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Bridging Engineering Education with Lean Manufacturing through Teamwork, Awareness of Lean Information and Employee Involvement

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Abstract:
Basic guidelines for the preparation of a technical work for an Test Engineering and Management Journal Publication are presented. This document is itself an example of the desired layout (inclusive of this abstract) and can be used as a template. It contains information regarding desktop publishing format, type sizes, and typefaces. Style rules are provided that explains how to handle equations, units, figures, tables, abbreviations, and acronyms. Sections are also devoted to the preparation of acknowledgments, references, and authors' biographies. The abstract is limited to 150–200 words and cannot contain equations, figures, tables, or references. It should concisely state what was done, how it was done, principal results, and their significance.

Keywords: *At least 5-6 keywords separated by comma.*

I. INTRODUCTION

The concept of lean manufacturing has gradually become very important for many manufacturing industries because of its great benefits such as the efficient flow of production process and the reduction in the amount of waste from the manufacturing process of a product (Chetthamrongchai& Jermsittiparsert, 2019; Saengchai & Jermsittiparsert, 2019). These benefits ultimately result in the increase in productivity of that particular organization (Aguilar-Duque, Hernandez-Arellano, Balderrama-Armendariz, Amaya-Parra, & Avelar, 2018). Some of the tools that are used in lean manufacturing process include just in time, supply chain management, total quality management, total productive maintenance, seven waste concept and 5S workplace methodology. By using the process of lean manufacturing, the productivity can be improved because the output product is increased while the input factors such as raw materials, labor etc. are decreased (Bai, Satir, & Sarkis, 2019). This ultimately results in the increase in profits and revenues of that company. Despite of all these factors, lean manufacturing is observed to result in the decrease in quality of the product and the effectiveness of production as well.

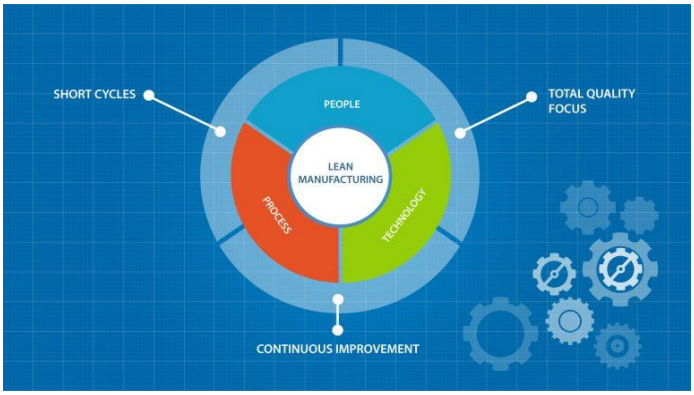

Figure 1. Lean Manufacturing (Source: 6sigma.us)

Figure 1 shows different aspects and components related to lean manufacturing. Teamwork, as the name implies, is the process or any act that is performed by certain teams or groups dedicated to achieve a certain goal or objective. Teamwork is considered as the most important factor in the improvement or effectiveness of that particular task on which the groups or teams are working (Brock, McAliney, Ma, & Sen, 2017). In addition to that, the efficiency of the people that are in the group or team is also enhanced as a result of proper team work. This enhancement does not depend ob the individual people but on the team or group as a whole.

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Awareness of lean information refers to having required information and knowledge about the techniques and processes used in the process of lean manufacturing process. As we know that, lean manufacturing involves increase in output with the minimum waste of materials. This increase in output and decrease of wastage requires specific technical skills and knowledge that can be used by employees for such processes (Carmeli, Brammer, Gomes, & Tarba, 2017). Employee involvement is actually the process that allows the employees to participate in the decision making processes which ultimately affects their own job. Every organization has some goals and a specific mission to be accomplished. When the management of that organization allows its employees to put forward their ideas, suggestions and opinions in order to accomplish those goals and mission, this process is referred as employee involvement. These ideas, opinions and suggestions may be related to decision making and problem solving in that particular organization (Cherrafi, Elfezazi, Chiarini, Mokhlis, & Benhida, 2016). Employee involvement can be in various forms; employees can send a representative to put forward their ideas and opinions or an employee may directly go to the management for the same purpose. Employee involvement actually depends upon the leadership, culture and environment of that particular organization. Employee involvement not only increases the productivity and performance of an organization but also increases the levels of satisfaction, commitment and loyalty in the employees of that particular organization (Chuang, Jackson, & Jiang, 2016; Fenton- O'Creevy, 2015; Fidalgo-Blanco, Sein-Echaluce, García-Peñalvo, & Conde, 2015). Engineering education provides technical and managerial skills to the employees, which results in the increase in the performance and growth of an organization. These skills may be related to the technical aspects of operating the equipment and machinery used in the production processes. These skills also involve some knowledge about management practices of a particular organization.

Engineering education provides skills and knowledge that can be used in the process of lean manufacturing. Team work, awareness of lean information and employee involvement are the factors that can be achieved by engineering education and that can assist the manufacturing industries in the lean manufacturing process. But unfortunately, in Malaysia, engineering education is not reformed and designed in proper way that decreases the teamwork, awareness of lean information and employee involvement (Gonzalez-Rivas & Larsson, 2017). This ultimately results in the inefficient lean manufacturing process in that organization. Other than Malaysia, other developing and under developed countries are facing the same issue of inefficient lean manufacturing. If this problem prevails for a longer time and is not solved as soon as possible, it will have serious outcomes in the form of decreased profits, revenues and productivity in the manufacturing sector of Malaysia. Therefore, it is very crucial to solve this problem by introducing reforms in the education education and promoting teamwork, awareness of lean information and employee involvement (Heckscher, 2018).

There are various researches that have studied about engineering education, teamwork, awareness of lean information and employee involvement and lean manufacturing process. A fewer studies have shown the impact of engineering education on lean manufacturing process but no research has been conducted in order to study the mediating role of teamwork, awareness of lean information and employee involvement. So, a research paper has recommended studying the mediating role of teamwork, awareness of lean information and employee involvement in this regard (Ng & Ghobakhloo, 2018). This research has following important objectives:

- To analyze the significant impact of Engineering Education on Lean Manufacturing in the manufacturing sector of Malaysia
- To analyze the significant mediating role of teamwork between Engineering Education and Lean Manufacturing in the manufacturing sector of Malaysia
- To analyze the significant mediating role of awareness of lean information between Engineering Education and Lean Manufacturing in the manufacturing sector of Malaysia
- To analyze the significant mediating role of employee involvement between Engineering Education and Lean Manufacturing in the manufacturing sector of Malaysia

With the increase in globalization in Malaysia, it has become difficult for the manufacturing sector to fulfill the needs and demands of the costumers. In order to overcome this issue, manufacturing firms have started to move move towards the use of lean manufacturing in their industries or organizations (Helleno, de Moraes, & Simon, 2017). Moreover, due to the increase in the competition among different manufacturing companies, these companies have become more interested in switching towards the lean manufacturing processes. The use of these processes increases the production and decrease the amount of waste in production process. This research is significant because it provides enough literature on the concepts of engineering education, teamwork, awareness of lean information, employee involvement and lean manufacturing process (Henrique, Rentes, Godinho Filho, & Esposto, 2016). Practically it will assist the manufacturing companies of Malaysia to give importance to engineering education and promote teamwork, awareness of lean

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information and employee involvement. It will also help the government to devise policies favorable for lean manufacturing so that the productivity and profits can be increased and that will result in the growth and development of the country.

II. Literature Review

Value Steam Mapping

Value steam mapping is a technique that is used to analyze and design the process of production of a product or provision of a service to the costumers. In this technique, the current flow of processes is prepared and then a future flow of processes is made with the view that the future flow must contain considerably less waste as compared to the current one (Yang, Kuo, Su, & Hou, 2015). Value steam mapping consists of a number of symbols and signs that show the flow of processes of production. Various factors of production are mapped in such a way that there is always value addition for the costumer with the minimum waste and maximum efficiency in the process (Hussain et al., 2018). Value steam mapping is valuable for almost all the sectors. In supply chain management, value steam mapping will identify the areas where delays in the chain have been taking place. Similarly, in the manufacturing of a product, this technique finds out the areas in the production process, where waste is being produced. Other than that, in service sector, this technique is beneficial in speeding up the processes of the system through which services are being provided to the costumers (Jimmerson, 2017). In healthcare sector, value steam mapping makes sure that the patients are being treated effectively in a right way. One of the most important of value steam mapping is that the waste produced during the process of production is considerably reduced. The causes and reasons behind the production of those wastes are also evident because of the visualized flow of processes. Other than that, it also assists the employees to work in an efficient way and show more contribution towards their job. There certain challenges that are faced by the technique of value steam mapping (Lacerda, Xambre, & Alvelos, 2016). While doing value steam mapping, it must be made sure that its return in the form of profit is enough. As this is a difficult or complex process, it must also be made sure that this is done under the supervision of experts and seniors so that no loophole may remain in the process. Overall, value steam mapping is a beneficial technique that can be used by almost all the important sectors of a particular country in order to improve and increase their productivity and profits, as well as revenues and sales (Maskell, Baggaley, & Grasso, 2017). All this becomes possible because this technique increases the output product and reduces the waste during the production process of any product. This model can be used to explain the impact of engineering education on lean manufacturing with the mediating role of teamwork, awareness of lean information and employee involvement.

Impact of Engineering Education on Lean Manufacturing

Lean manufacturing is a process that is used in organizations in order to increase the output product by reducing the waste produced during the process. This process is gaining popularity day by day because of its benefits to the organizations. Engineering education plays an important role in this regard. Engineering education provides the employees or workers technical and managerial skills and knowledge that can be applied in the organizations, either manufacturing or service sectors, in order to apply the lean manufacturing process in that particular organization (Maskell et al., 2017; McVay, Kennedy, & Fullerton, 2016). Studies have shown that the essence of lean manufacturing process is waste reduction in the production process. This waste reduction is not an easy task to achieve. It is a complete technical procedure with several important steps that must be designed by an expert or senior so that efficient and effective results can be obtained by them. Waste reduction is not only applicable in manufacturing industries but also in service industries as well as some other sectors. In supply chain process, the reduction of waste implies to the decrease in the delays so that the products reach costumers timely (Meudt, Metternich, & Abele, 2017). In service industries, this aspect can be viewed in such a way that there is reduction in the wastage of time for the provision of services. In other words, the services are delivered very quickly to the costumers which ultimately add value in those services. Studies have shown that engineering education provides the skills related to these procedures that result in the reduction of production waste in manufacturing industries. The other basic aspect of lean manufacturing is the increase in the output product which is again a technical procedure. Organizations use equipment and machineries specialized to produce quality products in minimum time with use of minimum raw material and less labor force, which actually represents the efficiency of the production process (Müller, Vette, Hörauf, Speicher, & Burkhard, 2017). Studies have shown that such equipment and machinery are also developed by using the technical skills provided by engineering education. All these aspects i.e. increased production and decreased wastage result in the increase of sales, revenues, profits and overall productivity, which indicate the betterment in the performance, development and growth of that particular organization (Ohlsson, 2017). This impact is clearly in accordance with value steam mapping. From all the above discussion, we can

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say that engineering education has significant impact on lean manufacturing in the manufacturing sector of Malaysia. We can generate the following hypothesis in this regard:
H 1: Engineering Education has significant impact on Lean Manufacturing in the manufacturing sector of Malaysia

Mediating Role of Teamwork between Engineering Education and Lean Manufacturing

Teamwork plays an important role as a mediator in our research. Teamwork actually refers to a group or team of people that are working for a same cause together. All organizations have some goals and objectives; people work in teams or groups in order to achieve those goals and objectives in an effective and efficient way. Studies have shown that engineering education provides technical and managerial skills to the people that enhance the factor of teamwork in them (Rangus & Slavec, 2017). They are trained in such a way that they give efficient results when they work in a team as compared to when they work individually. Lean manufacturing is the process in which certain technical procedures are used in order to increase the production and reduce the waste produced during the production process. Studies have shown that this process in not individual's task; a whole team is required instead. The people of the team that is involved in the actual production of product must work in collaboration with each other to increase the efficiency of the process (Redeker, Kessler, & Kipper, 2019). After this, other teams of the actors involved in the supply chain of that particular organization such as suppliers and distributors must also cooperate with the production team for the timely delivery of products to the costumers. Other organizations such as service sectors, healthcare sectors etc. also use lean manufacturing process in order to boost the speed of their service delivery to the costumers. Such efficient processes, production and timely delivery of the products to customers result into high profits, sales and revenues; which ultimately is in the best interest of the organization (Rohac & Januska, 2015). It increases the growth and development of that organization and enhances the level of customer satisfaction. From all the above discussion we can conclude that teamwork has significant mediating role between engineering education and lean manufacturing. We can generate the following hypothesis:
H 2: Teamwork has significant mediating role between Engineering Education and Lean Manufacturing in the manufacturing sector of Malaysia

Mediating Role of Awareness of Lean Information between Engineering Education and Lean Manufacturing

Lean information involves all the necessary information, knowledge and skills that are crucial for implementing lean manufacturing system in an organization. As engineering education provides a lot of technical and managerial skills to the concerned people, we can say that engineering education has a crucial role in the implementation of lean manufacturing process. These skills are not only related to the manufacturing process but also to the delivery of the products to their respective costumers (Salas, Shuffler, Thayer, Bedwell, & Lazzara, 2015). We can say that lean manufacturing practices requite technical as well as managerial skills for better implementation. Studies have shown that technical skills are used in the manufacturing process because it involves equipment and machinery which gives more output by reducing the amount of waste in the production process. Engineering education has crucial role in providing these technical skills. Similarly, for the smooth running of supply chain for the faster delivery of products and services to the costumers, some managerial skills and some knowledge related to it are required. Other than manufacturing industries, service sectors also shoe interest in implementing lean manufacturing system in their service firms (Salmon, Stanton, & Jenkins, 2017). Their basic purpose of doing this is actually to speed up certain processes that are involved in their system of delivery of a particular service to the costumer. Researches have shown that other sectors such as healthcare sector, financial services sector are also interested in implementing this system in their organizations. These skills are also important in lean manufacturing process and are basically provided by engineering education. Researchers have discussed that these skills when applied for the effective implementation of lean manufacturing process in any organization often result in the increase in profits and revenues of that organization that is the sign of enhancement of productivity and increase in the growth and development of that organization (Sanders, Elangeswaran, & Wulfsberg, 2016; Schniederjans, Schniederjans, Cao, & Gu, 2018). To put this in a nutshell, we can say that engineering education provides enough technical and managerial skills that increase the awareness of lean information in employees of an organization who use that information in implementation of lean manufacturing process in that particular organization, which can be observed through value steam mapping. This process results in several benefits mentioned above. From this whole discussion, we can conclude that awareness of lean information has significant mediating role between engineering education and lean manufacturing. We can produce the following hypothesis:
H 3: Awareness of lean information has significant mediating role between Engineering Education and Lean Manufacturing in the manufacturing sector of Malaysia

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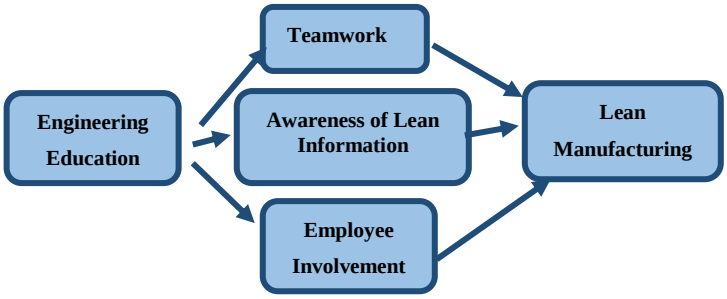
Mediating Role of Employee Involvement between Engineering Education and Lean Manufacturing

Employee involvement revolves around the concept that when employees are allowed to put forward their ideas, opinions and suggestion in the decision making and problem solving processes of an organization, this increases the involvement of those employees in their job as they feel encouraged and privileged. Studies have shown that engineering education plays a vital role in employee involvement as it provides required skills and knowledge to the employees, which as a result increases their intellectual level and thus they get opportunities to participate in the decision making and problem solving processes in an organization (Stanton & Baber, 2017). As these employees have got enough knowledge and information about the lean manufacturing systems, they convey that information to the management of that organization. This depends upon the management, environment and culture of that particular organization whether they accept the opinion of employees or not (Tapping & Shuker, 2018; Tyagi, Choudhary, Cai, & Yang, 2015; Valentine, Nembhard, & Edmondson, 2015). Researches have shown the fact that an employee oriented organization accepts the ideas and suggestion of their employees and then apply them in their organizations. If the ideas and information about lean manufacturing is accepted by the management of an organization and agree to implement that process in their organization, the employees can use other technical skills in order to improve the efficiency and effectiveness of lean manufacturing process (Wallace, Butts, Johnson, Stevens, & Smith, 2016). Studies have shown that this process is not only confined to manufacturing firms but they are also used in other sectors such as services sectors, healthcare sectors etc. To put it in a nutshell, engineering education increases the employee involvement in an organization and their ideas, suggestions and technical skills increase the efficiency of lean manufacturing system in accordance with the value steam mapping. Employee involvement also results in increased employee job satisfaction and loyalty towards his job (Wood, 2016). From all the above discussion we can say that employee involvement has significant mediating role between engineering education and lean manufacturing in the organizations of Malaysia. We can generate the following hypothesis:

H 4: Employee Involvement has significant mediating role between Engineering Education and Lean Manufacturing in the manufacturing sector of Malaysia

Research Model



III. Research Methodology

Population and Sample

This proposed study is about the checking the influence of engineering education on lean manufacturing, with mediating role of employee involvement and teamwork, awareness of lean information by collecting the data set from specific population. Researcher has been chosen the Malaysia as a population of the study because manufacturing or construction sector of the Malaysia contributes a lot in the economy that's why researcher gathered data from manufacturing companies of Malaysia. Sampling frame of the proposed study composed of those manufacturing firms which located in peninsular Malaysia. By the help survey administered technique, data has been collected from manufacturers of these companies. These qualified manufacturers have been selected by purposive sampling technique and with the assistance of Federation of Malaysian Manufacturers and organization from Malaysia Ministry of Industry and International Trade. As far as the sample size is concerned, it has been calculated with the assistance of Klein (2015) idea such as number of questions*10. As the number of questions are 35 that's why sample size is 350, questionnaires have been distributed between 350 respondents. After discarding the invalid and incomplete responses, only 319 valid responses have been used.

Data Collection Procedure

Researcher has been used questionnaire for the collection of primary and numeric data because it can be analyzed more easily and accurately with statistical techniques. Questionnaire has been composed of two types of closed ended questions such as researcher asked about the respondent's demographic information and in second part researcher asked about the relationship of the independent, dependent and mediating variables. Further, researcher conduct pilot study in order to investigate and verified whether questionnaire items understandable or not understandable. After collecting the feedback from selected number of respondents, researcher modified the questionnaire according to the suggestions. Before finalizing the questionnaire, researcher verified that language must be in accordance to the respondents and

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content validity has been checked by industrial practitioners. Researcher administered the final questionnaire with online questionnaire administering technique because it is more convenient for respondents, as they can solved it at any possible time.

RELIABILITY AND VALIDITY OF MEASURES

Measurement model validity has been measured by AMOS but criteria to examine convergent and discriminant validity are totally different. For the evaluation of convergent validity, two criteria have been examined such as items loading and average variance extracted. Items loading λ has to be greater than 0.70 because its values were stronger at above 0.70. Average variance extracted criterion states that its values has to be greater than 0.50. As far as discriminant validity between constructs is concerned, square root of AVE has to be greater than all other inter-corelated coefficients of remaining constructs. On the other hand, reliability of measures has been evaluated by using AMOS and criteria to examined the assessment are composite reliability, its values have to be exceeded the threshold range 0.70 because desirable level of items reliability achieved only when its values greater than 0.70. Second criterion for the assessment of reliability is Cronbach's α which has to be greater than 0.70 because it ensured significant level of internal consistency.

Set of variables varies according to the respective studies that's why researcher has to use different measures to evaluate them. When the researcher not considered the distinction among every study and evaluate the variables on the bases of single factor then common bias method has been observed in the study. For the identification of the common method bias in the study, researcher has been used Harman's single factor test. In this test all the variables have been evaluated on the bases of one criterion, which states that not more than 50% of variance accounted by single factor will ensured the inexistence of CMB. Researcher takes into account all the variables of the proposed study such as engineering education, employee involvement, lean manufacturing and teamwork, awareness of lean information. After running the test, it has been concluded that 87% of variance accounted by factor solution and 21% of variance accounted for by single factor. Consequently, inexistence of CMB has been confirmed and it has been reported that proposed study has not been gone through common method bias.

MEASURES

Different measures have been adapted from the work of authors in earlier literature, for the measurement of the variables of this study. These measures are as follow.

A. Engineering Education

Measures for measuring the independent variable engineering education have been adapted from the related studies of (Jarrar & Anis, 2016). Researcher asked the 12 questions from respondents about the impact of the engineering education on OP. The 12-items has been measured on the bases of 5-point Likert scale, which illustrate that responses will be categorized in the range of 1-5 where 1 refers as strongly disagree and 5 refers as strongly agree.

B. Lean Manufacturing

Lean manufacturing as dependent variable has been measured with 4 items scale, which has been adapted from the earlier study of (Ng & Ghobakhloo, 2018). In these survey items researcher asked respondents about the lean manufacturing, one of these survey items is "Lean manufacturing get improved with the addition of engineering education". The scale used for these survey items evaluation is 5-point Likert scale, in which responses has been collected in the range of 1 strongly disagree to 5 strongly agree.

C. Awareness of lean information

For the measurement of awareness of lean information, researcher adapted the measures from the work of (Ng & Ghobakhloo, 2018). This variable has been evaluated on the bases of 5 questions, in all question's researcher asked about the influence of the respective variable. One of these survey questions is, "Our firm ensured lean manufacturing by providing the lean information to the employees". Respondents record their responses in the form of 5-point Likert scale, which states that responses have to be categorized in the range of 1 strongly disagree to 5 strongly agree.

D. Team Work

Team work as mediating variable of the study has been measured with the 6 questions which have been adapted from work of authors in previous literature such as (Ng & Ghobakhloo, 2018). Respondents were asked about the mediating role of team work in the relationship of independent and dependent variables. Out of these 6 items, one survey question is "Our firm workers are well coordinated that's why lean production can be achieved". Moreover, these survey items have been evaluated on the bases of 5-point Likert scale, ranges from 1 (strongly disagree) to 5 (strongly agree).

E. Employee Involvement

Researcher of this study evaluate the employee involvement variable on the basis of the 5 items, which have already been used in earlier studies of (Ng & Ghobakhloo, 2018). These survey items are verified as most accurate measures because it has already been sued in previous literature. One of these survey items is, "Our firms employees involved in the process of strategic planning of manufacturing process". 5-point

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Likert scale has been takes into account for the measurement of these survey items, respondents responses are in range of 1 strongly disagree to 5 strongly agree.

HYPOTHESIS TESTING

It is mandatory to perform the hypothesis testing during research work because after the testing researcher can report which hypothesis will be accepted or which hypotheses get rejected. Researcher has been used structure equation modeling for hypothesis testing, which runs on AMOS. Path analysis of the structural model has been performed for evaluating the acceptance or rejection status. This analysis has been accompanied in the two steps, in the first step standardization of paths has been checked and in second step relative significance of influenced path has been checked. After that, researcher report which hypothesis is positive related and which hypothesis is negative related.

IV. FINDINGS

The present paper assessed the impact of engineering education (EE) on the lean manufacturing (LM) along with the mediating roles of awareness of lean information (AOLI), teamwork, and employee involvement (EI) by analyzing data collected from 319 respondents. Results of demographic analysis of respondents revealed that proportion of male respondents in the sample was less than that of female respondents because males were 40.4 percent while females were 59.6 percent of total sample. The age of most of the respondents was ranging between 21 and 30 years (83.4%). There were 13.2 percent respondents in the sample whose age was ranging from 31 to 40 years while respondents with age ranging from 41 to 50 years were 2.8 percent in total. Least respondents were of age more than 50 years (0.6%). The demographic analysis further reveals that 7.2 percent of total respondents were having degree of graduation, 50.2 percent of total respondents were having degree of post-graduation, and 39.5 percent respondents were having degree of Masters while only 3.1 percent respondents were having other education qualification. It means that most of the respondents were young, post-graduated females.

1) Descriptive Statistics

319 responses were put in to analysis to check the relationships proposed in this study however, the descriptive statistics of all variables were tested before running main analysis (see table 1).

Table 1
Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
EE	319	1.00	4.92	3.5444	1.10465	-.805	.137
Teamwork	319	1.00	5.00	3.5460	1.08841	-.812	.137
AOLI	319	1.00	5.00	3.4884	1.15930	-.683	.137
EI	319	1.00	5.00	3.4533	1.12950	-.565	.137
LM	319	1.00	5.00	3.5580	1.11670	-.773	.137

Table 1 is indicating that the means, standard deviations, minimum values, maximum values and skewness of teamwork, LM, EE, AOLI, and EI are all falling within acceptable ranges. There is no outlier in the data of any of these variables identified so, the data of all these variables is in its normal and acceptable condition. The skewness of all of them is within acceptable range (i.e. more than 1 and less than +1). Furthermore, the current data is suitable because KMO for it is 0.938 (see table 2) and p-value is <0.05 so, the current data is suitable for analysis as well.

Table 2
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.938
Bartlett's Test of Sphericity	Approx. Chi-Square	12251.734
	df	496
	Sig.	.000

2) Convergent validity and Discriminant validity

To check the internal consistency of variables and multicollinearity in the data, the convergent and discriminant validity were checked (see table 3).

Table 3
Convergent Validity and Discriminant Validity

	CR	AVE	MSV	MaxR(H)	EI	EE	Teamwork	AOLI	LM
EI	0.923	0.804	0.224	0.972	**0.896**				
EE	0.902	0.746	0.310	0.986	0.473	**0.864**			
Teamwork	0.942	0.733	0.293	0.992	0.383	0.541	**0.856**		
AOLI	0.922	0.797	0.336	0.993	0.332	0.557	0.530	**0.893**	
LM	0.931	0.772	0.336	0.994	0.406	0.518	0.388	0.580	**0.879**

The value of CR >0.7 for EI, EE, teamwork, AOLI, and LM, AVE >0.5 for all of them, and MSV<AVE for all studied variables are suggesting that the convergent validity of all

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these variables is confirmed. The discriminant validity of all variables is proved through the fact that each variable is highly correlated with itself more than with any other variable. For instance, EE has the correlation of 0.864 with itself while its correlations with EI, teamwork, AOLI, and LM are all less than 0.864. Hence, the convergent as well as discriminant validity of variables has been proved by results.

3) Model Fitness (CFA)

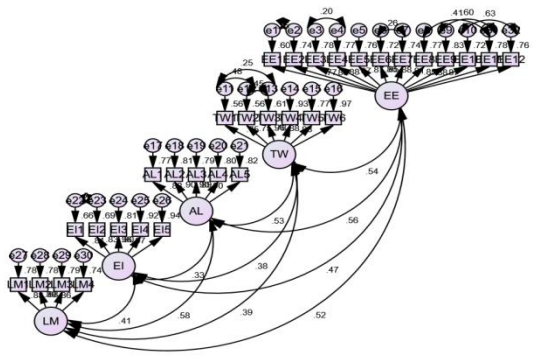
The current model containing EI, EE, teamwork, AOLI, and LM variables has a good fit because results of "confirmatory factor analysis" (CFA) have proved that all key indicators of model fitness are giving appropriate values for the present model (see table 4).

Table 4
CFA

Indicators	Threshold range	Current values
CMIN/DF	Less than or equal to 3	2.236
GFI	Equal or greater than .80	.843
CFI	Equal or greater than .90	.955
IFI	Equal or greater than .90	.955
RMSEA	Less than or equal to .08	.062

The value of CMIN/DF for current model is 2.236, GFI is 0.843, CFI is 0.955, IFI is 0.955 and RMSEA is 0.062 that are all falling within acceptable ranges of these indicators therefore, the current model has the good fitness.

Figure 1
CFA



4) Structural Equation Modeling (SEM)

SEM was performed on the collected data for sake of hypotheses testing through which the direct, indirect and total effects of EE, teamwork, AOLI, and EI on lean manufacturing were estimated (see table 5).

Table 5
SEM Results

Total Effect	EE	EI	AOLI	Teamwork
EI	.466***	.000	.000	.000
AOLI	.536***	.000	.000	.000
Teamwork	.538***	.000	.000	.000
LM	.496***	.170**	.367***	.055
Direct Effect	EE	EI	AOLI	Teamwork
EI	.466***	.000	.000	.000
AOLI	.536***	.000	.000	.000
Teamwork	.538***	.000	.000	.000
LM	.191**	.170**	.367***	.055
Indirect Effect	EE	EI	AOLI	Teamwork
EI	.000	.000	.000	.000
AOLI	.000	.000	.000	.000
Teamwork	.000	.000	.000	.000
LM	.305***	.000	.000	.000

Note: *** indicates p-value <0.001, ** indicates p-value<0.01, * indicates p-value <0.05.

Table 5 is revealing that all proposed effects have been supported through results except one (i.e. the mediation of teamwork between EE and LM). It is indicated through results that EE has a significant positive impact on LM with a total effect of 0.496 however, this total effect is not completely the direct effect of EE on LM because EE has caused an indirect effect of 0.305 on LM which has been caused due to EI and AOLI because EI and AOLI significantly mediated between EE and LM. However, the teamwork has not caused any significant effect on LM so, its mediation between EE and LM is not significantly supported by results. It means that all hypotheses of the current study are accepted except the hypothesis regarding the mediating role of teamwork between EE and LM.

Figure 2
SEM

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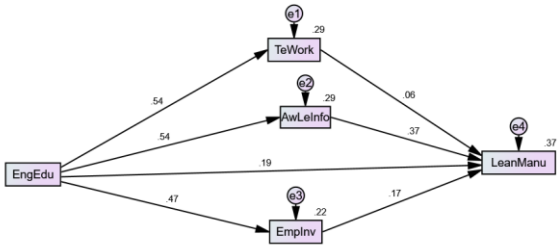

V. Discussion

The aim of the current study was to now about the relationship between engineering education and lean manufacturing (Abele et al., 2015). Engineering education, which provides the organization with the professional practices of engineering and lean manufacturing which is associated with the minimum wastage of resources and this Japanese method was introduced to promote maximum customer satisfaction involving the manufacturing of order based customized products for the customers. Engineering education can impact the lean manufacturing in different ways which will be discussed further in this part (Bucciarelli & Kuhn, 2018). The study incorporated team work awareness of lean information an employee involvement between the engineering education and lean manufacturer as a mediating variable. The study conducted a detailed review of past studies related to the variables involved in this study. That literature review covered a lot of previous gaps and produced four brief hypotheses regarding the statement of the problem. Those hypotheses were analyzed for their validity; confirmatory tests were run for the hypothesis (Chao, Chen, & Chuang, 2015). The results of the analysis will be discussed in detailed in this section. The first hypothesis prosed by the study was that engineering education has a significant a positive impact on lean manufacturing. Engineering education, which provides the organization with the professional practices of engineering and lean manufacturing which is associated with the minimum wastage of resources and this Japanese method was introduced to promote maximum customer satisfaction involving the manufacturing of order based customized products for the customers and according to the study of (Devadiga, 2017), engineering education today is proposing several ways to promote and implement lean manufacturing systems involving minimum wastage of the resources. The second hypothesis proposed by this study was that, team work significantly and positively impacts as a mediator between engineering education and Lean manufacturing. This hypothesis is rejected. According to the past theory proposed by (Horváth, 2016), team work has nothing to do with lean manufacturing as it is more of a characteristic feature of traditional manufacturing system and engineering education enables' solo workers to work on the lean manufacturing system so, team work has no significant and positive mediating role between these two variables. The third hypothesis proposed by the study was that, "awareness of lean information has a positive and significant mediating role between the engineering education and lean manufacturing." This hypothesis is accepted, based on the conclusion of the research conducted by (Karabulut- Ilgu, Jaramillo Cherrez, & Jahren, 2018), it was proved that without proper lean information no amount of engineering education can significant support the lean manufacturing process. It is because lean information involves the information regarding the lean manufacturing which should involve exact figures in the knowledge of the respective and right people. Being unaware of the advantages and the requirements of the lean manufacturing processes, there is no use of the cutting of the costs involved in the traditional manufacturing process and moving towards the lean manufacturing process. It is accepted that awareness of proper lean information enhances the impact of engineering education on the lean manufacturing process (Newstetter & Svinicki, 2015). The fourth hypothesis proposed by the current study was that, "employee involvement plays a very significant mediating role between engineering education and lean manufacturing. By the evidences from the past study and the analysis of the collected data the study came to a conclusion that, employee involvement really has a significant and a positive mediating role between engineering education and lean manufacturing according to a study of (Lima, Andersson, & Saalman, 2017), employee involvement is necessary where engineering education is to be implemented with respect to needs of the current era, even some companies regardingly train their employees to engage in innovative and current engineering education for the purpose of techniques involving minimum input and maximum output from the manufacturing processes (Martin, 2015). The lean manufacturing is just the right type of process which can give maximum efficiency with the minimum usage and the wastage of the input resources. So, it is proven number of times that employee involvement enhances the impact of engineering education on lean manufacturing (Martínez-Núñez, Fidalgo-Blanco, & Borrás-Gené, 2015).

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VI. Conclusion

The aim of the current study was to now about the relationship between engineering education and lean manufacturing. Engineering education, which provides the organization with the professional practices of engineering and lean manufacturing which is associated with the minimum wastage of resources and this Japanese method was introduced to promote maximum customer satisfaction involving the manufacturing of order based customized products for the customers. Engineering education can impact the lean manufacturing in different ways which will be discussed further in this part. The study incorporated team work awareness of lean information an employee involvement between the engineering education and lean manufacturer as a mediating variable. For the purpose of data collection 250 questionnaires were distributed in the qualified manufacturers of Malaysia. And these manufacturers were identifying from various resources. Through assistances of federation of Malaysians manufacturers and organizations. The collected data was analyzed, and the computed results were that engineering education has a significant impact on lean manufacturing, awareness of lean information and employee involvement significantly mediates between engineering education nd lean manufacturing while, team work has an insignificant impact between engineering education lean manufacturing.

VII. Implications of the Study

This study significantly contributed towards the literature material. This study has provided practical guidelines purely based in the outcomes from the opinions of the Malaysian manufacturers in order to implement improved processes in the lean manufacturing system via engineering education and have enhanced the importance of the implementation of proper awareness regarding lean information the study have proposed a very structured model containing all of the important variables for the improvements of lean manufacturing system. The research method used questionnaires for the purpose of collection of data which has contributed very significantly to the world of lean research.

VIII. Limitations and Future Research Indications

This study was only limited to a specific sector and specific city Peninsular, Malaysia, which proposes that the results of this study can hardly be generalized even in Malaysia. Moreover, the responses might be biased because of the collection of data from only he qualified and potential manufacturers. Future researchers are recommended to fill up the gaps by removing the biasness and removing the boundaries of data collection processes.

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