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APPLICABILITY OF MANUFACTURING LEAN TOOLS IN SERVICE OPERATIONS

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ABSTRACT

Lean manufacturing is a philosophy with fewer wastes which acts as the role to seek for minimizing unnecessary time, material and efforts in the production processes. Although lean tools have been used in the manufacturing industry since a long time ago, they are new for service industry. From previous studies, it shows there is a lot of waste in a service operations and it has a huge impact on reducing productivity. Thus, this research is carried out to rank the applicability of the lean tools to practice in the service operations/industry. This research used multi-attribute decision-making methods with the use of expert panels. A framework for applicability of lean tools in service industries is provided by this research. The framework will be useful for the industry practitioners and advisors. It is among the first lean tools applicability frameworks in service operations/industry.

Key words: Applicability, Lean Tools, 5S, Chaku-Chaku.

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1. INTRODUCTION

"Lean" is known as a philosophy of "manufacturing without waste". However, it is widely used in manufacturing industry rather than service industry since a long time ago. From the study, it shows that there is still some confusing or not confirm on the usage of lean tools in service operations/industry. This is due to the lack of understanding of lean principles and lean thinking by service industry worker [1]. Lack of skills, experience and right mind-set of worker toward adoption of lean in service industry had made the services industry less practices of lean tools. New introduction of lean principles also make worker resistance toward this new improvement system. The validity of the system and the useable of the lean principles and lean thinking still is a question mark for worker [1].

2. LITERARURE REVIEW

According to Dictionary.com, service industry is meant by an industry that provides service such as transportation, hospitality, education, banking and other services to the customer rather than produce goods. It consist a lot of firms and normally it is divided into two types

which is the equipment-based service firm and people-based service firm. Equipment-based service firm is known as an organization that performs any tasks or duties by using machinery or any others technology to complete them. Whereas people-based firm is known as somebody who are able to maintain the knowledge that being learn and using the professional for delivering the service and perform tasks completely [2].

There are some service industry practicing lean tools such as public service sector, healthcare, surgery, industrial training courses/ programme, financial service as well as others service industry. First of all, public service organizations have come under increasing pressure to improve efficiencies and delivery quality services to customer [3]. As the biggest employer, government has to move effectively and should not only rely upon the number of civil servant, but they should focus on increasing the quality, productivity and also reducing the high cost of management expenses. In order to cope with the need to improve performance while reducing the costs, government agencies have discovered to use lean management practices which is mostly used in private service organizations [3].

Besides that, due to the financial issue which is seriously take into consideration in health care service has caused health care service faced challenges in delivering high quality and affordable care to customer. In order to improve patient safety and financial performance, healthcare organizations have applied lean process improvement. It being proven [4], where they stated that "effectiveness of lean can reducing the lead times, improving the space utilization, increasing throughput, improving the quality and also increasing the financial performance." Healthcare teams consist of various functional people, for instance, nurses, physicians, pharmacologists, equipment providers, and others who focus on improving all aspects of the process in medical area [5]. Comprehensive lean requires different practices and processes that apply cross-functional teams to promote communication and coordination [6].Thus, an effective improvement method can stimulate common understanding, in conjunction help to strengthening hospital organizations for the long term benefits where it helps in reducing costs and risks in addition facilitating growth and expansion of organization. Prior research has acknowledged that the implementation of lean initiatives improves communication and encourages cross-functional team collaboration, which leads to greater strategic alignment [7].

Traditional method of anesthesia for cardiac surgery was based on a high-dose intraoperative opioid anesthesia technique that required postoperative endotracheal intubation and mechanical ventilation for up to 24 hours. In the year 1990, cardiac surgery case volumes increased rapidly. Therefore, in order to decrease hospital cost and resource utilization, lean work design principles have been used. Patient care processes were redesigned using lean work design principles and it shows that this principle has help to minimize the barriers. Besides that, Fast-track extubation (FTE) guideline was also implemented to facilitate FTE. With that, a broad range of benefits that can be proven from this lean work design principles which it helps to optimize outpatient efficiency, to improve operating theatre efficiency, to decrease operative complications, to reduce ward-based harms, to reduce mortality and to limit unnecessary cost and length of stay room [8].

In addition, total quality management approach style of training programs is very particular and significant nowadays. It gives a huge contribution in the industrial world since the year of 1980. During the economy downturn, companies had felt the necessity to invest in changes that could offer them real competitive advantages for the future. Thus, training programme has become, even more than before. This is due to the factor which industrial training is a strategy for optimizing companies' outputs according to market requests. The demand of industrial training courses is growing more qualified, whereas requests for the realization of training programs in service industry are becoming even more definite, aiming

at precise improvement goals consistent with the company's quality plan. Quality function deployment is certainly an innovative tool to face the development of a new service. In fact there will certainly not a lack for industrial training. Nevertheless, there still have some problems that faced [9].

Other than that, Lean Six Sigma (LSS) is also consider a method that can help financial institutions to improve operational efficiency and effectiveness [10], by combining the strengths of lean thinking and Six Sigma. It had been implemented in most of the financial services organization for the benefit purpose which it can help in lowering the operational costs, improving processes and product quality and increased efficiency of organization. With that, it would lead to the increase of productivity of organization and organization is able to obtain the agility and versatility which is vastly outweighs the costs. To remain competitive, efficient and agile, companies in services need, increasingly, a constant investment in innovation in the processes. Its advantages include the cost control and capital investment, and improvements in the quality of service and customer satisfaction. It is considered an accurate and efficient methodology to support the development of a system of integrated quality management in any business in order to perform virtually free of errors and waste of time [11].

Besides the service industries mentioned above, there is also others service industry apply the lean tools in their workplace (for instance supermarket, information technology (IT) industry, banking service, restaurant and others). From studies, it shows that supermarket had applied lean tools where supermarket is opened branch at everywhere customer are and connect to distribution center in order to increase the speed and agility of product distribution in the same time also reduce the transportation waste and motion [12].

3. RESEARCH METHODOLOGY

This research is conducted using mixed methods which are draw from qualitative and quantitative methods. In order to have a smooth research planning, it would begin with a research framework which briefly describe the stages of methodology involving of hypothesis development, research design, population, sampling procedure, data collection technique, development of measures: design of questionnaire and statistical analysis, goodness of results, validity of data collection tool, reliability data, consistency of results, and external validity of findings [13].

In this research, qualitative part of research that being used is through literature review where it is used to identify the list of lean tool that used in service industry as shown in Table 1.

Table 1 Lean tools

Code	Criteria	Code	Criteria
LT1	5S or Workplace Organization	LT14	One-Piece Flow
LT2	Andon	LT15	Plan-Do-Check-Act (PDCA)
LT3	Autonomation/Jidoka	LT16	Poka-Yoke or Mistake-Proofing
LT4	Chaku-Chaku	LT17	Quality-Function Deployment (QFD)
LT5	Check Points and Control Points	LT18	Root Cause Analysis
LT6	Continuous Flow	LT19	Service Value Stream Management (SVSM)
LT7	Elimination of Wastes (Muda)	LT20	Six Sigma
LT8	Failure Mode and Effects Analysis (FMEA)	LT21	Standardization
LT9	Gemba (The Real Place)	LT22	Statistical Process Control (SPC)
LT10	Hoshin Kanri (Policy Deployment)	LT23	Takt Time
LT11	Just-in-time (JIT)	LT24	Visual Management
LT12	Kaizen (Continuous Improvement)	LT25	Work Balancing
LT13	Kanban (Pull System)		

Next will be quantitative research where it uses a number of methods to collect, interpret, and report what these numbers mean using statistics, tables and graphs [14]. Therefore, in order to achieve the objective, questionnaire is being used in this research. It is created for expert whose apply lean tool in service industry to fill and rank it to obtain quantitative data for statistical testing on reliability, normality test, mean and standard deviation through pair-wise comparison analysis method.

Pair-wise comparison is used to solve complex decision problems through multi-criteria decision making (MCDM). A multi-level hierarchical structure which consists of objectives, criteria, sub-criteria, and alternatives is created to make pair-wise comparisons. These comparisons are used to obtain the weightage of the decision criteria, and the relative performance measures of the alternatives in conjunction with individual decision criterion [15]. The comparisons are made using absolute scale judgments and the derivation of priority scales normally is depend on the judgments of experts to ensure the consistency. The derived priority scales are synthesized by multiplying them with the priority of their parent nodes and adding for all such nodes.

Alam demonstrated that there are some calculation steps that should be used in a data analysis which are hierarchy construction, construction of pair-wise comparison matrices, weights determination and synthesis of weights [16].

STEP 1: During construction of Hierarchy process, objective should be highlighted and criteria and alternatives would be identified. The objective for using pairwise-comparison is to rank the identified lean tools (alternatives) on service industry (criteria).

STEP 2: Construction of pair-wise comparison matrices for all the criteria and alternatives. This pair-wise Comparison is adopted from the studies of Tayfun and Uyan [10]. The matrix is represented mathematically at below Eq. 1.

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{12} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \vdots & \vdots & \cdots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

Where A = a_{ij}, $a_{ij} > 0$, and $\frac{1}{a_{ij}} = a_{ij}$

If “n” number(s) are given for pair-wise comparison, it performs the above process to determine the weights of criteria. A = n x n, where “A” represent the alternatives and $a_{1,1}$ - $a_{1,n}$, and others represent the pair-wise comparison(s). A scale of 1 to 9 will be used for comparison in order to know the degree of importance [15, 17-19].

STEP 3: Determine the weight of the criteria and the local weight through standardization method. The study will determine the weights of the criteria and local weight of the alternatives from the matrices in STEP 2 by dividing each value in a column ‘j’ by the total of the values in a column ‘j’. The total of the columns in the matrix must be 1, hence, a standard of the pair-wise comparison matrix is expressed as Eq. 2 [10,17].

$$Aw = \begin{bmatrix} \frac{a_{11}}{\sum a_{i1}} & \frac{a_{12}}{\sum a_{i2}} & \cdots & \frac{a_{1n}}{\sum a_{in}} \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ \frac{a_{n1}}{\sum a_{i1}} & \frac{a_{n2}}{\sum a_{i2}} & \cdots & \frac{a_{nn}}{\sum a_{in}} \end{bmatrix} \quad (2)$$

STEP 4: Obtain a global weights of the alternatives through synthesis of the local weights. Firstly, the eigenvector of matrix A will be determined by calculating Ci as the average and then the Ci as the average values in the row 'i' of Aw matrix will be calculated for the column vector C where Ci value indicates the relative degree of importance [17].

$$C = \begin{bmatrix} C_1 \\ C_2 \\ . \\ : \\ C_n \end{bmatrix} = \begin{bmatrix} \frac{a_{11}}{\frac{\sum a_{i1}}{n}} + & \frac{a_{11}}{\frac{\sum a_{i1}}{n}} + & \cdots & + \frac{a_{1n}}{\frac{\sum a_{1n}}{n}} \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ \cdots & \cdots & \cdots & \cdots \\ \frac{a_{n1}}{\sum \frac{a_{i1}}{n}} + & \frac{a_{n2}}{\frac{\sum a_{i2}}{n}} + & \cdots & + \frac{a_{nn}}{\frac{\sum a_{in}}{n}} \end{bmatrix} \quad (3)$$

In order to aid the assessment and calculation of the findings, all the computations would be generated through Microsoft Excel to examine the study's proposed models. Microsoft Excel is able to reduce complex decision to a series of pair-wise comparisons and then synthesizes the results. Also, it is relatively free as compared to other commercial software and effectively computes the individual steps including pairwise comparisons, standardization, weights synthesis, consistency indices, among others.

In this research, target population is being used where those people in the service industry and have apply lean tools in their industry would be the target population for getting information and study. It does not have specific details shows that which company had applied lean tools in their daily services, thus researcher's target companies are only specific for company that had applied lean tools in their service industry and have knowledge on lean tools. Those companies have those criteria would be researcher targeted companies for collection of those data. While for the "sample" for this research is about 10 to 15 of samples are taken to check for the reliability of the result.10 to 15 experts of lean is selected as samples to determine the applicability of lean tools used in services industry. According to Multi-alternative decision making, it is suitable and appropriate number of samples for testing of the reliability.

The questionnaire is designed in the form of semi-structured format where some of the questions are predetermined while some are known from the interview session. The questionnaire consists of three parts which is section A and section B.

Section A: It is typically about the personal details of respondents, such as the company's name, respondent's, gender, age, nationality, number of years working experience in the company, highest qualification of education level, current position and department they are working in and et cetera.

Section B: It is most probably to determine or identify the most applicable lean tools that are used in service industry. Among all the lean tools, service industry would use which lean tool the more frequent in their working environment especially deals with varies of customers and problems. It involves pair-wise comparison and respondents will be asked to rank lean tools which represent the criteria for this study using a scale of one to nine.

For the data analysis of pairwise comparison matrix, the process started from the group decision making. Group decision making are used to get the average of panel of experts. Researcher was using the average of each question that rated for 10 questionnaires to do analysis on it. Based on the average of group decision making, researcher present the numerical preference rating to the pairwise comparison matrices. There were 15 service industry companies which had applied lean tool in their industry being invited to participate in the study during the data collection period and only 10 were participating in data collection. Thus, the response rate during data collection was 66.67 present.

4. RESULT

The first pairwise comparison matrices are criteria versus criteria. It measures 25 criteria's as shown in the figure above. It shows numerical preference ratings of criteria versus criteria from 10 different experts (respondents). Meanwhile, respondents are required to list the criteria's horizontally and vertically in order to develop pair – wise comparison matrices of criteria versus criteria. The first horizontal of criteria is comparing with the second vertical criteria and rating score is given. The value of 1.00 is always assigned when comparing with same criteria. Microsoft Excel is the software being used to calculated the mean and others mathematical problem in the analysis.

After the paired comparison, researcher makes the reciprocal matrix. During conducting of the reciprocal matrix, there are two preference values would be stated that is actual judgment value and reciprocal value. The actual judgment value is the judgment of 1, 2, 3, 4, 5, 6, 7, 8 and 9 ratings. Meanwhile judgment of 1/2, 1/3, 1/4, 1/5, /1/6, 1/7, 1/8, 1/9 and ratings is called reciprocal value. Reciprocal matrix is obtained by upper diagonal and lower diagonal. In the first round, to make reciprocal matrix, researcher need to complete the judgment ratings in the upper diagonal plot. Then researchers use the reciprocal value from upper diagonal to make lower triangular matrix. For example, A_{ij} is the factor of row, i then column, j of the matrix while the lower diagonal will be filled using the formulae $A_{ij} = 1/A_{ij}$. Hence all the factors in the pair – wise comparison matrix are positive and/or > 0. It is being denoted that "i" represents row, whereas "j" represents column. If "i" is higher rating (more important) than "j", then it will be an integer value (1, 2, 3, 4, 5, 6, 7, 8 or 9). In contrast, if "i" is lower rating (less important) than "j", then it will be a fraction value (1/2, 1/3, 1/4, 1/5, /1/6, 1/7, 1/8, or 1/9).

After undergoes all the mathematical and statistical calculation process, the priority vector is determinate. Based on the priority vector that analyzed, researcher has made the rating from the highest number of priority vector value (the most applicable) to the lowest number of priority vector value (the least applicable), as shown in Table 2.

Table 2 Rating of Criteria

Lean Tools	Priority vector		Ranking
	Numerical value	Percentage (%)	
LT1	0.1265	12.65	1
LT2	0.0100	1.00	21
LT3	0.0089	0.89	22
LT4	0.0063	0.63	25
LT5	0.0601	6.01	7
LT6	0.0681	6.81	6
LT7	0.0934	9.34	3
LT8	0.0070	0.70	23
LT9	0.0112	1.12	20
LT10	0.0113	1.13	19
LT11	0.0777	7.77	5
LT12	0.0857	8.57	4
LT13	0.0137	1.37	18
LT14	0.0184	1.84	16
LT15	0.0202	2.02	15
LT16	0.0523	5.23	8
LT17	0.0300	3.00	12
LT18	0.0232	2.32	14
LT19	0.0454	4.54	9
LT20	0.0403	4.03	10

LT21	0.0346	3.46	11
LT22	0.0268	2.68	13
LT23	0.0064	0.64	24
LT24	0.0149	1.49	17
LT25	0.1074	10.74	2
Total	1.0000	100.00	

5. CONCLUSIONS

From the result researchers found out the 5S/ Workplace Organization lean tool that is the most applicable in overall service operations/industry. The following four top tools are Work Balancing, Elimination of Waste (MUDA), Kaizen (Continuous Improvement) and Just-in-time (JIT). In contrast to the most applicable, there are also five lean tools that are the least applicable in overall service operations/industry which are Andon, Autonomation/Jidoka, Failure Mode and Effect Analysis (FMEA), Takt Time and Chaku-Chaku.

Among limitations of this research is its general approach to the service operations. Future studies may focus on specific industries, such as Ansal et al. [20, 21], to explore more accurate results.

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