DEVELOPMENT OF A TRAINING PROGRAM IN LEAN MANUFACTURING

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Abstract

Lean Manufacturing is quickly becoming a philosophy adopted by manufacturer's through out the world to cut out waste and improve productivity. Lean is a people-centric philosophy, which focuses on changing the work-culture within an organization and across the supply chain. Thus, training the work force in lean principles is a major part of any lean implementation. This paper presents the development of a lean training program for the Apprentice School at Northrop Grumman Newport News. The instructional pedagogy relies on both classroom instruction and hands-on simulation activity to relay lean concepts to students. The training program is being incorporated into the curriculum at the Apprentice School of Northrop Grumman and at Old Dominion University.

I. Introduction

The adoption of Lean Manufacturing philosophy by manufacturer's worldwide has created a demand for workers who are trained in the lean principles and have an eye for the waste in the value stream [1]. The Lean Enterprise training program is designed to graduate students who are technically qualified in the implementation techniques of lean.

The training program is modular in nature and contains seven modules which can be either used independently or as one cohesive unit. The training program has been developed under the summer faculty internship program offered by Northrop Grumman Newport News. Currently, the work continues under a research grant from Northrop Grumman.

Upon completion of this course, the students will understand the fundamental principles of lean and the value of reducing waste within an organization. They will be

familiar with various techniques for implementing lean on the shop floor including value stream mapping, 5S, cellular manufacturing, interdisciplinary teams, perfect quality and pull scheduling.

A number of organizations have failed in the implementation of lean manufacturing by failing to sustain it [2], [3] & [8]. The energy to sustain often comes from employees who understand the lean principles and have made them part of their daily routine. This training program will help sustain the implementation process by producing apprentice graduates who are versed in the lean principles.

II. What is LEAN ?

The term lean was first coined about 15 years ago at Massachusetts Institute of Technology and later published in a book called *Machine That Changed the World,* written by James Womack and his colleagues [4]. The generally accepted definition of lean in the industrial community is that it is:

"A systematic approach to identifying and eliminating waste (non-value-added activities) through continuous improvement by flowing the product at the pull of the customer in pursuit of perfection."

The lean principles have evolved from the works of Henry Ford and subsequent development of Toyota Production System in Japan. Lean manufacturing principles improve productivity by eliminating waste from the product's value stream and by making the product flow through the value stream without interruptions [1], [4] & [5]. This system in essence shifts the focus from individual machines and their utilization to the flow of the product through processes [7].

In their book *Lean Thinking*, James Womack and Dan Jones [1] outline five steps for implementing lean:

1. Specify the *value* desired by the customer.
2. Identify the *value stream* for each product and challenge all waste.
3. Make the product *flow* through the value creating steps.
4. Introduce *pull* between all steps where continuous flow is possible.
5. Manage toward *perfection* by continuously improving the process.

When lean principles are applied not just to manufacturing but to business operations not only within the organization but across all supply chains, a lean enterprise is created. The training program contains a module on lean enterprise which discuses the issues involved in the transition of a company to lean enterprise.

III. Apprentice School at Northrop Grumman Newport News

Throughout recorded history, apprentice training has served as a vital means of preserving and continuing craftsmanship. In the ancient civilizations of Greece and Egypt, apprenticeships reached a high state of development.

An apprenticeship is a formal training program which allows a person to receive thorough instruction and experience - both theoretical and practical - in the various aspects of a skilled trade. Today's apprentices are fully trained, well-paid men and women acquiring skills and knowledge that will serve them well throughout their careers.

The Apprentice School of Northrop Grumman Newport News offers four-year, tuition-free apprenticeships in 17 skilled trades to qualified men and women. Apprentices work a regular 40-hour week and are paid for all work, including time spent in academic classes. Two optional design and production planning apprenticeship programs are available for selected apprentices after completion of required academics and about two years in craft training. The five-year design program prepares individuals in one of six design disciplines, including hull, machinery design, electrical, piping, ventilation and nuclear design. The four and a half year program prepares individuals for planning positions at various levels within the organization.

IV. Engineering Technology Department at Old Dominion University

The primary goal of the Department of Engineering Technology is preparation of students for both short and long term career success in engineering and technical fields. Our Bachelor of Science in Engineering Technology (BSET) programs are developed specifically for students who desire a technical undergraduate education with an emphasis on solving actual work place problems. These programs provide an exceptionally strong foundation for applications of scientific and engineering knowledge and methods in the work place.

There are two main program alternatives leading to the Bachelor of Science in Engineering Technology and the next sections describe them briefly.

The first program category is for students who are interested in professional practice and licensing as a professional engineer or land surveyor. Three concentration areas for the TAC of ABET BS in Engineering Technology degree programs are:

Civil Engineering Technology (CET) with options in Structural Design, Construction Engineering, and Surveying / Site Development Technology.

Electrical Engineering Technology (EET) with options in Electrical Systems and Computer Engineering Technology.

Mechanical Engineering Technology (MET) with options in Manufacturing, Systems, Mechanical Systems Design, and Nuclear Engineering Technology.

The second program category is designed to meet the needs of those students working in technical fields that do not require a professional engineering or surveying license: the Bachelor of Science in Engineering Technology with a concentration in General Engineering Technology (GET). The BS-GET program is designed for technology fields that require advanced knowledge as a foundation for professional accomplishment, success, and advancement. This includes a wide range of areas such as

maintenance/ operations support, manufacturing, technical management, technical sales, and computer network operations. Current GET options include:

Operations Management Technology

Construction Management Technology

Electromechanical Systems Technology

Computer Network Operations Technology

Geographical Information Systems and Geomatics Technology

V. Structure of the Course

The lean training program is divided into 7 individual modules of instruction as shown in Figure-1. The first six modules provide the theoretical knowledge about lean manufacturing, and the last module incorporates the knowledge base of the first six modules in the form of simulation exercises. First module is designed to provide a brief history of the evolution of manufacturing techniques and the founding principles of lean. It provides the big picture of the lean concepts.

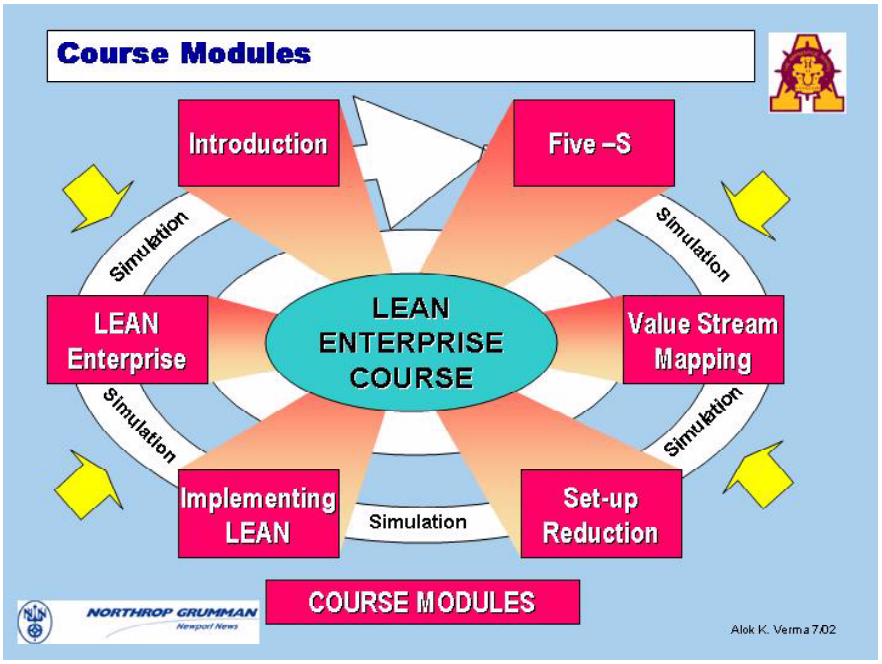

Figure - 1

Modules 2, 3, and 4 deal with specific techniques for implementing lean. These modules can be taught out of sequence. Module 5 deals with the implementation process and module 6 deals with the concept of lean enterprise and the transition from lean manufacturing to lean enterprise.

VI. Delivery Method

The course is instructor-led classroom training combined with in-class simulation exercises designed to invite class participation. This approach aids in the individualized instruction given to the participant. Instructional methods include facilitated discussion, hands-on simulation of production, and on-the-job practical applications. PowerPoint presentations are used to deliver the course supplemented by a series of videotapes from Society of Manufacturing Engineers and Productivity Inc. Students are encouraged to participate in the lean implementation projects.

VII. Simulation Exercises

Simulation has a proven record as a teaching tool. Concepts often hard to grasp are made easy by the use of simulation exercises. Module-7 provides two simulation exercises designed to teach students principles of lean enterprise. The first simulation exercise includes building a model of tugboat Dorothy as illustrated in Figure-2.

During the simulation, students track performance metrics like lead-time, cycle time and throughput while implementing various tools of lean in phases. The second exercise simulates the fabrication and outfitting of an aircraft carrier compartment as shown in Figure -3. This exercise takes into account logistical issues such as inspection reports, engineering reports, getting a drawing from a drawing vault, and employee absenteeism, in addition to fabrication and outfitting. It also involves issues related to supply chain such as delivery lead-time for engines and other components.

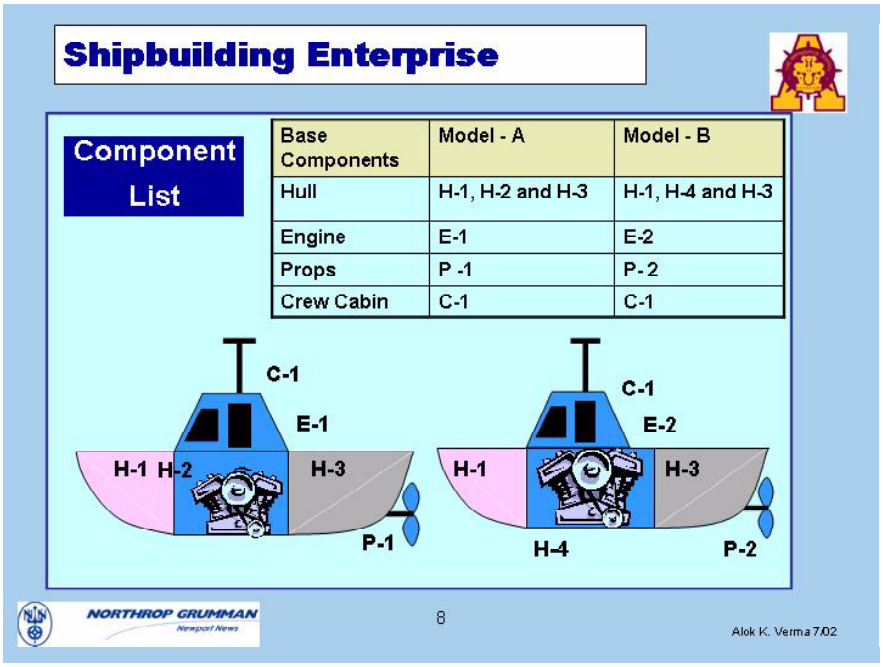

Figure-2

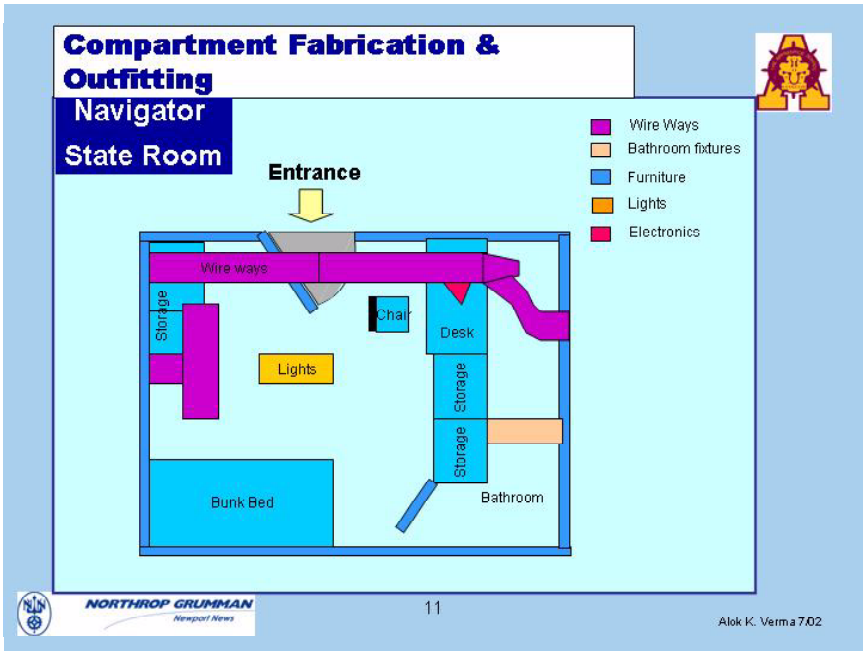

Figure-3

Simulation exercise starts with the traditional manufacturing model involving push system and functional layout. During the second phase, lean concepts like 5-S, standardized work and empowered teams are incorporated. Finally, during the third phase concepts like cellular manufacturing, pull system and point-of-use-storage are implemented. The first simulation activity has been offered in pilot programs both at the Apprentice School and at ODU. Initial feed back from students and faculty are positive.

VIII. Other Course Components

The complete training program consists of:

1. Power point presentations
2. Instructor's Guide
3. Student's Guide
4. Simulation Exercises and kit of parts.
5. Video Cassettes on Lean

Society of Manufacturing Engineering has published a series of videocassettes on Lean manufacturing. These tapes have been incorporated into the training program at strategic locations. In addition, videocassettes on 5S from the Productivity inc. also have been incorporated into the curriculum. These tapes provide real life examples of lean implementation by companies both inside USA and abroad.

IX. Testing the Course Modules

The training program has been tested in Apprentice School classes at both the core and advanced program levels. Student responses have been collected and evaluated. Student and Instructor comments have been utilized to modify the presentations. Student comments indicated positive response towards the program content and method of presentation.

X. Implementation of the Training Program

The Lean Enterprise Course can be either implemented as a stand-alone course or in the form of individual modules in various apprentice school courses. It is recommended that all the modules be viewed in the numeric sequence when used as a complete course. The last module is designed to bring together the knowledge gained in the first six modules and challenge students to apply it to simulation exercises, further enhancing the understanding of lean concepts.

Planning for the implementation of the training program is currently underway. It is envisioned that some of the modules will be incorporated into courses as stand alone units. At least one course will contain the entire training program.

XI. Conclusions

The lean training program developed for The Apprentice School at Northrop Grumman provides flexibility in implementing the training program. Each of the modules can be either used on their own or used together in a comprehensive training program. The program is designed to train students in the principles of lean manufacturing and how an organization can be transformed into a lean enterprise. Student learning is enhanced by examples of actual lean implementations in various industries both in USA and abroad. Hands-on simulation exercises provide understanding of the concepts and first hand verification of the advantages of lean.

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Biography

ALOK K. VERMA

Alok K. Verma is Associate Professor and Director of the Automated Manufacturing Laboratory at Old Dominion University. He received his B.S. in Aeronautical Engineering from the Indian Institute of Technology, Kanpur in 1978 and MS in Engineering Mechanics from Old Dominion University in 1981. He joined the Mechanical Engineering Technology Department in 1981. He is a licensed professional engineer in the state of Virginia, a certified manufacturing engineer and has certification in lean manufacturing. His publications are in the areas of Fluid Dynamics, Advanced Manufacturing Processes, CAD/CAM, and Robotics. His current area of research is development of cost estimation models for non-traditional manufacturing processes and Implementation of LEAN principles to low volume high variety environments like ship building and aerospace. Alok Verma has co-edited the proceedings of the International Conference on CAD/CAM & Robotics for which he was the general chairman. He is active in ASME, ASEE and SME.

JAMES HUGHES

Jim is Manager, Training with The Apprentice School of Northrop Grumman Newport News. He is responsible for academics and administration for the 650-student program. The Apprentice School provides education and training in skilled trades, design disciplines, and production planning. Apprentices complete a four- or five-year program of study and work experience. Prior to joining The Apprentice School in 1985, Jim was an Assistant Professor, School of Education and Psychology, at North Carolina State University. Jim also served as curriculum consultant to the Saudi Technical Development Project for Saudi Aramco and was special projects director for the National Association for Industry-Education Cooperation. Jim earned an undergraduate degree from Middle Tennessee State University, a master's degree from the University of Tennessee at Knoxville, and a doctorate from the University of North Carolina at Chapel Hill.