UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Development of a Simulation Based Kanban System for Lean Practitioner

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Manufacturing Management) (Hons.)

by

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ABSTRAK

Pembuatan kejat telah dikenali sebagai kaedah mengurangkan tujuh kerugian dalam industri pembuatan. Walau bagaimanapun, alat latihan untuk membantu pengamal kejat untuk belajar dan bereksperimen dengan pembuatan kejat adalah terhad dan memerlukan kos yang tinggi. Matlamat utama kajian ini adalah untuk membuat satu sistem kaedah pembelajaran bagi pengamal kejat belajar dan bereksperimen dengan sistem Kanban melalui pendekatan simulasi yang dinamakan K-STTS. K-STTS mengandungi dua modul, iaitu GKS-module yang bertujuan menyampaikan teori Kanban dengan menggunakan pendekatan simulasi dan GKC-module untuk membantu pengamal kejat dalam pengiraan Kanban. Perisian simulasi Arena 14 digunakan bagi membuat GKS-module dan perisian Visual Basic 6 digunakan untuk membuat GKC-module. Kajian telah dilaksanakan untuk menilai K-STTS dari segi estetika muka pengguna, keboleh kendalian, keboleh kepenggunaan dan kesesuaian fungsi. Hasil kajian menunjukkan bahawa kedua-dua modul sesuai untuk digunakan oleh pengamal kejat, bagaimanapun keboleh kendalian dan keboleh kepenggunaan GKS-module memerlukan penambahbaikan. Sebagai cadangan, model simulasi boleh dihasilkan berdasarkan senario sebenar dan menambah lagi sistem kaedah pembelajaran pembuatan kejat untuk meningkatkan kefahaman pengguna pada pembuatan kejat.

ABSTRACT

Lean Manufacturing (LM) has been widely known to reduce the seven wastes in manufacturing industries. However, there are few training tools to help lean practitioner in learning and experimenting the LM tools and techniques as they are costly and difficult to create. This research aims is to built a platform for the lean practitioner to learn and experiment with the general Kanban system, by developing Kanban Simulation Training Tool System (K-STTS). K-STTS contains two modules, General Kanban Simulation Module (GKS-module) to deliver Kanban theory by using simulation approach and General Kanban Calculator Module (GKC-module) to help the lean practitioner in Kanban calculation. Arena 14 simulation software and Visual Basic 6 were used to develop the two module respectively. A feasibility study was conducted to assess K-STTS feasibility in terms of user interface aesthetics, operability, learnability and functional suitability. Both module are feasible to be used by lean practitioner, however operability and learnability of GKS-module need a improvisation. Future works include creating simulation based on real scenarios and other LM training tools platform to enhance user's experience on LM tools.

DEDICATION

I dedicate this thesis to my beloved family and friends.

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Alhamdulillah wa shukru lillahi rabbil alamin. Praise to Allah and thanks to Allah the creator of the universe. I am grateful that I have completed the final year project and gained knowledge from the development. I wish to express my sincere thanks to Dr. Effendi bin Mohamad, as Supervisor of my project, for providing me with all the knowledge, help and support through this venture.

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LIST OF ABBREVIATIONS, SYMBOLS AND NOMENCLATURE

CO	-	Customer Order
CT	-	Cycle Time
D	-	Demand
DDL	-	Demand During Lead Time
EOQ	-	Economic Order Quantity
FCFS	-	First Come First Serve
FIFO	-	First In First Out
GKS	-	General Kanban Simulation
GKC	-	General Kanban Calculator
GUI	-	Graphical User Interface
T	-	Lead Time
TPS	-	Toyota Production System
JIT	-	Just In Time
K-STTS	-	Kanban Simulation Training Tools System
LM	-	Lean Manufacturing
MIT	-	Massachusetts Institute of Technology
Muda	-	Wastes
OB	-	Outbound Buffer
IB	-	Inbound Buffer
OP	-	Operation
P	-	Process
PLT	-	Production Lead Time
PSM	-	Projek Sarjana Muda
PT	-	Process Time
S	-	Storage
SMED	-	Single Minute Exchange Die
SMEs	-	Small and Medium Enterprise

SPT	-	Shortest Process Time
TLT	-	Transport Lead Time
TPM	-	Total Preventive Maintenance
TQM	-	Total Quality Management
TRI	-	Total Required Inventory
WIP	-	Work In Progress
WS	-	Workstation
WSC	-	Winter Simulation Conference
X	-	Buffer or Safety Factor
Y	-	Number of Cards
>	-	More than
<	-	Less than
>=	-	More or Equal than
<=	-	Less or Equal than

INTRODUCTION

1.1 Motivation of Project

Since the Lean Manufacturing (LM) has been introduced, it's become a phenomenon that responsible for the changes of most production companies. These change the way of the production company in managing the production flow, and also introduce the way of reducing the wastes (muda). Most LM tools and techniques are actually methods to steadily eliminate and identify the wastes. There are many LM tools and techniques that had been used widely by organizations such as 5s, Poka-yoke, Single Minute Exchange Die (SMED), Jidoka, and Kanban.

Even though, the LM being adopted by many companies, but not all companies become fully successful with the philosophy. This matter was mostly caused by confusion and wrong way of approaching the method. The failure may cause by lack of understanding of the LM philosophy, the LM principles, low preparation, organization, and overemphasis of the LM tools by Aulakh and Gill (2008). Therefore, the right knowledge and the right method should be proposed before implementing the LM itself. This statement can be support of the research made by Rathje *et al*. (2009), which they found that companies fails to do it right for the first time or failed to implement the LM in the first place.

However, J. Liker (2004) found out that it is easy to implement the LM tools by focussing eliminating the wastes (muda) on the process, but the real problem is when it comes to stabilize the system.These statements show that LM cannot be easily adapted to the ready system before or even after implementing the LM.

Recently, the simulation had been one of popular method that being used for study or analyse a system possible behaviour. It was successfully used as one of training methods for some LM tools by Mohamad and Ito (2013). Because of the effectiveness of the simulation method, it has been widely used for training, studies and demonstrating the positive outcomes of LM by Bicheno (2009). This method can be used as preparation, design and evaluation of a LM system before implementing it into the real system. As stated by Chan and Smith (1991), simulation can be used to predict the performance of the system and also determine the best performance for the system. Once a system has been designed, lean practitioner can modify the system (via simulation) as to determine the value of parameters fit with the real system limitation. Therefore, the ability of modifying is one of the purpose of simulation software. Chan and Smith (1991) also stated that the modification proposed for the real system can be evaluated in the simulation for analysing the effectiveness of the proposed modification.

1.2 Problem Statement

It is necessary to develop a simulation base to help the LM trainee study the LM tools before implementing in the real system. In this project, Kanban system was chosen as the LM tool. This project is focused on developing a simulation based on a Kanban system for Lean practitioner, also named as Kanban Simulation Training Tool System (K-STTS). K-STTS are divided into two parts, the Kanban's general simulation module, also named as General Kanban Simulation Module (GKS-Module) and the Kanban calculator, that have been named as General Kanban Calculator Module (GKC-Module).

Therefore, the K-STTS main purpose is to help the Lean practitioner to analyse, simulate, and modify the parameters selected by referring the framework in Figure 1.1.

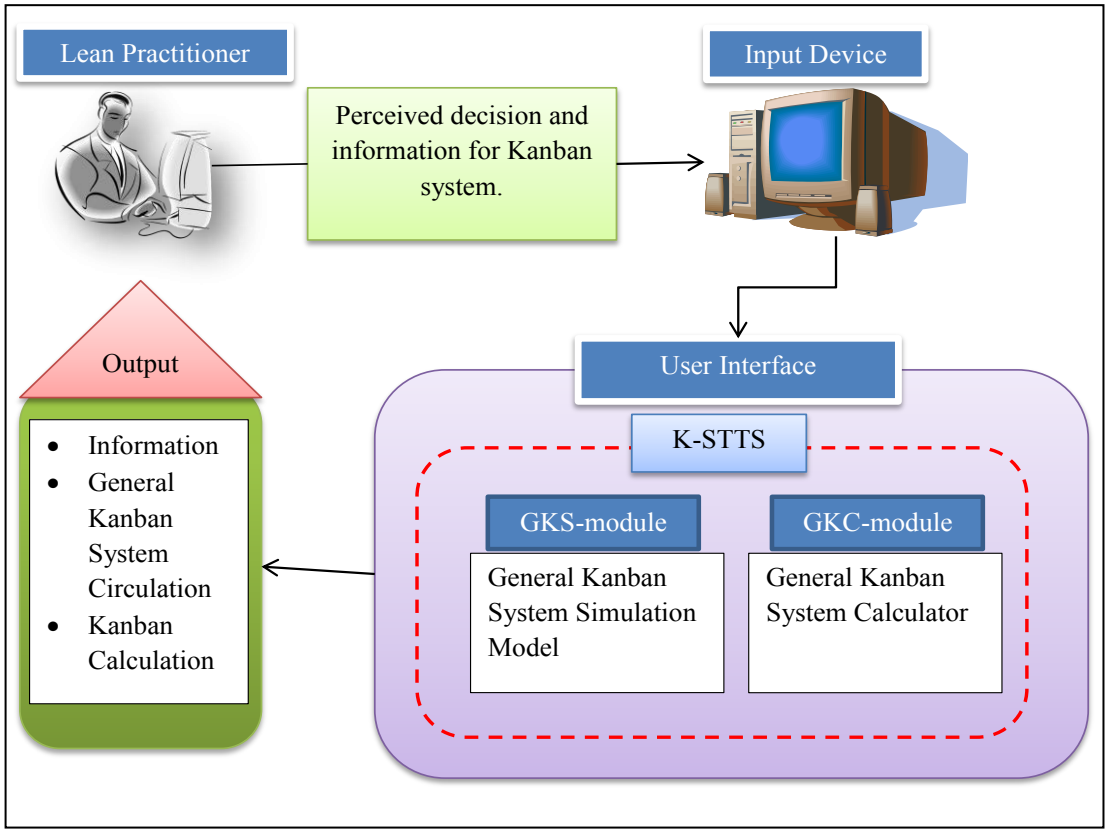

Figure 1.1: Basic framework for K-STTS.

Failures in implementing LM caused by lack of understanding of the LM philosophy, the LM principles, low preparation, organization, and overemphasis of the LM tools by Aulakh and Gill (2008).

Many small companies are lacking in training and materials to learn or to educate their employees about LM tool applications and LM concepts. It is an urgent task for manufacturing researchers to introduce LM concepts and to provide training methods to the companies by Wang and Koch (2008).

It is difficult to provide a full-scale experiment in a factory setting as it will be highly cost. The direct practical study is also difficult for students to be allowed into the factory by Cudney (2011).

Simulation studies are an effective way of teaching LM. But most of the development is either not well documented, too simplistic, or too complex requires special (costly) kits by Silva *et al.*(2013).

Self-learning educational software for the lean practitioner to train the LM techniques and tools in the form of simulation interactive are rarely developed. It is because the development of the training tools in a simulation is very challenging (Kao and Chen, 1996).

1.3 Project Objectives

The main goal of this project is to develop a Kanban-based simulation for lean practitioner. Thus to achieve the goal, three objectives have been set for the project course:

I. To develop GKS-module based on general Kanban theory using Arena 14 simulation software for the lean practitioner to learn and experimenting with the basic Kanban system.
II. To develop GKC-module based on the general Kanban mathematic model using Visual Basic 6 for the lean practitioner to calculate the Kanban calculation.
III. To conduct a feasible study on K-STTS that was developed in this project.

1.4 Project Scopes and Limitations

This project is concerned on the development of an educational platform for the lean practitioner known as K-STTS. The platform can be used for experimenting and gain knowledge of a Kanban system that divided into two sections where there are S-Module and GKC-Module. GKS-Module was developed using Arena 14 software to deliver the simulation and simulator model for the lean practitioner. GKC-Module was developed using Visual Basic 6 software that contains 4 Kanban calculators in the single extension file.

Both will be developed by using simulation software (Arena 14) and application development software (Visual Studio 6) respectively. The simulation model will be based on the General Kanban System, and the model's assumptions will be changing suite with the module development. The module operation will be limited by the final simulation model behaviour that will be developed as below:

- GKS-module development using the Arena 14 simulation software.
- GKC-module development using Visual Basic 6 software.
- Simulation and Calculation only based on general Kanban theory.
- Feasibility study based on four (4) chosen quality model characteristic that provided by ISO/IEC 25010:2011 under the tittle of Systems and Software Quality Requirements and Evaluation. The chosen characteristic are user interface aesthetics, operability, learnability, and functional suitability.

1.5 Report Outline

This report contains five (5) chapters,

Chapter 1 are presenting the introduction of the project, highlighting the problem statements, defining the project objectives, project scope and limitation.

Chapter 2 are discussing about the literature review regarding the project field, namely LM (LM) and simulation.

Chapter 3 contains the methodology that will be used to deliver the K-STTS. The methodology divided into several parts, which are data preparation, GKS-module development, GKC-module development and K-STTS feasible study.

Chapter 4 provide results and discussion that includes developed graphical user interface, GKS-module simulation model, GKS-module's and GKC-module'suser guide, and K-STTS feasibility results.

Chapter 5 discussing about the conclusion and the findings of this project and also recommendations for the future work.

CHAPTER 2
LITERATURE REVIEW

2.1 Overview

This chapter will review a brief introduction about LM, problems and constraint that occur while implementing LM tools, and established simulation in the LM field in order to develop the Kanban simulation for lean practitioner. The discussion of the problem statement, objectives and methodology were based on the journals, books, website and related articles. The literature review starts with wastes types as it is the main objective for lean practitioners. LM background and LM tools will be reviewed afterward, where problems and misconception that made by most companies in implying LM will be highlighted. Then, the review will be more focus on Kanban system. In this part, there will be a review about the Kanban general system types. At the end of the literature review, studies and established simulation of Kanban System will be reviewed. This review will give a better understanding to gain the crucial factors and the right method in order to develop the simulation based on a Kanban system for the lean practitioner.

2.2 Wastes in Manufacturing

In general, wastes can be defined as any activity that add cost, but does not add any value or consuming more resources (time, space, money and etcetera) than necessary to produce the products, or services that the customer demand. The wastes are categorized into two types, incidental wastes and pure wastes. Incidental wastes is the action that needs to be done based on how the current system operates, but the action does not have any added value. Pure wastes are referring to the actions that could be stopped without affecting the customer. While activities that do not give any added value to the process are called “muda” in Japanese term by Puvanasvaran (2014).

In 1976 and 1977, Toyota Motors made a large profit of $597.4 million and $716.7 million respectively. They shocked the world at that time since they manage to buff their profit by eliminating wastes in their operations. Toyota Motors stand on their philosophy “to totally eliminate waste, and seek utmost in rationality in the way we make things” for their system of production that also known as Toyota Production System (TPS) by Taiichi Ohno is one of the TPS fathers, defined the seven types of wastes that exist in all organizations or any company. The seven wastes (muda) are waiting, overproduction, rework, motion, transportation, processing, and inventory. Nowadays, the seven wastes become one of the important tools for implementing LM by JMA (1989). Focussing on waste (Muda) is the most common approach to "implementing LM tools" as it is easy to identify process waste by Liker (2004).

2.3 Lean Manufacturing. (LM)

Back in 1987, TPS was labeled by John Krafcik as 'LM' to describe what the system did. He was one of the researchers at MIT as part of the International Motor Vehicle Program. He wrote the comparison between the TPS and the traditional mass production in term of performance attributes on a whiteboard. The TPS attributes that he wrote were less human effort to design services and products, the given amount of production capacity required less investment, fewer defects for finished products, used fewer suppliers, less inventory for every process step, fewer employee injuries, and went from concept to launch, order to delivery, and problem to repair in less human effort and less time. Krafcik commented "It needs less of everything to create a given amount of value, so let's call it LM." by John & Martin (2009).

Within the LM production system, such as the Toyota Production System (TPS). There is a base methodology that utilized by most manufacturers in Japan under the heading of Genba Kanri or if rendered in English can be known as "Shop floor management". Genba Kanri is the basic operating rules that have been developed by many years in Japan that what make they are now implicit in manufacturing operations by Handyside (1997).

In this 21st century, the markets become fiercely globalize and competitive that demand high variety of products with high quality, reducing the cost and lesser lead time of the operation. This scenario makes most manufacturers want to change their system with more capability of providing efficiency, more responsiveness and better quality manufacturing paradigm that can deliver the demands without mistake. LM is one of the system that claims to achieve the manufacturer such goal. Eventhough, some LM can be dated back to 1940, but the present framework of LM came with the publication of "The Machine That Changed The World", written by Jim Womack et al in 1991 byAulakh and Gill (2008).

LM practices have been increasingly implemented by the manufacturer in order to increase their performance. (Boyer, 1996; Swink *et al.*, 2005; Adamides *et al.*, 2008; Shah *et al.*, 2008;Fullerton and Wempe, 2009).One of the methods is byeliminating activities that have no added value to the products which frequently represent a significant cost by Womack and Jones (1996). Therefore, LM is a management principle that mainly eliminating the activities that generate no value and as such, are considered waste by Womack *et al.* (1990).

2.3.1 Principles of LM

There are five principles of LM thinking that have been used by many lean practitioners, which they have to follow step by step in order to make the LM successful (Picchi & Granja, 2004):

1. Specify Value: The value that specified by the customer. Their own needs and definition that could lead to value activities identification, that the activities will create value to the end product. The customer product specification should identify first.

2. Identify the Value Stream: The process of identifying wastes along the value stream. Everything that does not provide or have any value to the end product should be eliminated. That's mean, the production must be stopped if something gone wrong and solve it at once. The processes which have to be avoided areoverproduction, materials storage, miss a production, unnecessary processes, materials transportation, movement of labour and movement of product, and lastly the production of products which does not live up to the standard that the customer demand, as well as all kinds of unnecessary waiting time.

3. Continuous Flow: By ensuring that there is a continuous flow in the value chain and process by focusing on the entire supply chain. The focus must be on the process and not at the end product. However, to get the optimal continuous flow, customer value must be specified first, and the value stream should be already identified.

4. Pull: Use the pull system concept for the production and the process instead of the traditional push system. The pull system produces the exactly of what the customer demand and specify. While always prepared as the customer needs will change over time. Just In Time (JIT) is one of beneficial management tool for pull system and unnecessary production can be avoided.

5. Perfection: The principle of perfection is to always find the perfect solution and continuous improvements. Produce and deliver the product that reach the customer's expectations and needs within the agreed time schedule, while the product must be in perfect condition with no defects or mistake (zero defect). As to apply this principle, close communication is needed between the customer, as well as manager and employees.

Since many of companies nowadays have changed their organization guided by the LM philosophy in order to make benefit from LM enterprise. The LM thinking becomes one of the most promising initiatives that can be adapt by almost all kind of systems since intellectual architecture of the LM thinking is flexible and high reponse. The Ford, Boeing and General Motor are outstanding world class companies that examples of LM success. However, there are also many of SMEs that failed while trying to implement the LM while there are also many that does not confidence with the LM by Aulakh and Gill (2008).