The manufacturing technology optimisation model: the crucial contribution of industrial mass-training in improving company performance

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Abstract : Fierce global competition, volatile changing market and the spread of advanced manufacturing technology have forced significant changes in the competitive arena of manufacturing industries. This manuscript presents the Manufacturing Technology Optimisation Model, which discusses the crucial role of industrial mass training in improving manufacturing company performance. This model provides insights toward the proper allocation of resources which will bring about optimum condition of improved company performance. Four lessons can be learnt from the model: (a) companies should focus first on improving their capability in effectiveness - doing the right things - before pursuing efficiency and adaptability; (b) the attainment of effectiveness can be accelerated by providing employees with on-the-job mass training on certain practices; (c) companies can continue to pursue the efficiency after they have excellent capability in effectiveness; (d) the pursuit of adaptability may simultaneously advance with that of efficiency, aimed at more responsive to customer requirements. A subsequent paper will demonstrate that selection of appropriate 'people-based' practices may accelerate improved company performance.

1. Introduction

Trends in competitive priorities, and hence strategies, change over time [1, 2]. As suggested by the principle of mass production, manufacturers in the 1960s favour cost reduction through the production of large quantities. Although pressures to reduce manufacturing cost are still huge up to this time, a low-cost production strategy is not itself capable of attracting and maintaining customers. In the post-

industrial environment, the elements of competitive advantage have increased both in their variety and intensity [3].

This situation triggers the pursuit of excellence in manufacturing, which is characterized by an emergency paradigm of innovative production efficiency. In the course of time, methods to increase production efficiency without using buffer inventory, such as Total Quality Management (TQM), Just in Time Manufacturing (JIT), and Total Productive Maintenance (TPM) have been recognized as powerful tools for superior superior performance. These methods are best stated as person-based, steady, all-inclusive, continuous improvement [4], and are referred to as World-Class Manufacturing [5].

Based on a comprehensive survey of manufacturing management and improvement literature, Sukarma [6] developed a new perspective for achieving excellence in manufacturing or a new framework to the World Class Manufacturing (WCM). This framework combined principles of TQM, JIT and TPM and is complemented by a series of practices as well as methods for measuring and monitoring company performance aiming at attaining excellence in manufacturing [7]. The effectiveness of the WCM Framework had been confirmed empirically in [8]. It was revealed that the factory implementing TQM, JIT or TPM was superior to those who did not implement it, and the factory implementing all the paradigms would be completely superior to those who only used one or two approaches.es.

In order to assist manufacturers to obtain substantial benefits from the implementation of the WCM Framework, this manuscript presents a critical analysis of the Manufacturing Technology Optimisation Model. The model provides insights toward the crucial role of human resources in improving company performance, vis-a-vis effectiveness, efficiency and adaptability.

2. The WCM Framework and Practices

Sukarma [6] recommends a framework that integrates TQM, JIT and TPM, or basically the new WCM framework. This approach mainly stems from WCM's definition as "capturing the breadth and essence of fundamental changes taking place in industrial companies" [5]. The WCM logic is fully described in [7]. It brings together principles, practices and performance measurements related to TQM, JIT and TPM. In terms of achieving goals, this production paradigm shares complementary goals including improving quality (Q), delivering products on time (D), and reducing costs (C) through eliminating equipment-centered losses.

For these approaches to be effective, infrastructure or common practices are needed to support their execution [9, 10]. These common practices comprise new approaches to managing human resources, workplace, and suppliers, as well as practices for continuous improvement. These constitute the Infrastructure for implementing TQM, JIT and TPM.

The WCM framework embodies a set of 38 practices, four business performance indicators and 15 manufacturing performance indicators (Figure 1). Implemented in concert, these methods may also yield synergy [11, 12]. The use of TQM not only contributes directly to improved performance in quality, but also it indirectly leads to the improvement of others (just-in-time and cost performances). Likewise, JIT and TPM contribute to quality improvement by respectively reducing inventory, and hence exposing opportunities for process improvement, and to reducing defects due to equipment-related problems.
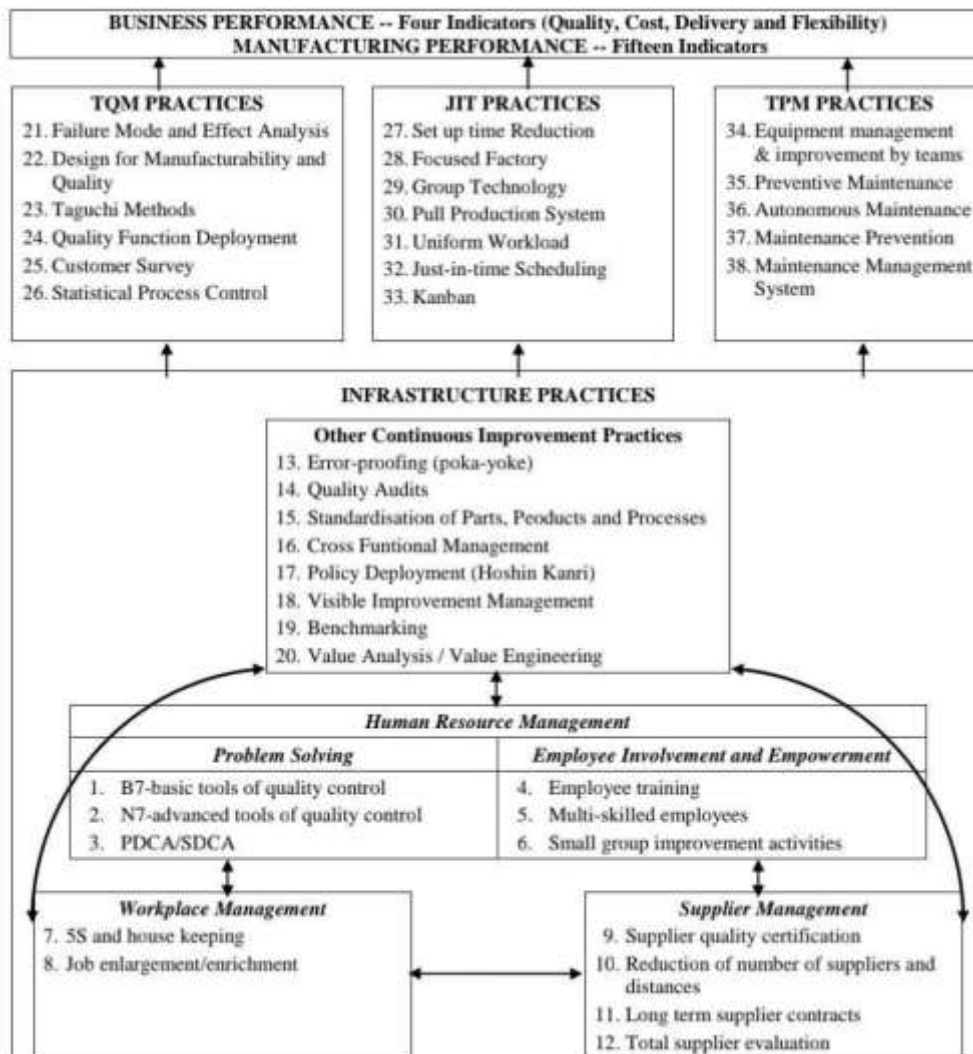
Figure 1. The WCM framework and practices [6]

To achieve standards of performance in manufacturing and enable them to support the core approach, the general practice of Infrastructure must be applied. Infrastructure practices are further classified into problem solving, employee engagement and empowerment, workplace management, supplier relations, and other continuous improvement practices. The implementation of the Quality Trilogy: quality planning, quality control, and quality improvement, to managing for quality is advised by [13]. They are interrelated processes aimed respectively at meeting quality goals during design, operations, and breaking through to remarkable levels of performance. In the manufacturing process, quality is built initially at the stage of product design, is realised by planning and administering activities necessary to make the product, and is achieved ultimately by listening continuously to the voice of the customer. Thus, quality management practices can be classified into Product Design, Process Management, and Customer Focus.

The JIT method is intended to make producers more responsive to customer demand by eliminating or minimizing all types of waste. If the manufacturer chooses to compete in shipping and costs, then JIT might be more appropriate. These practices include Set Up Reduction (SUR), focused factories, Group Technology (GT), pull production systems, uniform workloads, JIT scheduling, and Kanban.

TPM is implemented by extended responsibility for equipment maintenance to every operator, and

is not just limited to the maintenance specialists. It can be seen as the logical extension of TQM [14]. In terms of installing the TPM program, [15] suggests that non-Japanese plants should take three distinct stages: planning and preparation, pilot project, and plant wide implementation.

This framework does not stand alone, companies implementing WCM techniques need to adopt performance measurement and monitoring methods which, in some cases are very different from those in traditional systems, as explained in the next section.

3. The Measures of Performance for The WCM Practices

In addition to using WCM practices, producers must modify their ways to measure performance in their efforts to achieve excellence in manufacturing [16]. Efforts towards the WCM environment are characterized by, among other things, highly competitive products, product mix and volume, short lead times and custom orders, and frequent introduction of new products [17]. The implications of applying the WCM method in measuring company performance comprehensively are described in [18].

As seen in Figure 1, there are two kinds of performance measurement proposed in the WCM framework: business and manufacturing performance. Business performance explains the company's ability to meet customer needs, so that most customers feel their measurement. Quality, Cost, Delivery, and Flexibility Performance are identified as business performance. This is a performance that explains customer satisfaction and, in many cases, has been proven to bring business financial success [19], and increase competitive advantage [20].

The definition of quality of Juran's as 'suitability for use' [21], for example, can be seen as business performance, because its valuation is largely based on the customer's point of view. For customers, quality includes among others all eight dimensions [22]. Therefore, companies must look for the needs of their 'right' customers, prioritize them, and try to satisfy them as much as possible.

Manufacturing performance designs company performance that can be measured in accordance with specified standards. It is a collection of benchmarks to assess its ability to satisfy customers by measuring the effectiveness of its resources. This is a performance that must be measured by the company and measured correctly. This paper proposes fifteen manufacturing performance as the main indicators of performance for companies that achieve manufacturing excellence, as described in [18]. Measuring of manufacturing performance must include three criteria: effectiveness, efficiency, and adaptability [23]. The three performance indicators are defined as follows:

Table 1: The meaning of performance indicators [23]

The Performance Indicators	The Meaning
Effectiveness (doing the right things)	The extent to which customer needs are satisfied
Efficiency (doing things right)	The extent to which the total resources in the company are used in an effective and economic way
Adaptability (ability to change)	The extent to which the company is prepared to handle changes in surrounding conditions (strategic awareness)

Furthermore, Table 2 presents a grouping of fifteen manufacturing performance according to these three indicators of performance.

Table 2: Manufacturing performances and indicators of performance

Num.	Manufacturing Performance	Indicators of Performance		
		Effectiveness	Efficiency	Adaptability
1	Process Defect	▲		
2	Product Return	▲		
3	Cost of Manufacturing		▲	

Num.	Manufacturing Performance	Indicators of Performance		
		Effectiveness	Efficiency	Adaptability
4	Cost of Maintenance		▲	
5	Turnover of Inventory		▲	
6	Delivery's On Time			▲
7	Production Lead Time			▲
8	Cycle Time			▲
9	Space of Effeciency		▲	
10	Equipment Availability	▲		
11	Equipment Performance Effeciency	▲		
12	Labour Productivity	▲		
13	Employee's Morale and Motivation	▲		
14	Accident Frequency	▲		
15	Efficiency of Capital Investment		▲	

According to [24], effectiveness is an indicator for assessing company activities related to doing the right thing at the right time, with the right quality. In Table 1, the effectiveness criteria are related to quality management measures (items 1 and 2), equipment maintenance (items 10 and 11), Human Resource Management (items 12 and 13), and frequency of accidents (items 14). Company performance measures are interrelated; in the sense that quality management performance is not only influenced by TQM practices but also by several other practices (specifically HRM and TPM practices).

Whereas traditional systems are primarily concerned with the efficiency of each individual work center, efficiency is defined as the ratio between the resources expected to be consumed and actually consumed [24]. The efficiency criteria in Table 2 are represented by items 3, 4, 5, 9 and 15. Items 3 and 4 are measures of efficiency in spending resources related to equipment manufacturing and maintenance. To get optimal quality costs, companies must allocate their resources properly. Items 5 and 15 are for measuring efficiency related to inventory and capital investment. Finally, item 9 is a measure of efficiency related to space use. Again, this performance measure reflects the results of applying several practices rather than a single technique.

Last but not least, producers must be sensitive and adapt (or nimble) to changing environments in order to survive and thrive in the market. Hamel and Prahalad [21] perspective of competition for the future as an arena to create and oppose opportunities that arise, not only to compare products and processes of competition and change their methods. Items 6 to 8 manufacturing performance (on-time delivery, production time, and cycle time).

The following section will discuss a theoretical perspective on how smart and appropriate allocation of resources will lead to the greatest of performance improvement vis-a-vis effectiveness, efficiency and adaptability.

4. The Manufacturing Technology Optimization Model

The basic premise of the Manufacturing Technology Optimization Model is that the application of WCM practices will lead to improved organisational performance ➔ $P = P_0 + \Delta P$. In this case, the resulting additional improvement (ΔP) relies heavily on the readiness of a company to allocate resources, which can usually be expressed in financial terms.

As explained previously, measures of performance comprise three indicators: effectiveness, efficiency, and adaptability. Assuming resources are allocated to improve company performance in these criteria, ΔP can be written as:

$$\Delta P = f (E_1 + E_2 + E_3) \tag{1}$$

where E_1, E_2, and E_3, represent company efforts, by way of allocating resources, aimed at improving performance respectively pertaining to effectiveness, efficiency, and adaptability.

Manufacturers should be concerned first with effectiveness (doing the right things), and then with efficiency (doing things right) [25]. Therefore, the priority is on E_1. However, no previous reference is available about the order of importance of E_2 and E_3. It depends on the circumstances. Companies that choose to compete on price will allocate more resources via E_2 rather than via E_3, but those which wish to improve their speed of operation will select the other choice.

In fact, the contributions of E_1, E_2, and E_3 are time-dependent, and (1) can further be expressed as

$$\Delta P = \Delta P\, C_1 + \Delta P\, C_2 + \Delta P\, C_3 \text{ and } C_1 + C_2 + C_3 = 1 \qquad (2)$$

where C_1, C_2, and C_3, represent the relative contributions to additional improvement on performance due to resource allocation aimed at improving effectiveness, efficiency, and adaptability respectively

Assuming that there is no negative impact on performance, the performance (P) will remain unchanged, or $\Delta P = 0$, unless there are additional improvements in one of the three, or at least C_1, C_2, or $C_3 > 0$. In addition to the amount of resources provided, the relative magnitudes of C_1, C_2, C_3 are determined by the initial performance (P_0) and driving forces from its customers and environment. High-performance corporations show improvement more slowly than low-performance companies. A company in a protective industry has less incentive to improve performance than that of a competitive industry.

Thus, (2) can be simplified into

$$\Delta P = \Delta P_1 + \Delta P_2 + \Delta P_3 \qquad (3)$$

where ΔP_1, ΔP_2, and ΔP_3, represent the additional improved performance with respect to effectiveness, efficiency, and adaptability respectively.

Equation (3) implies that overall improved firm performance (ΔP) is the sum of improvements in each component. Whatever the initial performance (P_0), the main objective of using WCM practices is to raise level of manufacturing performance on each dimension so that the overall system performance ($P_0 + \Delta P$) will improve. This research seeks a better way to allocate resources in a business process in such a way that its additional improved performance (ΔP) can reach maximum.

In the case of allocating resources for improving management of *people*, improving management of *equipment*, and improving management of *others*, Equation (3) can be written as:

$$\Delta P = (r_1 + r_2 + r_3)\, \Delta P_1 + (r_1 + r_2 + r_3)\, \Delta P_2 + (r_1 + r_2 + r_3)\, \Delta P_3 \qquad (4)$$
Or
$$\Delta P = r_1\, (\Delta P_1 + \Delta P_2 + \Delta P_3) + r_2\, (\Delta P_1 + \Delta P_2 + \Delta P_3) + r_3\, (\Delta P_1 + \Delta P_2 + \Delta P_3) \qquad (5)$$

$r_1 + r_2 + r_3 = 1$
where
r_1: Relative of contribution to company performance due to improved management of *people*;
r_2: Relative of contribution to company performance due to improved management of *equipment*; and
r_3: Relative of contribution to company performance due to improved management of *others* (materials, energy, and information).

Equation (4) indicates that the additional improvement in each dimension results from a concerted effort in improving the management of people, equipment, and others simultaneously. Likewise, Equation (5) infers that improved management of people, equipment, and others may bring about improvement of company performance in all the three dimensions.

HRM plays an important role in managing infrastructure and supporting core approaches (TQM, JIT, and TPM). In fact, improved management of people contributes to improved management of equipment and others. In other words, r2 and r3 in Equation (5) contain people's contributions.

Separating people component from r_2 and r_3, then $r_1 + r_2 + r_3 = 1$ can be written as

$$r_1 + (r_{21} + r_{22}) + (r_{31} + r_{32}) = 1$$

where

r_{21} and r_{31} are the contributions of improved management of "people" to improved management of equipment and others respectively;

r_{22}: the relative contribution to performance due to improved management of equipment after separating people component; and

r_{32}: the relative contribution to performance due to improved management of others after separating people component.

$$(r_1 + r_{21} + r_{31}) + r_{22} + r_{32} = 1$$

Or $\quad r_{\mathbf{people}} + r_{\mathbf{equipment}} + r_{\mathbf{others}} = 1$

where $r_{\mathbf{people}} = r_1 + r_{21} + r_{31}$ is all "**people**" contributions

Really, we can significantly enhance people contribution when a company attempts to involve and empower employees in every aspect of management. In other words, $r_{\mathbf{people}}$ can be greater than both $r_{\mathbf{equipment}}$ and $r_{\mathbf{others}}$. In fact, a new approach to managing equipment suggests transfer of responsibility and authority from maintenance specialists to operators. With this new approach, the twelve types of resistance to managing workplace (5S), which originate from the shop-floor or clerical staff (dealing with the management of people), can be resolved [28].

Now, equation (5) becomes

$$\Delta P = r_{\mathbf{people}} (\Delta P_1 + \Delta P_2 + \Delta P_3) + r_{\mathbf{equipment}} (\Delta P_1 + \Delta P_2 + \Delta P_3) + r_{\mathbf{others}} (\Delta P_1 + \Delta P_2 + \Delta P_3) \qquad (6)$$

or

$$\Delta P = r_{\mathbf{people}} (\Delta P_1 + \Delta P_2 + \Delta P_3) + (r_{\mathbf{equipment}} + r_{\mathbf{others}}) \Delta P_1 + (r_{\mathbf{equipment}} + r_{\mathbf{others}}) (\Delta P_2 + \Delta P_3) \qquad (7)$$

Thus, manufacturers should focus on the *first* and *second* parts of Equation (7). The *first* part implies that, if $r_{\mathbf{people}}$ can be made greater than both $r_{\mathbf{equipment}}$ and $r_{\mathbf{others}}$, improved management of people may lead to significant improvement in effectiveness, efficiency, and adaptability simultaneously. The *second* part infers that resource allocation aimed at improving the management of equipment and others should concentrate first on improving company capability in doing the right things – effectiveness (ΔP_1), before improving efficiency (ΔP_2) and adaptability (ΔP_3), the *third* part of the equation.

Is there any way to accelerate performance improvement in a reasonable time?

The answer is in the first part of Equation (7). People management is the most real and most easily influenced, but its success in improving company performance is determined by many factors. Education (studying in formal schools) and training (learning in the workplace) are the two most important factors in improving employee skills and in gaining sustainable competitive success [29].

If the contribution to additional performance due to improved management of people (people) is divided into education (p. 11), training (p. 12), etc. (p.13), then the first part of Equation (7) can be written as $\Delta P_{\mathbf{people}} = (p_{11} + p_{12} + p_{13}) (\Delta P_1 + \Delta P_2 + \Delta P_3)$ ……………………………………………(8)

Since education and others (e.g. employee relations) can only lead to long-term improvement, the best way to improve company performance "quickly" is through industrial mass-training.

Then, Equation (8) can be written as:

$$\Delta P_{\mathbf{people}} = p_{12} (\Delta P_1 + \Delta P_2 + \Delta P_3) + (p_{11} + p_{13}) (\Delta P_1 + \Delta P_2 + \Delta P_3)$$

or

$$\Delta P_{\mathbf{people}} = p_{12} \Delta P_1 + p_{12} (\Delta P_2 + \Delta P_3) + (p_{11} + p_{13}) (\Delta P_1 + \Delta P_2 + \Delta P_3) \qquad (9)$$

Additional improvement of $\Delta P_{\mathbf{people}}$ can be accelerated by multiplying the amount of industrial training, particularly concerning with improvement in effectiveness. Thus, Equation (9) becomes

$$\Delta P_{people} = k\,p_{12}\,\Delta P_1 + p_{12}(\Delta P_2 + \Delta P_3) + \frac{(p_{11}+p_{13})}{(\Delta P_1 + \Delta P_2 + \Delta P_3)} \quad (10)$$

| ΔP_{people} Improvement in performance due to improved management of people | = | $k\,p_{12}\,\Delta P_1$ Improvement in effectiveness due to training | + | $p_{12}(\Delta P_2 + \Delta P_3)$ Improvement in efficiency and adaptability due to training | + | $(p_{11}+p_{13})$ $(\Delta P_1+\Delta P_2+\Delta P_3)$ Improvement in all indicators due to education and other people management |

where k > 1

Figure 2 illustrates progress of company performance over time. In this case, for simplicity, only Equation (10), or the first part of (7), ΔP_{people}, is depicted. The whole of (7) can easily be visualised usi a similar logic.
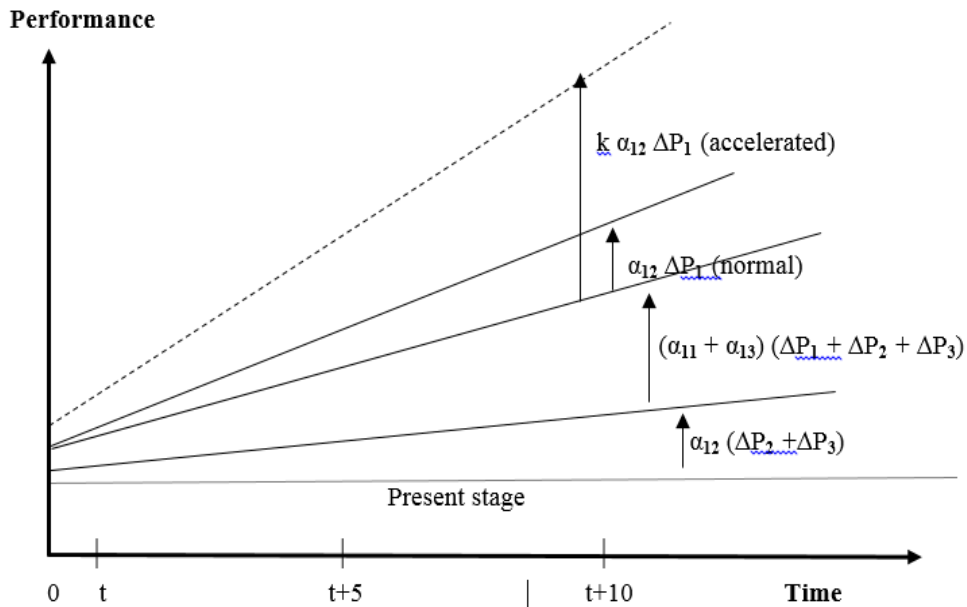

Figure 2 . Company performance as a function of time-dependent resource

5. Conclusions

From the Manufacturing Technology Optimization Model, manufacturers can learn several lessons:

Firstly, a manufacturer should focus first on improving its capability on effectiveness before pursuing efficiency and adaptability. The effectiveness capability can be achieved when every employee has excellent skills: a) required by its products, manufacturing processes and customers; b) in improving and maintaining industrial house-keeping; c) in improving and maintaining the condition of his/her own equipment; and d) in problem solving.

Secondly, the achievement of the effectiveness can be accelerated by providing employees training on the job. Besides being less costly, on the job training is preferred because it provides 'hands-on' learning experience that facilitates learning transfer and can fit into the organisation's flow of activities [29].

Thirdly, the pursuit of improved company performance may then be continued by attempting to enhance the efficiency. This can be done, among others, using some practices of the core approaches. TQM expands its product life cycle by developing quality at source via product design; JIT extends its materials flow via supply chain management towards integration of suppliers; and last but not least, TPM continues its equipment life cycle via total maintenance system [30]. On the job training alone is

not enough to achieve efficiency.   This is especially true when a concurrent engineering methodology is applied, wherein, engineers should have expert skills and multiple expertises. Thus, formal education to some extent plays a central role in enhancing efficiency.

Fourthly, the pursuit of adaptability may proceed simultaneously with that of efficiency. The primary goal is to respond quickly to customer requirements in terms of products, lot sizes, and customised demands for individual customers, et cetera [13]. Adaptability indicates maintaining effectiveness and efficiency in a changing environment. Hence, in addition to the above efforts, companies have to use several other practices in order to improve its adaptive ability. JIT practices of the WCM Framework are among the core practices leading to its realisation. But their success has to be supported by the core practices under TQM and TPM as well as the Infrastructure practices (e.g. supplier partnerships).

References
[1]   Skinner, W,1985. The Focused Factory, in W. Skinner (1985) Manufacturing, the Formidable Competitive Weapon, John Wiley & Sons, Inc., pp. 71-83.
[2]   Gibson, P., G. Greenhalgh, and R. Kerr, 1995, Manufacturing Management: Principles and Concepts, *Chapman & Hall*, London.
[3]   Jaikumar, R., 1986, Post-industrial Manufacturing, *Harvard Business Review*, Nov-Dec.
[4]   Arndt, G., 1990, An International Perspective on "Kaizen" in Manufacturing, *Fifth International Conference on Manufacturing Engineering*. The Institute of Engineers, Australia.
[5]   Schonberger, R. J., 1986, World Class Manufacturing: The Lessons on Simplicity Applied, *The Free Press*, New York.
[6]   Sukarma, L. 2000, A Model for Guiding and Measuring Company Performance towards Achieving Manufacturing Excellence, *PhD Thesis*, The University of Wollongong.
[7]   Sukarma, L., Azmi, H., and Abdullah, N.L., 2014, The Impact of World Class Manufacturing Practices on Company Performance: A Critical Review, *Applied Mechanics and Materials 564*, pp. 727-732.
[8]   Sukarma, L., 2014, Enhancing Firm Competitiveness through Concurrent Implementation of TQM, JIT and TPM, *Applied Mechanics and Materials 660*, pp. 976-982.
[9]   Sugimori, Y. K., Kusunoki, F. C., and Uchikawa S., 1977, Toyota Production System and Kankan System – Materialisation of Just-in-Time and Respect-for-Human System, *International Journal of Production Research 15/6*, pp. 553-564.
[10] Harrison, A., 1992, Just-in-Time Manufacturing in Perspective, *Prentice Hall Int. Ltd.*, UK.
[11] Flynn, B. B., S. Sakakibara, and R. G. Schroeder, 1995, Relationship between JIT and TQM: Practices and Performance, *Academy of Management Journal 38/5*, pp. 1325-1360.
[12] Nakamura, M., S. Sakakibara, and R. G. Schroeder, 1999, Just-in-Time and Other Manufacturing Practices: Implications for U.S. Manufacturing Performance, in J. K. Liker, W. M. Fruin, and P. S. Adler (eds.), 1999, *Remade in America: Transplanting and Transforming Japanese Management Systems*, Oxford University Press, New York.
[13] Juran, J.M. and H. Blackiston, 1995, Universal Approach to Managing for Quality, in Shelton, Ken M. (ed) *In Search of Quality*, Executive Excellence Publishing, Provo, USA, pp. 183-93.
[14] Arndt, G. 1995, From TQM to TPM: An Australian Perspective on Developments in Japan and Germany, Feature Paper at "*TPM in Actions*" **Forum, Synergy** Conventions, Sydney.

[15] Hartmann, E. H., 1992, Successfully Installing TPM in a Non-Japanese Plant, ***TPM Press***, Inc., Pittsburgh, Pennsylvania.

[16] Eccles, R.G, 1995, The Performance Measurement Manifesto, in J. Holloway, J. Lewis, G. Mallory (Eds.), ***Performance Measurement and Evaluation***, Sage Publications, London, pp. 5-14.

[17] Maskell, B.H., 1996, Making the Numbers Count: The Accountant as Change Agent on the World Class Team, ***Productivity Press Inc***., Portland, Oregon.

[18] Sukarma L. and Azmi H. 2015, The Measures of Performance for World Class Manufacturing Practices: A Critical Review, ***Applied Mechanics and Materials 761***, pp. 545-549.

[19] Hausner A. and Arndt G., 1999, Linking Quality Management Practices and Business Performance, ***3rd International Research Conference on Quality Management***, Melbourne.

[20] Singh M., 2013, Product Quality for Competitive Advantage in Marketing, ***International Journal of Business and Management Invention, Volume 2/6***, June. 2013, pp. 05-08.

[21] Juran, J. M. 1988, Quality ***Control Handbook***, McGraw-Hill Publishing Co., New York.

[22] Garvin, D. A. 1987, Competing on the Eight Dimensions of Quality, ***Harvard Business Review, Nov-Dec***, pp. 101-109.

[23] Moseng, B. and Bredrup H., 1993, A Methodology for Industrial Studies of Productivity Performance, ***Production Planning and Control, Vol 4/3***.

[24] Sink, S. and Tuttle T., 1989, Planning and Measurement in Your Organisation of the Future, ***Industrial Engineering and Management Press***, Norcross, GA

[25] Prahalad, C. K., & Hamel, G. 1994. Strategy as a field of study: why search for a new paradigm?. ***Strategic management journal, 15/S2***, pp 5-16.

[26] Pall, G. A. 1987. ***Quality Process Management***, Prentice-Hall, Inc., Englewood Cliffs, NJ.

[27] Riley, Jr., J. F. 1999, *Process Management, in Juran's Quality Handbook*, The McGraw-Hill Companies, Inc., New York, p. 6.1 – 6.21.

[28] Hirano, H., 1990, ***5 Pillars of the Visual Workplace, the Sourcebook for 5S Implementation***, Productivity Press, Portland, Oregon.

[29] Schuler, R.S., Dowling, P.J., Smart, J.P., and Huber, V.L. 1993, Human Resource Management in Australia, ***Second Edition, Harper Educational Publishers***, Pymble, NSW.

[30] Enkawa T. 1998, Production Efficiency Paradigms: Interrelationship among 3T: TPM, TQC/ TQM and TPS (JIT), ***98 World-Class Manufacturing & JIPM-TPM Conference***, Singapore

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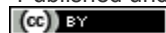
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