

Validation of Lean Manufacturing Implementation Framework Using Delphi Technique

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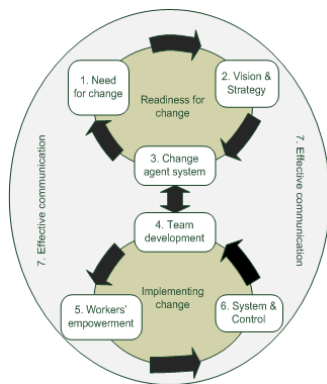
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Graphical abstract



Abstract

Lean manufacturing is a proven approach for success in manufacturing industry. However, several organisations failed in their attempt to implement lean manufacturing system. The transition to lean manufacturing requires radical change which involves a total reshaping of purpose, system and culture of the organisation. Therefore, a lean manufacturing implementation framework was developed. This framework is intended to provide practitioners with a better understanding of lean transition and minimize the conflicts of implementing lean manufacturing system. The purpose of this paper is to validate the proposed lean manufacturing implementation framework using Delphi technique. This technique is a process of gathering opinions of experts, which designed to achieve a convergence of opinions on a specific real-world issue. The work continued over two iterative rounds until consensus or stability is reached. Comments and suggestions given by the experts help to further improve and validate the framework. As conclusion, the final framework of lean manufacturing implementation is presented.

Keyword: Lean manufacturing; implementation framework; framework validation; Delphi technique

Abstrak

Sistem pembuatan *lean* adalah satu pendekatan yang telah terbukti kejayaan dalam industri pembuatan. Walau bagaimanapun, terdapat beberapa organisasi yang masih gagal dalam usaha mereka untuk melaksanakan sistem ini. Peralihan ke sistem pembuatan *lean* memerlukan perubahan radikal yang melibatkan penstrukturan semula pada tujuan, sistem dan budaya di dalam organisasi. Oleh itu, satu kerangka pelaksanaan sistem pembuatan *lean* telah dibangunkan. Kerangka ini bertujuan untuk memberikan pemahaman yang lebih baik kepada pengamal industri tentang pelaksanaan sistem pembuatan *lean*, dan mengurangkan konflik semasa peralihan ke sistem pembuatan *lean*. Tujuan kertas kerja ini adalah untuk membentangkan proses penentusahan kerangka pelaksanaan sistem pembuatan *lean* dengan menggunakan teknik Delphi. Teknik ini adalah satu proses pengumpulan pendapat para pakar untuk mencapai satu persetujuan pendapat mengenai satu isu khusus semasa. Proses ini berlanjutan sebanyak dua pusingan sehingga konsensus atau kestabilan pendapat dicapai. Komen dan cadangan yang diberikan oleh para pakar membantu untuk meningkatkan dan menentusahkan kerangka yang dibangunkan. Sebagai kesimpulan, satu kerangka akhir pelaksanaan sistem pembuatan *lean* telah dihasilkan.

Kata kunci: Pembuatan *lean*; kerangka pelaksanaan; penentusahan kerangka; teknik Delphi

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1.0 INTRODUCTION

The increasing challenges in today's global competition have prompted many manufacturing firms to adopt new manufacturing management tools in order to improve the firm's efficiency and competitiveness. Lean manufacturing has been adopted by some manufacturing firms as a management tool and lean techniques are applied in many different forms, and assumed under different names.

Nowadays, lean manufacturing has become a widely accepted and adopted best manufacturing practice across countries and industries. The ultimate goal of a lean organisation is to create a smooth, high quality organisation that is able to produce finished products at the rate of customer demands with minimal or no waste. However, in reality, many organisations are not able to transform themselves into lean manufacturing organisations that can be recognised as world-class companies. Transformation toward lean manufacturing is full of formidable challenges. It has

been reported that many lean manufacturing implementations, even those undertaken with the best intentions, are often destined for failure at some point of their implementation [1, 2].

A thorough analysis on lean manufacturing framework done by Anand and Kodali [3] had pointed out that most of the existing lean manufacturing framework are categorised as ‘design/conceptual framework’. These frameworks do not describe how to implement lean manufacturing and do not show how each element in lean manufacturing is related within an implementing organisation. Therefore, Nordin *et al.* [4] have proposed a lean manufacturing implementation framework to provide practitioners with a better understanding of lean transition and unambiguous guidance, and/or tools to minimize the resistance and conflicts of implementing a lean manufacturing system.

This paper presents a validation process of the proposed lean manufacturing implementation framework. The purpose of framework validation is to identify whether the factors that need to be taken into account in engaging lean manufacturing implementation are applied. This paper commences with literature review focussing on lean manufacturing implementation, the proposed framework and framework validation. Research method section has described in detailed on Delphi technique process. Then, the results of the validation process are explained Results and Discussion section. Finally, the final lean manufacturing implementation framework is presented.

2.0 LITERATURE REVIEW

2.1 Lean Manufacturing Implementation

Today, change is not an exception but a steady going process. As change has its own impact on both processes and people, thus attention is required. The change to lean manufacturing system is a radical process and not an easy task [5]. Lean manufacturing represent a holistic approach to change. In order to create the foundation for lean manufacturing to take hold, a significant organisational change must occur within the organisation. According to Narang [6], the process of lean transition requires significant changes in the functions of the company. Changes that are required in lean manufacturing can be divided into four categories such as: changes in process; changes in function, co-ordination and control; changes in values and human behaviour; and changes in power within organisation [7]. Table 1 shows the changes required during the transition to lean manufacturing

Table 1 Organisational changes required in lean manufacturing

Categories in organisational change	Changes in lean manufacturing	Authors
Changes in process	Application of the full set of lean tools, multi-skilled worker	[8], [9], [10]
Changes in function, co-ordination and control	Teamwork building, cross-functional movement, network relationship with suppliers and customers, information transparency, participative management, teamwork rewarding	[11], [9], [12], [10]
Changes in values and human behaviour	teamwork, open communication and information sharing, continuous improvement culture, knowledge learning and sharing	[11], [13], [9], [10]
Changes in power within the organisation	Decentralised responsibilities, autonomous leadership	[14], [15]

2.2 Lean Manufacturing Framework

Yusof and Aspinwall [16] defined framework as a “perspective set of things to do”. According to Anand and Kodali [3], a framework from an organisational perspective, can be described as a guiding torch that helps a manager in providing necessary direction during the change management programmes that are implemented in an organisation. It may consist of various elements or blocks, which an organisation needs to follow when it tries to implement a change in the current way of functioning. A framework also can be portrayed through diagrams, graphical representations or descriptive.

Anand and Kodali [3], in their analysis has identified 30 frameworks in lean manufacturing. Majority of these frameworks fall under the category of “design/conceptual” framework. Whereas, the number of frameworks under the “implementation” framework are very less. According to Yusof and Aspinwall’s [16] definition, the design/conceptual framework is about the content of lean manufacturing. The implementation framework deals on how to implement lean and sequence of activities that need to be taken up.

2.3 Proposed Framework

A framework for lean manufacturing implementation is developed by the authors through survey questionnaire and multiple case studies [4]. The proposed framework as shown in Figure 1 is built-in with a concept whereby; the lean manufacturing system implementation process could be conducted in stages and depending on the company’s needs and available resources (i.e. financial, human, technical, time) and not on wholesale basis. This framework represents a road map, which a manufacturing company could use as a guide towards successful implementation lean manufacturing implementation.

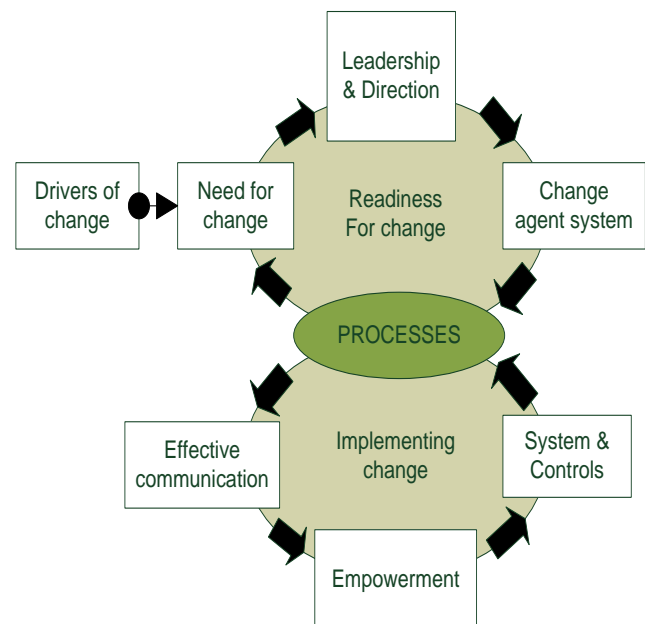


Figure 1 Proposed lean manufacturing implementation framework

The framework clearly shows the major stages in the process to lean manufacturing implementation. The most fundamental level of this framework consists of two cycles: first, readiness for change, and second, the change implementation. However, before

a company is ready for change, a sense of urgency needs to be established. The drivers for change to a lean manufacturing system may stem from domestic and international market pressures for competitive products. Therefore, it is the responsibility of the top management to ensure these Drivers of Change are well communicated and established, in order to create the sense of urgency for change to a lean manufacturing system.

For the change to take hold and succeed, the organisation and the people who work in that organisation must be ready for the transformation. The readiness for change can be addressed by identifying and understanding the Need for Change, having clear and consistent Leadership and Direction, and creating a strong Change Agent Team. Following clarity on readiness for change, the next step that the company should do is to take up and implement the lean tools and techniques or Processes. As the top circle of the proposed framework focuses more on engaging strategic alignment, the lower circle stresses on the needs to be understood, measured, and approved. The Implementing Change cycle is very critical in lean manufacturing. The implementation of change must be aligned with the operational issues, so that people in the company can understand how they will affect and what must be done to address the challenges in the organisation [17]. Effective Communication, Education and Training, and System and Control are the essential factors for lean success.

The lower circle of the framework closes when the steps return to the Processes resulting in possible sustainable lean manufacturing implementation. When the change management process has been successful, the company typically absorbs the change. Taking another trip around the circle will verify the change process and anchors lean manufacturing in the work culture, where changes have become part of the “way we do things around here”. Lean manufacturing system should be regarded as intended direction, rather than a steady state. The process to lean does not actually provide an answer to a specific problem, it deals with all problems in the organisation. Lean manufacturing represents a unique culture that grows and improves with time. For the transformation toward a lean system, people should have a better understanding about lean and also need to be aware about the organisational change management principles.

2.4 Framework Validation

Validation is a process by which a judgement is made as to whether a tool is fit to purpose. In considering the types of validation process, it is important to take into consideration the contexts in which the validation process is carried out. The contextual factors that likely to impact the validation process are geographical region, cost involved in the process, and time [18]. There are a number of validation methods available. Inglis [18] has list down six approaches in validating a framework such as reviewing the research literature related to effectiveness in online learning, seeking input from an expert panel, undertaking empirical research, undertaking survey research, conducting pilot projects, and drawing on case studies. In this study, seeking input from an expert panel or Delphi technique was used.

Delphi technique is a process of gathering opinions of experts, which designed to achieve a convergence of opinions on a specific real-world issue [19]. The rationales of Delphi technique in validating the proposed lean manufacturing framework are:

- The use of expert panels offers a way of bringing a high level of expertise to bear on the process by reducing the level of bias compared to reliance on one expert alone [18],

- The technique does not require the experts to meet physically, which could be impractical for very busy expert [20],
- The technique employs multiple iterations designed to develop a consensus of opinion concerning a specific topic [19].

3.0 RESEARCH METHOD

The Delphi technique focuses on the overall framework structure and its practicality within manufacturing firms in Malaysia. The technique validates the proposed framework by asked the panel of experts to describe what they would do in particular circumstances. According to Skulmoski *et al.* [21], the Delphi process consists of: selection of expert panel, questionnaire design and scoring methods, number of iteration rounds, and data analysis. Figure 2 illustrates the framework validation using Delphi technique.

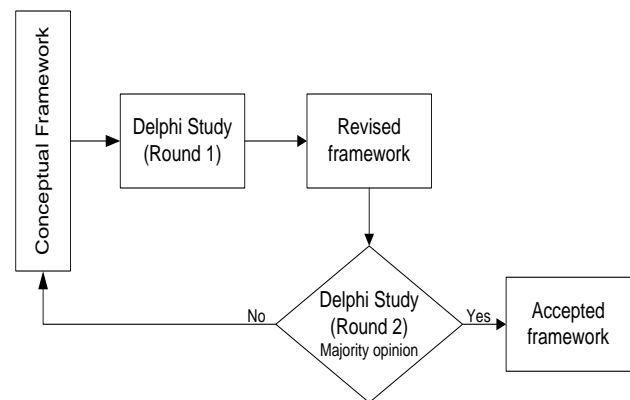


Figure 2 Framework validation using Delphi technique

Since Delphi technique focuses on eliciting expert opinions, the selection of expert panel is generally dependent upon the disciplinary areas of expertise required by the specific issue. According to Skulmoski *et al.* [21], the Delphi participants should meet four expertise requirement: i) knowledge and experience with the issues under investigation; ii) capacity and willingness to participate; iii) sufficient time to participate in the Delphi technique; and iv) effective communication skills. Regarding to the panel size, the representation is assessed by the qualities of the expert panel rather than its number. This is because the Delphi technique does not call the expert panels to be representative samples for statistical purpose [22, 23]. Therefore, for this study three experts were chosen based on their knowledge and experience in lean manufacturing implementation. Table 2 shows the general background of the expert panel.

The number of iteration round is variable and dependent upon the purpose of research. Skulmoski *et al.* [21], and Thangaratinam and Redman [23] suggest that two or three iterations are sufficient for most research. The purpose of first iteration is to identify the general issues relating to the organisational change framework in lean manufacturing implementation. The first round questionnaire is usually unstructured and seeks an open response. The questions were constructed based on a study of comparison analysis on previous lean manufacturing frameworks by Anand and Kodali [24]. The open-ended questions were employed in to solicit specific information about the framework developed and increase the

richness of data collection. A qualitative analysis of the results was then undertaken, which provides further improvement of the proposed framework and also as a basis to construct the second questionnaire.

Table 2 General background of expert panel

Expert	Position	Work experience	Experience in lean manufacturing
A	Lean Sigma Consultant	<ul style="list-style-type: none"> • Sony Technology Malaysia Sdn Bhd (13 years) • Geniussoft Advance Learning (4 years) • Hicom Diecastings Sdn. Bhd. (1 year) 	<ul style="list-style-type: none"> • Sony Technology Sdn. Bhd. Lean consultation for • Pos Malaysia • Proton
B	Assistant Manager	<ul style="list-style-type: none"> • Toyota Boshoku UMW Sdn. Bhd (10 years) 	<ul style="list-style-type: none"> • Toyota Boshoku UMW Sdn. Bhd
C	Consultant	<ul style="list-style-type: none"> • Sony TV Industry Malaysia Sdn. Bhd. (11 years) • Deloitte Consulting Sdn. Bhd. (3 years) 	<ul style="list-style-type: none"> • Sony TV Industry Malaysia Sdn. Bhd • Deloitte Consulting – strategy and operation consultant

The second round was more specific, with the questionnaire seeking the rating or ranking techniques. Therefore, the results obtained tends to be convergence to a consensus of opinion [19]. In this second questionnaire, the experts were asked to provide any condition for agreement and disagreement of the revised framework. The questions are set up on a five-point Likert scale to measure the extent of agreement. The scale range consists of 5 points from strongly disagree (1) to strongly agree (5). In a Delphi study, experts are confronted with the results after each round, until consensus or stability of results is reached. Consensus was defined as agreement between the experts on rating a particular item within a specific round. 75% was taken as a minimum percentage of agreement on any particular item [25]. Therefore, in this study, the consensus is achieved when the experts rate each item with a score more than 3.7.

The methods of data analysis appear to vary according to the purpose of Delphi technique, structure of the rounds, types of questions and numbers of participants. In this study, content analysis technique was used to identify the major themes generated by the initial unstructured questionnaire. These findings are then translated to improved framework and a structured questionnaire of the following round. Being quantitative in nature, the results are analysed using ranking and rating techniques. Finally, the final framework of lean manufacturing implementation is presented.

4.0 RESULTS AND DISCUSSION

In the first round, an interview was done with each of the experts. In this session, the experts were asked to provide qualitative feedback on the framework components. They were also asked to suggest success factors and implementation activities of lean manufacturing implementation. Results from the first round were used to provide further improvement of the proposed framework and also basis to construct the questionnaire for the second round of the Delphi study. There are three main comments and suggestion raised by the experts. Table 3 shows the comments made and the modifications done to the framework.

Table 3 Experts' comments and modifications done to the framework

Comment/Suggestion	Framework Modification/Improvement
1. The <i>Process</i> element does not meet the lean manufacturing implementation sequence	The <i>Process</i> element is removed from the framework. Improvement is done by linking <i>Change Agent System</i> directly to <i>Team Development</i> .
2. Framework does not explains the role and responsibility during lean manufacturing implementation	Extra explanation in separate table.
3. The <i>Effective Communication</i> factor does not meet the lean manufacturing implementation sequence	Remove the <i>Effective Communication</i> factor from the framework cycle.

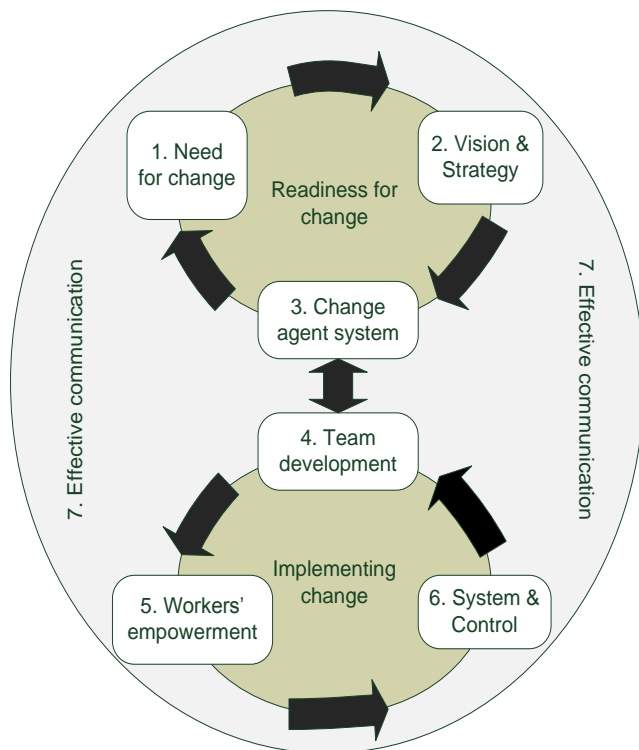
The first suggestion by the expert panel is the *Process* element does not meet the lean manufacturing implementation sequence. Thus, the element is removed from the framework. Improvement is made by linking the *Change Agent System* factor directly to *Team Development*. This is consistent with suggestion made by Herron and Hicks [26], that the role of change agent system is to ensure the principle of lean manufacturing can be understood by everyone in the organisation. In addition, the system is also responsible in developing and providing training to the teams that involved in lean manufacturing implementation process. The second comment by the experts is the framework does not explains clearly the role and responsibility involved during implementation process. Therefore, a separate table is developed to explain the roles and responsibilities. The third major modification done to the framework is to remove the *Effective Communication* factor from the framework cycle. This is because the experts regard the communication in lean manufacturing system should occur on a bilateral basis between management and workers, and continuous from the initial planning stage to final implementation of lean manufacturing system. Inconsistence and unclear communication could lead to implementation failure.

After round one, a questionnaire was distributed to each of the experts. Table 4 shows the results of Delphi study round two. The results of round two were stable, which each of the item scored more than 3.7. Therefore, it is not necessary to do a third round.

Table 4 Results of round two Delphi technique

Question	Expert A	Expert B	Expert C	Mean
A Overall structure				
1. Comprehensive approach and covers all the major aspects of lean manufacturing implementation.	4	3	4	3.7
2. Provide straight forward guide	4	3	4	3.7
3. Simplify the process even to someone who is new to lean manufacturing concept	4	3	3	3.3
B Abstractness				
1. Whether the reader would understand the sequence of the implementation	4	3	4	3.7
2. The stages are easy to understand and systematic guidance to successful lean manufacturing implementation.	4	3	4	3.7
3. The proposed stages are logical and practical.	4	3	4	3.7
C Role and responsibility				
1. Whether the framework provides information about the role of stakeholders in lean manufacturing environment.	4	4	4	4

Based on the results from this Delphi study, the framework has been modified and refined. Figure 3 shows the final lean manufacturing implementation framework. The framework is intended to provide practitioners with a better understanding of the lean transition and a clear guidance to minimize the resistance and conflicts for the implementation of lean and thus improves its chance of success. Failure to recognize the required organisational changes to adapt lean manufacturing system will hinder the long-term benefits of the organisation.

**Figure 3** Final framework of lean manufacturing implementation

5.0 CONCLUSION

The aim of this study was to validate a proposed framework of lean manufacturing implementation. A Delphi method was used to find out whether the lean experts could reach consensus on the stages or sequence of successful lean manufacturing implementation. After two rounds, the Delphi results were stable. One of the requirements of lean manufacturing implementation framework is that it could help a manager in providing necessary direction during the change management programmes that are implemented in an organisation. The authors believe that this condition is achieved, for the results indicate that the items have reached consensus of mean scores more than 3.7.

It should be acknowledged that the Delphi technique used in this study has some limitations. First, the expert panel involved in this study is very small. According to Skulmoski *et al.* [21], larger sample size may yield more sufficient results. Finally, as the validation process is not yet completed, the final framework should be field-tested. Therefore, in future research, the final framework will be tested and applied in the real working environment in order to further refine and eliminate any weaknesses that the framework might have.

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