final decision on worker selection practice are examined.
Findings – The important worker selection criteria with its important weights are drawn from both academic and industry standpoints in labor-intensive manufacturing. The worker selection model is presented and evaluated worker performance with respect to the selection rules.
Practical implications – The proposed method can be effectively used in labor-intensive environment which workforce is the main driver of the entire system. Nevertheless, the worker selection model can be applied in a wide range of industry sector with respect to the organization natures.
Originality/value – This paper highlights worker selection practice in the context of labor-intensive manufacturing, and the multiple skills are taken in to account.
Keywords Worker selection, Multiple skills, Labor intensive, Worker performance

Introduction
With the increasing of global competition, all manufacturing sectors have been forced to not only improve efficiency but also increase productivity gain along its supply chain. An efficient management on manufacturing resources is one key concern to be appropriately utilized and to reach the competitive advantage. In labor-intensive manufacturing environment, workforce plays an important role as a major resource that drives and control the entire system. By its nature, labor-intensive refers to an industry that requires a substantial involvement of worker especially in the operational level which directly impacts the overall production performance. Furthermore, the system mostly consists of small and inexpensive machines and equipment (Süer and Bera, 1998). Regarding to the importance of labor resource, worker's capabilities or skills have become an influencing factor since an individual worker will have different skills to perform a specific task. It is commonly agreed that workers with different skill levels will have different abilities in terms of operational understanding and response times, this highly effects the overall performance. To achieve a successful workforce management, the effective methods of evaluation and ranking for workers with different competencies are needed to select the most appropriate worker and place to the right task and it is the most challenging goal of all organizations (Güngör *et al*., 2009). However, in the workforce management

literature, much of the existing studies has been focused the final workforce management decision in allocating worker-to-task problem which strongly pushed by the mathematical models, without respect to the real manufacturing practice. On the other hand, workforce management decision in the first stage, namely worker selection, is an essential decision that should be made effectively. It is found from the previous studies that there is a little attention paid in this stage. In worker selection management, an effective evaluation of worker performance is required to individually indicate worker's performance.

In order to fill the gaps, this paper aims to present a methodology of workforce management in selection stage, with the different perspectives drawn from academia to real manufacturing. The important worker selection criteria with multiple skills from previous literature and real manufacturing practice are identified and prioritized using the Analytic Hierarchy Process (AHP) as a Multi-Criteria Decision Making (MCDM) tool. Furthermore, the worker selection practice is also investigated through a case study of a labor-intensive industry to represent as labor-intensive sector which reflects the real world problem. The rest of the paper is organized as follows: literature review, proposed methodology, computational results of AHP model, and conclusions.

Literature Review

This paper focuses on the labor-intensive manufacturing environment in the operational level, which is operated by "workers". In literature review section, it is organized as follows: (1) skill gaps, (2) worker selection, and (2) analytic hierarchy process (AHP).

Skill Gaps

The skilled workers are the most powerful assets in achieving the business goals (Güngör *et al*., 2009). In labor-intensive environment, it is commonly agreed that worker skill has a strong impact on the manufacturing performance. Skill is defined as one's ability to apply knowledge and use the know-how to perform tasks well. Generally, skills may be cognitive (use of logical, intuitive and creative thinking) or practical (use of methods, materials and tools) (Chryssolouris *et al*., 2013). In the context of a learning process, skills generally involve the following elements, observation and replication of actions, task reproduction from instruction or memory, reliable execution independent of help, adaptation / integration of expertise to meet requirements and automated (Bloom *et al*., 1956). Smits (2007) classified worker skills into two types; (1) generic skills and, (2) industry-specific skills. It is important for worker to have not only skills in specific industry, but also generic skills that create a wide range of applicability. Heijke *et al*. (2003) explained that generic skills are defined from a combination of learning abilities, analytical abilities, and problem solving abilities. On the other hand, Hendarman and Tjakraatmadja (2012) categorized skills into two types, one is soft skills and the other is hard skills. Soft skills refer to personal attributes that enhance an individual's interactions with work performance, while hard skills are a person's skills set and ability to perform a certain task. The skill list of Consoli and Rentocchini (2015) were drawn from the manufacturing which machines are the major resource. In this paper, worker skill is classified into two types; (1) general skills and, (2) technical skills. In whilst, general skills mainly refer to any fundamental skills which can be applied in different industry sector (i.e. analytical thinking, communication, learning), unlike technical skills which mainly focus on any specific skills used in operations of a specific industry sector (i.e. production and processing, quality control). In production planning and designing systems, workers are commonly assumed to be equal in their abilities and perform tasks at a steady pace (Bentefouet and Nembhard, 2013) and most of the mathematical models consider worker resource with only one skill (Wongwai and Malaikrisanachalee, 2011). Generally, these assumptions totally conflict the real world problem. Ignoring the impact of workers with various skills would result the effectiveness of services provided which lead to the organization's outcomes (Lee, 2004). In workforce allocation and scheduling problems, Warner *et al*. (1997) assigned workers to machines based on their human and technology skills. Wongwai and Malaikrisanachalee (2011) proposed an algorithm for resource scheduling which multiple skills had been considered. Fowler *et al*. (2008) studied decisions in workforce management with respect to differences in individual workers measured by general cognitive ability (GCA). The workforce flexibility was focused as an effective way to deal with the various variabilities in manufacturing systems. A mixed integer programming (MIP) model is used to determine different staffing decisions (i.e. hire, cross-train and fire) to minimize workforce related costs. It is seen that all of the afore-mentioned literature has emphasized on dealing with the differences of worker skills by generating skill level and placing it as a constraint in mathematical models. On the other hand, Mori *et al*. (2015) presented a quantitative approach for design and formation of workforce skills using simulations to achieve the efficient assembly. The skill of workers is one major cause of uncertainties. Demand fluctuations also cause the difficulty in maintaining the efficient skilled workers in machine tool production. From the literature review, it is found that there are a few studies on workforce management with the consideration of worker's multiple skills with regard to labor-intensive manufacturing nature. Thus, this paper aims to intensely investigate the influencing workforce skill required in labor-intensive industry sector.

Worker Selection

A lot of existing literature has been focused on workforce management problem which is carried out into different stages; e.g. worker evaluation, selection, allocation and worker scheduling in Majozi and Zhu (2005). This classification corresponds to Şen and Çınar (2010) which focused on worker evaluation and pre-worker allocation phase. In brief, evaluation refers to the performance measurement of workers (e.g. competency, experience). Selection refers to the question of "who" will be selected? (Nembhard and Bentefouet, 2014), and grouping is concerned with clusters of selected workers who have similar competencies. Worker allocation is concerned with "who works where?", but worker scheduling is concerned with "who works when?" (Majozi and Zhu, 2005). Worker allocation and scheduling problems are considered as the final workforce management decisions. They have been widely published in today's research with strong focuses on mathematical models. Meanwhile, there are prior activities in worker selection stage that has been still neglected in those study areas. In managerial viewpoint, the workforce management stage derived from the relevant literature is presented in Figure 1, consisting of selection, grouping and allocation. Each stage is connected by supporting the effective decision-making to another. In this paper, worker selection stage is only focused to response the question of "how to effectively select" worker with respect to their capabilities in the operational level of labor-intensive manufacturing. The most challenging goal of all organizations is to select the effective methods of ranking a group of workers with the different competencies (Güngör *et al*., 2009). It is evident that worker selection management plays a key role in achieving success of an organization through worker performance. To select workers, a proper performance evaluation process is required to identify strengths and weaknesses of each worker (Rani *et al*., 2014). Worker performance evaluation is considered as a critical operation in labor-intensive manufacturing since it strongly impacts the productivity gain.

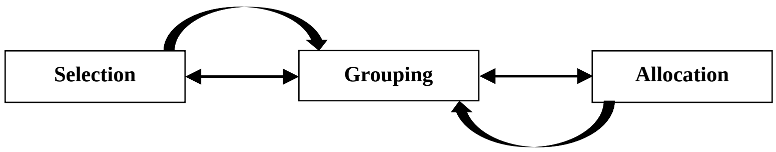

Figure 1: Workforce management stage

From the literature review, a few studies on worker selection in labor-intensive manufacturing are found. Most attention has been devoted to the capital-intensive industry which machine is a major resource in operations and worker skill is not seriously considered. Güngör *et al*. (2009) proposed a worker selection system based on Fuzzy Analytic Hierarchy Process (FAHP) to achieve the best qualified worker dealing with both qualitative and quantitative selection criteria. The criteria are built-up into three main categories, general work factors, complimentary work factors, and individual factors. Majozi and Zhu (2005) presented a worker selection with a consideration of worker evaluation (grading) using an application of Fuzzy Set Theory (FST). The selection criteria are defined, expertise, skill, age, health, and availability. Similarly, Şen and Çınar (2010) used a combined fuzzy AHP and max-min approach to deal with worker selection based on worker's individual performance. The powerful criteria were determine by reaching consensus from manufacturing experts, it resulted in five main criteria, competency, experience, personal characteristics, assemble capability, and control capability. An actual application in an electronic industry is also studied. On the other hand, Rani *et al*. (2014) studied the performance evaluation based on six main criteria derived from previous literature, i.e. competency, experience and skill, teamwork and time punctuality, personal characteristics, capability, and outcome. The six different ranking methods were presented and applied in a food processing industry. It is found that output criterion is the most important factor in selecting worker. Furthermore, they revealed that AHP is the suitable method to evaluate worker performance from a case study of the real manufacturing environment. They presented worker performance evaluation and ranking method by comparing six different multi-criteria decision making methods include Analytical Hierarchy Process (AHP), fuzzy AHP (FAHP), ELECTRE, PROMETHEE II, Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR). From this point, AHP is selected as an effective multi-criteria decision-making (MCDM) tool. Consequently, AHP is used in weighting and prioritization of the important worker selection criteria in labor-intensive manufacturing in this paper.

Analytical Hierarchy Process (AHP)

It is developed by Saaty (Saaty, 1980) which has found wide range of applications in today's studies and industry area. AHP is a simple tool to deal with complex, unstructured and multi-attributed problems using a hierarchical structure and utilizes pairwise comparisons. A core issue to influence the final decision choice in AHP is prioritization of the reciprocal matrix (Yuen, 2010). Furthermore, modeling the problem and identifying the decision hierarchy is the key factor in using AHP. In multi-criteria analysis, AHP is suggested as a tool for implementing a multiple criteria performance scheme (Güngör *et al.*, 2009). In AHP, verbal judgments are provided by decision makers, to be used in pairwise comparison, the reciprocal matrices are transformed from linguistic labels to numerical values (Yuen, 2010). The primary steps of AHP are provided as follows (Rani *et al*., 2014; Bhushan and Rai, 2004):

Step 1: Form a hierarchy consisting of the overall objective at the top, criteria, sub-criteria, and the alternatives at subsequent level of the hierarchy.

Step 2: Construct the pairwise comparison matrix based on Saaty's intensity importance table (as shown in Table1). The table is used by decision maker to prioritize the criteria, sub-criteria and decision alternatives within each sub-criterion.

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one activity over another
5	Strong importance	Experience and judgement strongly favour one activity over another
7	Very strong or demonstrated importance	An activity is favoured very strongly over another. Its dominance demonstrated in practice.
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2, 4, 6, 8	Intermediate values between adjacent scale values	

Table 1: Intensity of importance (Saaty, 2008)

Step 3: The principal eigenvalue and the corresponding normalised right eigenvector of the comparison matrix give the relative importance of the various criteria being compared. The elements of the normalised eigenvector are termed weights with respect to the criteria or sub-criteria and ratings with respect to the alternatives.

Step 4: The consistency of the matrix of order *n* is evaluated. Comparisons made by this method are subjective and the AHP tolerates inconsistency through the amount of redundancy in the approach. If this consistency index fails to reach a required level then answers to comparisons may be re-examined. The consistency index, CI, is calculated as $CI = (\lambda_{max} - n)/(n - 1)$ where λ_{max} is the maximum eigenvalue of the judgement matrix. This CI can be compared with that of a random matrix, RI. The ratio derived, CI/RI, is termed the consistency ratio, CR. Saaty (1980) suggested the value of CR should be less than 0.1.

Step 5: The rating of each alternative is multiplied by the weights of the sub-criteria and aggregated to get local ratings with respect to each criterion. The local ratings are then multiplied by the weights of the criteria and aggregated to get global ratings.

The AHP produces weight values for each alternative based on the judged importance of one alternative over another with respect to a common criterion. The prioritized criterion relies on the content of a pairwise comparison matrix which is used in worker performance evaluation regarding to its importance weight.

Proposed Methodology

The methodology in this paper is primarily carried out into three parts, (1) input/tools, (2) methodology and, (3) output which is illustrated in Figure 2. The study is introduced with the identification of worker selection criteria derived from previous literature and industry viewpoint. The important criteria are validated in the context of labor-intensive environment that considers workforce as a major resource of the entire system. After all selection criteria are validated, it is weighted and prioritized using AHP as a multi-criteria decision-making (MCDM) tool. Each criteria is individually weighted from the intensity of importance shown in Table 1 (Saaty, 2008), with the scale of 1 to 9 judged by an expert from labor-intensive manufacturing. This step contributes the important weights of each selection criteria which is used in worker performance evaluation. This paper examines worker performance evaluation with respect to the important weights of each criteria determined by AHP, the individual performance score of worker on all dimensions is assumed, given *n* equals 10 workers. Next, worker selection rules are then built-up using experiences to generate the worker selection model which can be effectively used.

Figure 2: Steps of proposed methodology

Data Collection

To propose workforce management decision models in worker selection stage drawn from the academic standpoint to the real manufacturing standpoint, data collection is organized into two sections;

(1) *Primary data* refers to the data that highly relies on the real manufacturing practice. An expert who was frequently involved in worker-related activities in labor-intensive industry, is investigated, using an in-depth interview as a research tool to intensely draw worker selection practice from the real industry setting, which includes the following elements;

- Manufacturing nature
- Worker selection criteria
- Worker ranking method
- Impacts of worker skills
- Worker selection rules

(2) *Secondary data* refers to the data from previous studies on workforce management which consists of worker skills, worker performance evaluation, and worker selection model, in the context of labor-intensive manufacturing nature.

The summary of worker selection criteria derived from previous studies and industry viewpoint, is presented in Figure 3. The criteria are hierarchically structured. Main criteria are at the first level and sub-criteria are at subsequent level.

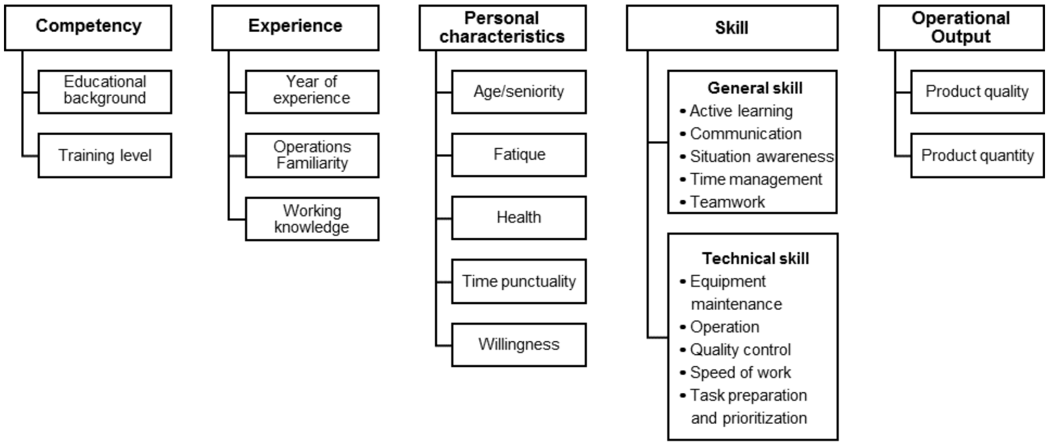

Figure 3: Worker selection criteria structure

Figure 3 illustrates the structure of worker selection criteria in the context of labor-intensive manufacturing. Both qualitative and quantitative criteria are defined to be individually considered in worker performance evaluation process. The hierarchical structure of selection criteria consists of five main criteria; namely competency, experience, personal characteristics, skill, and operational output formed as the first level of hierarchy. The main criteria are branched into sub-criteria which are in level 2 and 3. Descriptions of each criteria are provided in the following.

- *Competency* – It pertains to work mainly on the basis of educational background and previous job training achievements. There are two sub-criteria related to competency; namely educational background and training level.
- *Experience* – with the level of experience, the working performance can be predicted. As working basis, the operational performance of workers with high experience level can be quickly enhanced and compared to the lower ones. Three related criteria is taken into account; namely year of experience, operations familiarity, and working knowledge.
- *Personal characteristics* – They primarily introduce the individual qualifications in attitude, mind-set, and personal goal setting. Five criteria is associated with personal characteristics; namely age/seniority, fatigue, health, time punctuality, and willingness.
- *Skill* – Worker skills play a great role in the environment of labor-intensive manufacturing. It directly creates the enhancement on operational performance to achieve a sustainable manufacturing. In this paper, skill is categorized into two types, general skill and technical skill, where general skill is divided into five sub-criteria (level 3); namely active learning, communication, situation awareness, time management, and teamwork/cooperation. Similarly, the technical skill consists of five sub-criteria (level 3); namely equipment maintenance/repairing, operation and control, quality control, speed of work, and task preparation and prioritization.
- *Operational output* – According to the natures of labor-intensive manufacturing, the operational output which transforms from raw material to final products is the most important goal to be achieved for all organizations. The operational output represents how well the manufacturing is managed on cost reduction and service level improvements. Two sub-criteria is considered; namely product quality and product quantity.

In worker selection practice, the selection rules are needed to be determined. The selection rules here refer to the rules that were published by the organization, to determine the acceptance level of worker performance. A worker will be selected only if his/her performance complies with all selection rules. This paper investigates worker selection rules from a manufacturing expert in labor-intensive area, given in the following;
Rule 1: Competency performance of a selected worker must be equal or greater than 70%
Rule 2: Experience performance of a selected worker must be equal or greater than 80%

Rule 3: Personal characteristics performance of a selected worker must be equal or greater than 70%
Rule 4: Skill performance of a selected worker must be equal or greater than 80%
Rule 5: Operational output performance of a selected worker must be equal or greater than 80%
Rule 6: Overall performance of a selected worker must be equal or greater than 80%

AHP Model of Worker Selection Criteria

According to the proposed methodology, AHP is presented as MCDM to weight and set priorities for each worker selection criteria. The preliminary steps are organized as follows: (1) all selection criteria used for worker performance evaluation process are identified. (2) worker selection criteria is structured into AHP hierarchy, (3) each criterion is weighted by using the intensity of importance from Table 1 which includes the numerical values from 1 to 9. In this step, the pairwise comparison matrix is used, and (4) the importance weights computed from the eigenvector of the comparison matrix that is determined with respect to the consistency ratio. Traditionally, there are many ways to process data, including by hand, spreadsheet program, or the specialized AHP software. Regarding to worker selection problem from many criteria, this paper uses the specialized AHP software called Super Decisions to process the data. Super Decisions developed by Thomas Saaty is a decision making software based on AHP. Priorities are derived through pairwise comparisons on the criteria of the problem. The structure of AHP is illustrated in Figure 4.

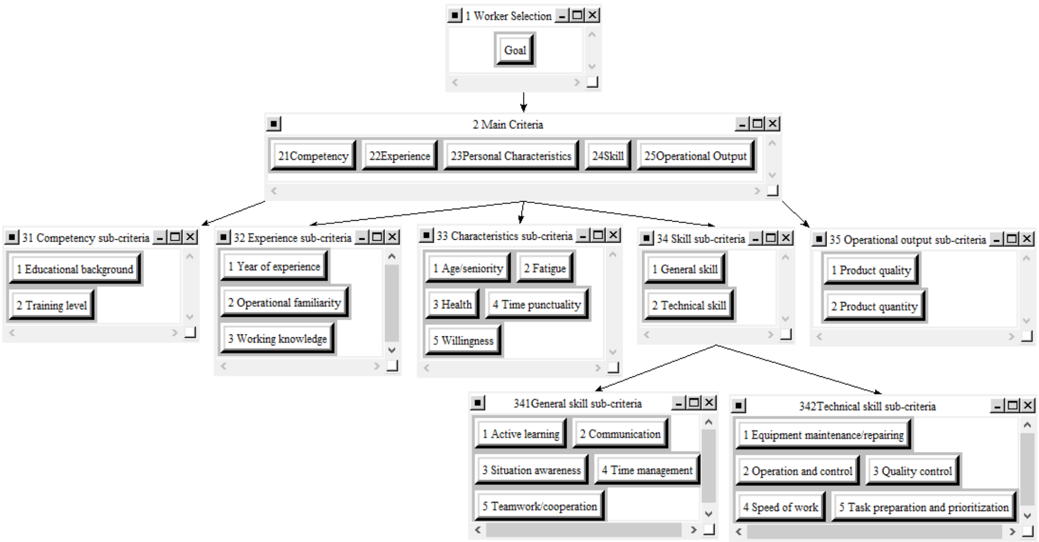

Figure 4: AHP model of worker selection criteria

The AHP model shown in Figure 4 is structured into hierarchy with four levels, worker selection is set as goal in the first level, followed by five main criteria in the second level, sub-criteria of each main criterion are constructed in the third level, and sub-criteria of general skill and technical skill are in the fourth level.

Computational Results of AHP Model

After the hierarchy structure of AHP model is constructed, the importance weight of each criterion is then calculated following the AHP steps explained in the previous section. The computational result of AHP model is shown in Table 2.

Worker selection criteria	Importance weight	Worker selection criteria	Importance weight
Competency	**0.080**	**Skill**	**0.210**
Educational background	0.143	*General skill*	*0.167*
Training level	0.857	Active learning	0.204
Experience	**0.471**	Communication	0.190
Year of experience	0.140	Situation awareness	0.206
Operational familiarity	0.528	Time management	0.179
Working knowledge	0.333	Teamwork/cooperation	0.221
Personal Characteristics	**0.038**	*Technical skill*	*0.833*
Age/seniority	0.031	Equipment maintenance/repairing	0.033
Fatigue	0.631	Operation and control	0.309
Health	0.207	Quality control	0.226
Time punctuality	0.071	Speed of work	0.365
Willingness	0.061	Task preparation and prioritization	0.067
		Operational Output	**0.201**
		Product quality	0.667
		Product quantity	0.333

Table 2: The importance weight of each criterion from AHP model

The results reveal that *experience* is the most important criteria in worker selection with the importance weight of 47.14%, in the context of labor-intensive manufacturing industry. The second rank is drawn by *skill* at 20.98% which is quite close to the *operational output* at 20.06%. The third and fourth ranks are competency at 8.03%, and *personal characteristics* at 3.79%, respectively. However, in the skill aspect, *technical skill* at 83.33% is considered to be more important than *general skill* at 16.67%.

Next, the performance of each worker is evaluated with respect to the determined importance weights. Figure 5 illustrates the worker selection rules model. Lines in the radar chart represent worker performances (*n = 10*). For example, the competency performance of worker 1 is calculated using the equation below;

$$P_{W1,\ competency} = [(0.143 \times S_{c1}) + (0.857 \times S_{c2})]$$

Where *W1* stands for worker 1, S_{c1} is score of criteria 1, and S_{c2} is score of criteria 2. The performance of each worker is computed by multiplying raw score of each criterion with its importance weights show in Table 2. After all worker performance is individually evaluated, the worker is ranked and selected with respect to the determined selection rules of the organization, as afore-mentioned. From Figure 5, the lines within the selection rules line represent workers with unsatisfied performance. In this example, worker 1, worker 3, worker 4, worker 5, worker 7, and worker 9 are only selected, but the rest of them are rejected.

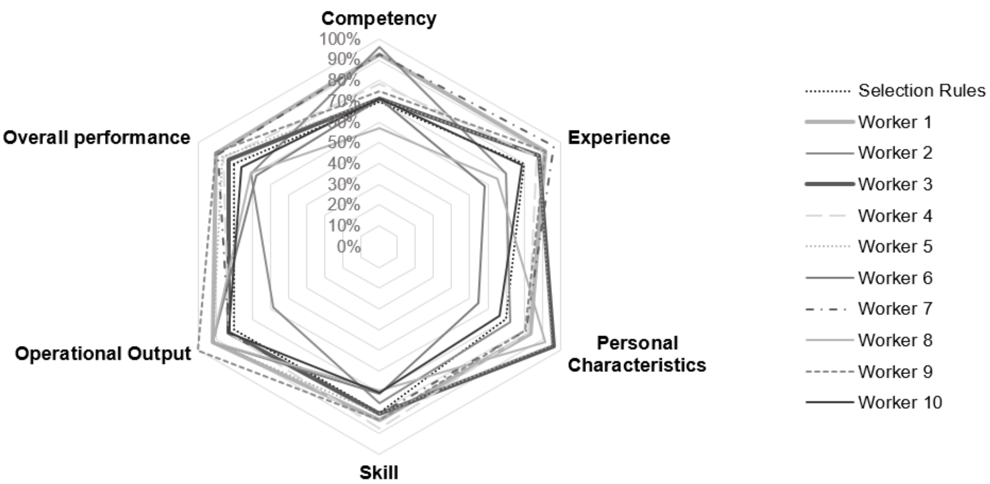

Figure 5: Worker selection rules model

This paper aims to contribute this worker selection practice to be applied in a wide range of the industry sector, especially in labor-intensive environment. Hence, the Overall Worker Performance (OWP) equation of a worker is originated as an effective worker selection tool for general use.

Overall Worker Performance (OWP) = $(W_{competency} \times S_c) + (W_{experience} \times S_e) + (W_{personal\ characteristics} \times S_p) + (W_{skill} \times S_s) + (W_{operational\ output} \times S_o)$

= $(\mathbf{0.080} \times S_c) + (\mathbf{0.471} \times S_e) + (\mathbf{0.038} \times S_p) + (\mathbf{0.210} \times S_s) + (\mathbf{0.201} \times S_o)$

Where *W* stands for the importance weight; S_c is score of competency, S_e is score of experience, S_p is score of personal characteristics, S_s is score of skill, and S_o is score of operational output.

Conclusions

In worker selection management, it is evident from the computational results of AHP model which reveals that experience is the most important criterion in worker selection practice. In labor-intensive manufacturing, it can be concluded that worker experience in terms of year of experience, operational familiarity, and working knowledge plays an important role in all worker-related operations. The skill and operational output criteria are followed as the subsequent important criteria which should be also taken into account in worker selection practice. For competency and personal characteristics criteria, it is not considered as the powerful factor in labor-intensive environment. However, the performance index is developed and named the overall worker performance (OWP) by previous equation. It is able to be applied in a wide range of industry sector with respect to the determined importance weights that represent different priorities of each factor and satisfy the organization natures. As extension of the current study, comparing the proposed method with other well-known multi-criteria decision making methods is suggested. Furthermore, in the context of manufacturing viewpoint, there is a significant relevance within experience, skill, and operational output. The crossed relationship of the proposed criteria could be considered in the future research.

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APPENDIX D
APPROVAL FROM THE MAHIDOL UNIVERSITY INSTITUTIONAL REVIEW BOARD (MU-IRB)

COA No. MU-CIRB 2016/060.0305

Mahidol University Central Institutional Review Board (MU-CIRB)

Certificate of Approval

Protocol No.: 2016/032.2602

Title of Project: Semi-skilled worker selection and grouping in labor- intensive industry

Approval includes:

1) Principle Investigator : Miss Teeraphattara Songsiri
   Affiliation: Faculty of Engineering, Mahidol University
   Research Site: Faculty of Engineering, Mahidol University
2) Submission form version date 21 April 2016
3) Protocol version date 26 February 2016
4) Participant Information Sheet version date 21 April 2016
5) Informed Consent Sheet version date 26 February 2016
6) Questionnaire version date 26 February 2016

MU-CIRB is in full compliance with International Guidelines for Human Research Protection such as Declaration of Helsinki, The Belmont Report, CIOMS Guidelines and the International Conference on Harmonization in Good Clinical Practice (ICH-GCP)

Date of Approval: *03 / May / 2016*

Date of Expiration: *02 / May / 2017*

Signature of Chairperson: ....

(Professor Dr.Rutja Phuphaibul)
MU-CIRB Chair

Signature of Institute Representative: ....

(Professor Dr.Sansanee Chaiyaroj)
Vice President for Research

* See list of Co-Investigators at the back page

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PUBLICATION/PRESENTATION	Songsiri, T. & Sirovetnukul, R. (2015). Worker Selection with Multiple Skills in Labor-intensive Industry, *Proceedings of the 7th International Conference on Logistics and Transport*, 31.