12. LEAN PHILOSOPHY TO PROMOTE QUALITY INITIATIVES IN ENGINEERING EDUCATION

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Abstract

This paper deals with the implementation of lean philosophy for continuous improvement and development in technical education. Lean management is a highly disciplined process that has helped businesses and services to increase productivity through process design and the elimination of wasted activities and tasks. Nowadays, efforts are being carried out to implement lean management in educational institutions to help them in attaining excellence. This paper provides new direction for implementation of different lean tools in improving the quality of technical education and the expected benefits that can be derived through it.

1. Introduction

Lean principles, which originated in manufacturing, can change the manner in which an organization functions (Bowen and Youngdahl, 1998; Goland et al., 1998; Lean Enterprise Institute, 2003; Swank, 2003; Shingo, 2004; Wysocki, 2004). These principles are known by a variety of synonyms like, lean manufacturing system, lean production system, Toyota production system, etc. and are formally defined as "A systematic approach to identifying and eliminating waste through continuous improvement, of the product at the pull of the customer in pursuit of perfection" (by National Institute of Standard and Technology Manufacturing Extension Partnership's Lean Network). Today, a large number of business and service entities are adopting lean management to improve business processes, and thereby increase productivity and competitiveness while attaining maximum customer satisfaction. The philosophy of lean management started in Japan and specifically in Toyota Motor Corporation (Ohno, 1988; Womack et al., 1990; Monden, 1993; Womack and Jones, 1996; Toyota, 2001; Emiliani, 2004), during mid 1930's and composed of key concepts practiced by Frederick Taylor (1967), Frank Gilbreth (1921) and Peter Drucker (1954) (figure 1. please refer page no. 118).

Lean Philosophy focuses on the minimization of waste of any form. With the cutting edge competition prevailing in the current era, there is a growing need to improve the quality of technical education in India. Therefore, lean principles/practices should be employed in India's educational system due to following reasons:

(a) To increase the efficiency and autonomy of an engineering institution.

(b) To improve the course/syllabus structure content wise.

(c) To improve the way in which technical

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knowledge is imparted to the students.

(d) To attain maximum student's satisfaction.

This paper details the application of lean philosophy (principles and practices) as a continuous improvement technique to improve the quality of technical education. The application of lean philosophy results in higher student satisfaction, minimization of ambiguity in course content, higher job opportunities, better personality development, socially active students, etc. In literature, several research studies have been proposed to improve the educational institute's functioning (Karapetrovic et al., 1999; Donaldson, 2002; Etzioni, 2002; Mintzberg et al., 2002; Pfeffer and Fong, 2002; Aspen Institute, 2003; Ghoshal, 2003) using similar concepts as used in lean management. Emiliani (2004a) implemented the lean philosophy for improving the business school courses. The results obtained by him indicate higher level of student satisfaction. A recent study by Patil et al. (2006) proposed the implementation of six sigma to achieve excellence in the field of education and considered students as client and the quality of learning they achieved as service. This paper will discuss the applications of lean philosophy in improving the functioning of an engineering institution to aid it in imparting better quality education and achieve excellence in all direction.

The rest of the paper is organized as follows: Section 2 provides an overview of lean philosophy of management and its various tools. The implementation of Lean Philosophy for improving the quality of technical education as well as the benefits that can be attained by it, are detailed in Section 3. Finally, Section 4 concludes the article with summary and conclusions.

2. Lean Management

Lean means no or minimum waste. Fundamental to lean thinking is the conversion of waste into customer-defined value (Womack, 1992). In manufacturing operations, lean systems apply the logic of continuous improvement using cross-functional teams (concurrent engineering) and individual employees empowered with information - to identify, analyze, and eliminate wasteful activities in manufacturing processes. Lean Manufacturing reduces costs of manufacturing by improving labor utilization, decreasing inventories, reducing manufacturing cycle times, and increasing capacities without capital expenditures.

Since its advent, lean philosophy has evolved over the time while keeping the base principles intact, in order to align itself with the required business objectives. Essentially, the lean philosophy is composed of various tools called as Lean Building Blocks. Although these tools could be implemented alone, the proper advantage of their application can only be realized when all of them are jointly applied in a sequential manner. The most commonly used lean building blocks are:

- Total Productive Maintenance
- Quick Changeover
- Five Ss (Sort, Sweep, Straighten, Shine and Sustain)
- Quality Function Deployment
- Batch Size Reduction
- Just in Time
- Kaizen
- Policy Deployment
- Root Cause Analysis
- Value Stream maps
- Concurrent Engineering

Table 1 provides an overview of the application of these Lean building blocks. During the last decade, Lean Philosophy and Six Sigma emerged as two, most popular methods for improving productivity and manufacturing quality (Pannell, 2006). Both these methods of continuous improvement have their own merits and complexities (table 2) and must be

implemented to achieve perfection. While six sigma increases productivity through quality improvements and reduces variations in process parameters that affect the quality characteristics of the product, Lean Philosophy improves productivity through process design and focuses on elimination of waste in the process. However, the advantages offered by Lean Philosophy ease of implementation and focus on process improvement makes it more suitable for implementation in technical institutions.

(Table No. 1 & 2 please refer page no. 119)

With the growing demand of customers, there is an increasing need for delivering goods and services at a faster rate and thereby Lean Philosophy methodology is being adapted at an increased pace by both manufacturing and service enterprises. Educational institutions also belong to the category of these organizations where the implementation of Lean Philosophy is being stressed upon to improve the overall quality and achieve maximum customer satisfaction. Next section will illustrate the implementational aspects of lean management in Technical Education system of India.

3. Lean Philosophy Implementation in Engineering Education

The technical education in India is imparted through universities and colleges, approved and accredited by the All India Council of Technical Education (AICTE) which is a statutory body for technical education and works under the supervision of Ministry of Human Resource and Development (MHRD). Most of the colleges/ universities are run by their respective Board of Governors (BOGs), which is a committee having a Chairman of BOG and other stakeholders as well as nominated members. It exercises control through the help of Director and structured faculty members. The engineering curriculum provides a four year program for Bachelor students and two year program for Master students. The programs are generally offered in disciplines of Computer Science, Electronics, Electrical, Information Technology, Mechanical, Chemical, Civil, Mining, Aeronautical, Manufacturing and Metallurgical Engineering and various specializations of these disciplines.

In this paper, the functional areas of an engineering institute have been categorized into three different categories, namely: Infrastructure; Opportunities; and, Vision (as shown in figure 2). The implementation of continuous improvement is essential in each of the aforementioned areas for achieving the goal of lean education. However, the execution of lean philosophy requires high level of commitment. Seven necessary components that must be ascertained before executing lean management program are identified as follows:

1. High Level Commitment of Board of Governors (BOGs)
2. Leadership enforced through Director and faculty members
3. Complete and impartial involvement of faculty, staff and students
4. Continuous measurement
5. Training of Faculty
6. Recognition of needs and sources of improvement
7. Effective communication between all members

(Figure 2, please refer page no. 118)

The coming subsection details various areas in which improvements are required with suggestion of the possible changes that should be made to keep the educational pattern aligned with the goal of achieving a lean education system.

3.1 Infrastructure

Infrastructure of any educational institution can be regarded as a platform. Since no building

can be made strong until it has a sound base, the aim of imparting high quality technical education can never be fulfilled without state-of-art infrastructure. Thus, it is the most important part where improvement is required. This study has categorized the infrastructure facilities into dissimilar groups to gain detailed insights of developments required in each area.

3.1.1 Location and Resources: Location is a prime factor in establishing the industry-institution relationship as well as decides the ease of availability of resources. On the other hand, existence of a reliable, flexible and high quality technological infrastructure with appropriate security arrangements and easy accessibility is a prerequisite for effective imparting of technical education. It is very vital for a student in engineering discipline to be exposed to the state-of-art technology. Lean philosophers also strive to incorporate this principle of continuous improvement (Kaizen) and advocate the adoption of latest technology in technical education for making improvements.

Effective utilization of existing resources to minimize the waste is a vital area for improving efficiency and cost effectiveness of the educational processes. Resources related to teaching and laboratory space, laboratory supervision, research and consultancy, networking, funds, etc. should be optimized to obtain best output. In addition, automation and increased use of computers can lead to substantial reduction in waste and increase the efficiency of faculty and staff members. Further, education should be imparted in an innovative manner making use of available facilities to relate the theoretical concepts to real world applications. Management must identify key resources on the basis of knowledge contributed through them and should make efforts for increasing the usage of under-utilized facilities without compromising with the quality of education. Outsourcing of services like, security, sanitation and maintenance can help the management and planners focus more on improving the core competency of the institution, i.e. the quality of education.

3.1.2 Faculty: The existing technology can only be best utilized when proper instruction regarding the way of its usage is present. The role of faculty can never be undermined while discussing about the improvement in the quality of technical education. In fact, faculty members are the largest contributors to the quality of teaching/learning processes and in building institutional name. Good faculty members are always in short supply. A healthy, participative and accountable management is essential to retain the best faculty. Thus management must appreciate the performance of faculty members and perks should be associated to retain the best ones.

Further, performance appraisal of teachers is a very useful tool for improving teaching effectiveness. The purpose of such evaluation is to help the teachers improve their skills through the feedback provided by the students and remove his/her weakness to increase the satisfaction of students who are the ultimate customers of an educational institution. If such appraisals are done earlier during the course, weaknesses in delivery and lack of interactivity can be removed during the course. For this, informal surveys can be frequently conducted by the concerned instructors to receive the opinion of the students in a timely or just in time manner. This gives them a chance to make necessary changes during the course and incorporate the customer's (students) voice in providing information and thought provoking suggestions. Further, the teachers should respond back to the feedback provided by the students in order to tell them the reason why their suggestions can/cannot be incorporated. This strengthens the student-teacher relationship and makes both of them responsible for shaping the course with current requirements.

3.1.3 Engineering Curriculum: Curriculum is the most important part requiring improvement and probably the most difficult one to be acted

upon at an institutional level due to the continuous review requirements and constraints imposed by the governing authorities like educational board or AICTE (All India Council for Technical Education). The curriculum must be flexible, up-to-date with information regarding modern trends and practices, aligned with popular engineering objectives, and impart the skills of self-directed learning for the purpose of application.

Lean thinkers advocate a comprehensive syllabus as it avoids repetition, provides thoroughness, is simple to understand and reduces variation in interpretation. However, any 'deletions' which reduces ambiguity are always welcome. In Indian scenario, technical education syllabus is more focused towards imparting of theoretical knowledge while practical aspects are ignored, at large. This leads to the creation of a workforce with sound knowledge of the operational principles but unaware of the method of their deployment. 'Policy deployment' in Lean Philosophy suggests for connecting theoretical knowledge with the practical aspects and recommends increased credits for the practical courses. Flexibility should be added in the curriculum through addition of more electives from different disciplines. Recent reports (Deo, 2006) have focused over the dark side of compartmentalization of engineering knowledge. At present, engineering courses are being branched into subfields leading to specialization in a particular direction. However, this increased specialization is also limiting the breadth of knowledge of young engineers in other areas like, human factors, psychology, sociology, economics, finance, etc. In the practical scenario, after few years engineers get promoted to higher levels of management and require management knowledge to simplify their decision making tasks. Therefore, technical education must focus towards imparting sufficient management knowledge combined with technical skills to enable an engineer get competitive edge over peers.

3.2 Opportunities:

The second most important thing that characterizes any educational system or institution is the opportunity that it provides to all those linked through it; whether it be students, faculty and staff members, industry or the common people that live around the institution. Various programs must be initiated by the management for the development of the members of the institution; thereby, the development of institution as a whole. The opportunities that an educational institution can provide are listed below:

3.2.1 Training and Placement: Training of the students, faculty and staff members is important to make them aware of the advances taking place in any discipline. Training must be provided to all the staff and faculty members to hone their skills and increase their productivity and quality. Continuing education must be supported by the management and faculty should be encouraged for it. Frequent visits to other colleges/institutes, seminars, conferences and must be organized for both students and faculty members. It can also prove helpful in retaining good faculty and staff. In addition, placement requirement of the students (who are the ultimate customers) should be given top priority. Knowledge must be imparted to the students keeping in mind their goals i.e. whether the student is inclined towards joining industry, academics or research. Similarly all the students must be exposed to two to three months training in industries so that they can have a clear view of jobs, processes, intricacies, and actions that take place there.

3.2.2 Research and Development: The opportunities of research and development provided by an educational institution can help it considerably in attracting some of the best minds from all over the world in form of both student and faculty. Research contributions mark an everlasting impression on the reputation of an institute. As an example, one can think of MIT (Massachusetts Institute of Technology) holding the glory of being world's best technical institution from long back till now only due to its groundbreaking research findings and abundant research facilities, which helped its management

to retain some of the best faculty members from round the globe. To promote a similar environment, educational institutions must promote research and development activities and encourage faculty members through perks, pay increases, promotions etc. to carry out research activities.

3.2.3 Industry Interaction: Industrial exposure of faculty, staff (lab assistants etc.) and student are extremely important, in order to make them clearly visualize the application of their acquired knowledge. Further, they are benefited by focusing on how the technology is used and not just the mechanics of its operations. Sufficient time, money and efforts are to be spent for industrial liaison cells; which acts as a direct medium/link between the institute and industry. The course structure of students must stress on the industry-institute interaction. Moreover, credit must be given to those, who perform well. Management should also make efforts to arrange lectures on technical know how and expertise, processes and the conditions prevailing in industries by some expert from industries. Faculty members should be motivated to provide consultancy for the benefit of industries and develop strong bond between the institution and industry.

3.2.4 Social Interaction and Development: Social interaction and development is also an important aspect to deal with, in order to shape the personality of the students. Services to community and economy should be made mandatory to motivate the student for solving the problems of local community and unorganized sector. These programs will try to induce social elements into the students instead of only monetary aspects. The students will get opportunities to interact socially with the people of different domains, thereby, improving their social and managerial skills. The interpersonal relations are also enhanced. These activities promote the tendency of root cause analysis among the students and increase their problem solving and team working skills.

3.2.5 Assessment of Students Improvement: The assessment of knowledge acquired by the students should be performed in order to gain insights related to the effectiveness with which the educational policy being practiced is successful in achieving its objectives. It provides a means to the faculty to assess student's performance and provide appropriate help to him. It also aids the student to assess his/her performance and improve accordingly. The assessment must be performed in a timely manner to ensure maximum opportunity for students. Such evaluation can be effectively done through assignments, quizzes, term papers and examinations.

Principle of 'reduction in batch size' advocates for smaller and frequent assignments. In addition, balanced number of group and individual assignments should be given in order to provide equal opportunities to the student for developing team based and individual skills. Finally, lean principle suggests that minor grading opportunities should be provided at frequent intervals through quizzes, assignments, tests, presentations, or minor projects apart from mid and end-term examinations. This induces continuous learning in the students. The evaluation reports must be made available to the students in a timely manner to provide them the opportunity to improve within the stipulated time for which they are enrolled in the course.

3.3 Vision

The vision of an institute reflects its anticipated goals and thereby decides the strategies it will follow to fulfill those goals. Vision is important to decide the functioning of an organization and should be made clear to all its members. Management of an educational institution should facilitate vision development towards achieving academic excellence. An organization can only fulfill its goal if all the members constituting it are committed for attainment of its goal. An organization's goal should be to become lean, autonomous and well performing.

3.3.1 Lean Management: Efforts must be

directed to have the lean engineering education system. This requires careful planning and implementation of lean building blocks or lean tools. The lean principle supports the continuous improvement process or can be interpreted as 'change for better'. The main objective of the lean philosophy is to: (i) eliminate wastes in any form that depreciates the quality of the students and engineering educational system; and, (ii) adopt the methods that add value to engineering education and students.

3.3.2 Autonomy: Each institution as well as concerned authority wants to have increased amount of autonomy. All academic, administrative and financial decisions should be transparently taken with maximum involvement of faculty and staff members. Institutions should plan their activities to minimize financial dependence. In fact, autonomy must be exercised in each aspect whether it is financial, administrative or academic. Continuing education programs and quality improvement programs are to be organized regularly with a clear focus on updating the knowledge of all concerned in it.

4. Summary and Conclusions

This paper discusses the implementation of lean management for achieving excellence in technical education. The benefits of implementing lean philosophy to an engineering institute are manifold, most important of them are listed below:

1. Optimum utilization of resources and facilities and minimization of wasteful activities.
2. Improvement in the efficiency of the educational process.
3. Environment of cooperative learning and development.
4. Achievement of cost efficiency and increased financial autonomy.
5. Improving personality and social skills of the student through community interaction programs and thereby increased services rendered to community development.
6. The resources saved through waste minimization can be further utilized for the development of existing facilities.
7. Continuous improvement in teaching quality and learning objectives.
8. Greater opportunity for academic and professional growth for deserving faculty.
9. Retainment of good faculty.

Although lean education will provide tremendous benefits to students, its successful implementation poses a serious challenge. It requires a committed management as well as dedicated faculty and staff members for realizing the vision and goals set forth to attain academic excellence.

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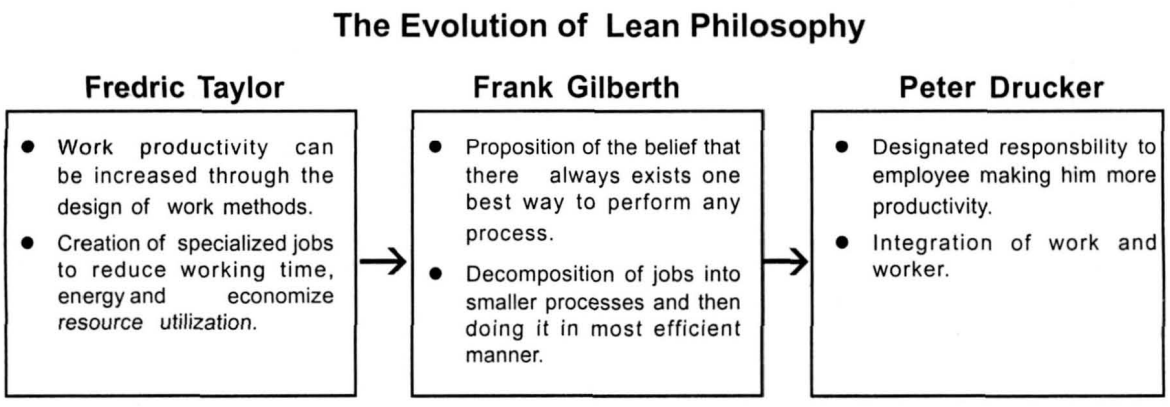

Figure 1 : The evolution of Lean Through the theories proposed by Taylor, Gilberth and Drucker.

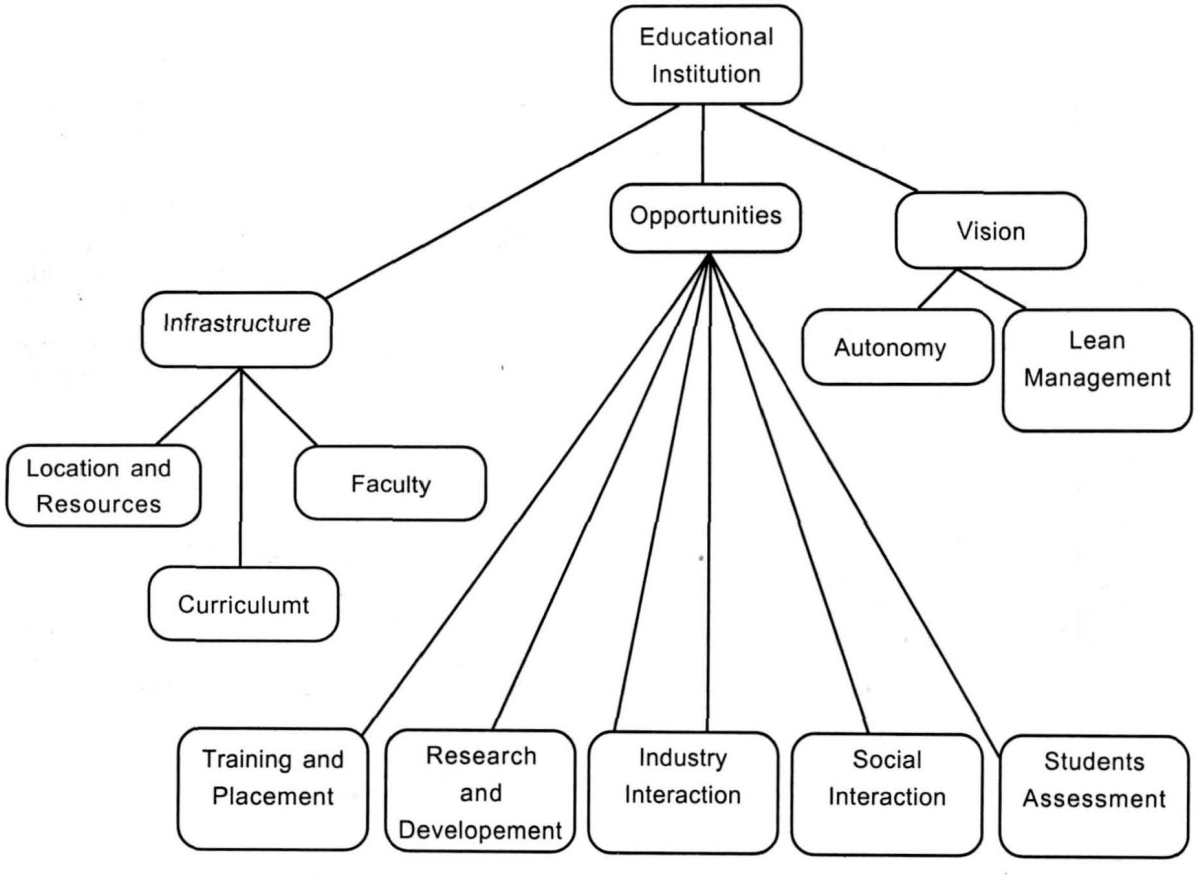

Figure 2: Classification tree of an educational Institution

Table 1: Lean tools and their Application

Lean	Application
Total Productive Maintenace	It is a progressive maintenance methodology that utilizes the knowledge and cooperation of operators, equipment vendors, engineers and support personel to optimize machine performance.
Quick Changeover	This technique increase process flexibility by reducing the amount of time required to change a process from running one specific type of product to another.
Five Ss	Sort, Sweep, Straighten, Shine and Sustain. Used in an integrated manner for maintaining an organized workplace.
Quality Function Deployment	Also known as 'voice of the customer' and wants to incorporate the desires of end customers.
Batch Size	Lean Philosophy supports shorter batch sizes to minimize inventory carrying cost and production cycle and enable the companies to deliver more quickly.
Kaizen	It is the process of continuous improvement. It focuses on identifying and eliminating waste.
Just in Time	In JIT production system, the inputs required by any operation are provided by the preceding operations at the time of need.
Policy Deploymnet	It is used to connect Strategies to objectives and resources for better planning and minimization of waste.
Value Stream Maps	A form of representation of material and information flows used to identify opportunities and eliminate waste.
Root Cause Analysis	These are the tools used to determine the root cause of a problem and include tools like, '5 Whys' and cause and effect diagram.
Concurrent Engineering	This technique supports the use of cross-functional team in an organization and helps in reducing the time to market.

Table 2: Difference between Lean Philosophy and Six Sigma

Lean Philosophy	Six Sigma
Focuses on Improving Time and Efficiency	Improvement in Product Quality
It is a deterministic approach	It is a stochastic approach
Macro level process	Micro level process
Focus on system	Focus on process
Productivity and then quality	Quality and then productivity
Aims Process design	Aim Product design
Reduction in wastage	Reduction in variation
Small Batches	Large Batches