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THE INTEGRATION OF A LEAN MANUFACTURING COMPETENCY-BASED TRAINING COURSE INTO UNIVERSITY CURRICULUM

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Abstract

The manufacturing industry has become extremely competitive in nature and each company's survival depends on gaining an edge in their respective field. Lean manufacturing has emerged as the leading management philosophy in this struggle. The original model of lean, called the Toyota Production System, is utilized by the phenomenally successful automotive manufacturer Toyota and many others have followed suite. There is a need for a course in schools that offer manufacturing curriculum which will integrate the lean concepts with the current manufacturing program of study. Lean is a proven management strategy and should be offered as a course of its own. Lean can be taught using both knowledge-based and competency-based learning styles. Through the use of academic, simulation, and real life examples these concepts can be understood. This research examines these issues and illustrates an implementation model which can be used to accomplish this goal utilizing these same lean principles.

Introduction

The principles and concepts of the Toyota Production System (nicknamed lean manufacturing) such as the total elimination of waste and continuous improvement (Kaizen), are being used by more businesses to better complete in today's global market (Til; Sengupta; Fliedner; Tracey; Yamada, 2005). Lean manufacturing is a competitive philosophy adopted by many companies to produce cost effective products and services (Allada & Srinivasaraghavan, 2006). It is one of the fastest-growing movements in the quality field, according to Paton (2002). "Success in modern manufacturing directly correlates to how a company handles global competition. Cost effective solutions and practices are much needed to stay competitive in the marketplace" (Allada & Srinivasaraghavan, 2006, p. 1159). The effective application of lean manufacturing techniques in the North American automotive industry is helping to improve performance (Harbour Report, 2004). Consequently, the need is great for employees who are able to participate in, as well as lead, the necessary changes to in order to achieve world class manufacturing status (Drickhamer, 2004). The logical question might then be, "What can be done to address this need?"

Purpose

Therefore, in response to that question, this research outlines the integration of a competency-based training into university curriculum, which addresses the subject of lean manufacturing. The students, in the beginning phase of their career in manufacturing, need access to a quality course that provides not only an academic foundation of the lean manufacturing concepts, but a practical hands-on approach as well. A knowledge-based course working in conjunction with competency-based learning activities would provide students with a unique opportunity to gain a better understanding of lean concepts and how they are incorporated in the manufacturing workplace. An important element for the success of the plan would be the capability of simulating a real world environment as found in the workplace. An ideal setting which utilizes academia for understanding lean concepts, simulation for visual reinforcement, and an industrial setting for actual manufacturing, would be greatly beneficial to the student.

Definition of Lean Manufacturing

Alukal (2003) states,

> Lean is a manufacturing philosophy that shortens the lead time between a customer order and the shipment of the products or parts through the elimination of all forms of waste. Lean helpful firms reduce costs, cycle times and unnecessary, nonvalue added activities, resulting in a more competitive, agile and market responsive company (p. 29).

Taiichi Ohno, a Toyota executive, first identified the seven types of MUDA (waste). Mr. Ohno's beliefs were shaped by his study of the Model T Ford's (1913) continuous flow in final assembly (Epply & Nagengast, 2006). Initially known as the Toyota Production System, the name lean manufacturing was coined by researchers Womak and Jones when they set out to write a book that showed how to create real and lasting value in any business (Womak & Jones, 1990). They noted this manufacturing philosophy focused on doing more and more with less and less and decided the term lean production was an appropriate description of the system. They also stated, Ohno focused on muda, the Japanese term for waste, and he was able to identify seven types of waste and they are:

1. Any human activity that absorbs resources but creates no value
2. Mistakes which require rectification
3. Production of items no one wants so that inventories and remaindered goods pile up
4. Processing steps which are not actually needed
5. Movement of employees and transport of goods from one place to another without any purpose
6. Groups of people in a downstream activity standing around waiting because an upstream activity has not delivered on time
7. Goods and services which do not meet the needs of the customer (p.15)

Why is there such an interest in lean now? The reasons lean is particularly important now include the following winning strategies (Alukal, 2003):

- The need to compete effectively in the global economy.
- Pressure from customers for price reductions.
- Fast paced technological changes.
- Continued marketplace focus on quality, cost and on-time delivery.
- Original equipment manufacturers' (OEMs) holding on to their core competencies and outsourcing the rest.
- OEM requirements that suppliers conform to quality standards such as ISO 9000:2000 or QS-9000 in the automotive industry (being replaced by the international ISO/TS 16949).
- Ever increasing customer expectations.
- The need to standardize processes to consistently get expected results.

According to Alukal (2003),

> To compete successfully in today's economy, you need to be at least as good as any of your global competitors, if not better. This is true not only regarding quality, but also for costs and for lead, processing, delivery, setup, response and other cycle times (p. 29).

Literature Review

The manufacturing workplace has been one of constant evolution. Man's quest to find ever greater models of production efficiency has been ongoing since the beginning of time. Early workforce structures relied on craftsmen to gain skills necessary to create products entirely by one person. This was the norm until around the turn of the nineteenth century when Frederic Taylor introduced a new model – Scientific Management. His method was to break every job down into individual components so that anyone could perform a simple operation, which resulted in less specialization. At this point, specific operational standards were set and each operation was subjected to a time study. A new level of efficiency was discovered and productivity rose. Henry Ford used this model but added an important new concept of his own. In 1913, Ford designed the Model T Assembly Line so that all the processes were in the same sequence as the build. “Prior to this, all manufacturing processes (stamping, welding, etc.) were grouped together creating batch manufacturing” (Epply & Nagengast, 2006, p.1).

Assembly lines in modern manufacturing facilities utilize similar, but greatly updated ideologies which have become known as lean manufacturing. Robert Green (2002), Quality Digest’s editor, points out in his article that this is not a new management practice or concept. Henry Ford actually practiced lean manufacturing in his company. Levison (2002) cites two of Henry Ford’s books, *My Life and Work* (1922) and *Moving Forward* (1930) as references which describe lean manufacturing techniques. “These references are a strong indication that lean manufacturing actually began in the United States decades ago” (Green, 2002, p. 64).

After Ford, the next evolutionary step in lean development was by Taiichi Ohno. The ensuing development of lean, originally known as the Toyota Production System, by Ohno became his life’s work and lasted more than three decades. Although largely ignored by the manufacturing community, Ohno’s ideas did eventually prove themselves with the phenomenal success of Toyota. Lean manufacturing principles are now being extensively adopted by manufacturers world-wide. The present-day need for additional training programs attests the belief in lean as a valid manufacturing philosophy by the manufacturing community at large.

To meet this need, courses are being developed that teach the lean philosophy. Stier (2003) suggests,

> Selecting an appropriate delivery system to teach lean manufacturing concepts may seem formidable because it isn’t some for of technology that can be purchased and infused into the laboratory activities. One instructional approach that seems to be a widely accepted method of improving student learning in today’s educational environment is to actively engage them in activities that simulate theories, concepts and principles that are being presented. Alternatively, lecturing on the subject does not adequately convey the concepts and allow the students to fully understand how this management practice works (p. 2).

Lego has been widely used in teaching a variety of engineering courses with the propose being to show students through hands-on Lego experiences, a variety of benefits from lean production (Self, 2004). Utilizing the traditional batch manufacturing techniques initially, the students were able to assume a range of worker positions within the simulated operation. Through transitional efforts to switch to the lean model, they were able to visualize the concepts of waste elimination and improve work flow. Another popular method of teaching lean manufacturing techniques is through industry.

Collaboration with industries utilizing lean methodologies, has been primarily the only real manufacturing opportunities available. Students at universities in lean courses experience lecture, sometimes the course may include hands-on simulation, and may include interaction with local industry. Some plants provide students opportunities to work on real industrial lean projects. At the Pepperidge Farm in Richmond Utah, students worked closely with a Lean coordinator and front line workers to identify problems, and offer possible solutions in an oral presentation to the Pepperidge Farm Managers (Cook, Fang, & Hauser, 2006).

Methodology

A decision to incorporate lean manufacturing as part of an institution's curriculum must begin with full administrative support. As with the adoption of lean manufacturing philosophies within the workplace, executive leadership support is instrumental in the success of the plan. Development of a lean roadmap will provide a sense of vision that helps to promote the plan (Allada & Srinivasaraghavan, 2006). Figure 1 illustrates a lean manufacturing curriculum implementation model, based on an adaptation of the "enterprise level roadmap" model in Allada and Srinivasaraghavan's article, where the lean philosophy has been utilized in the development process. Note that once all the steps have all been followed from beginning to end, the process proceeds from Phase 7 back to Phase 3, then to Phase 4, Phase 5, Phase 6, Phase 7, etc., to form a unending loop which establishes the "continuous improvement" component of a lean system.

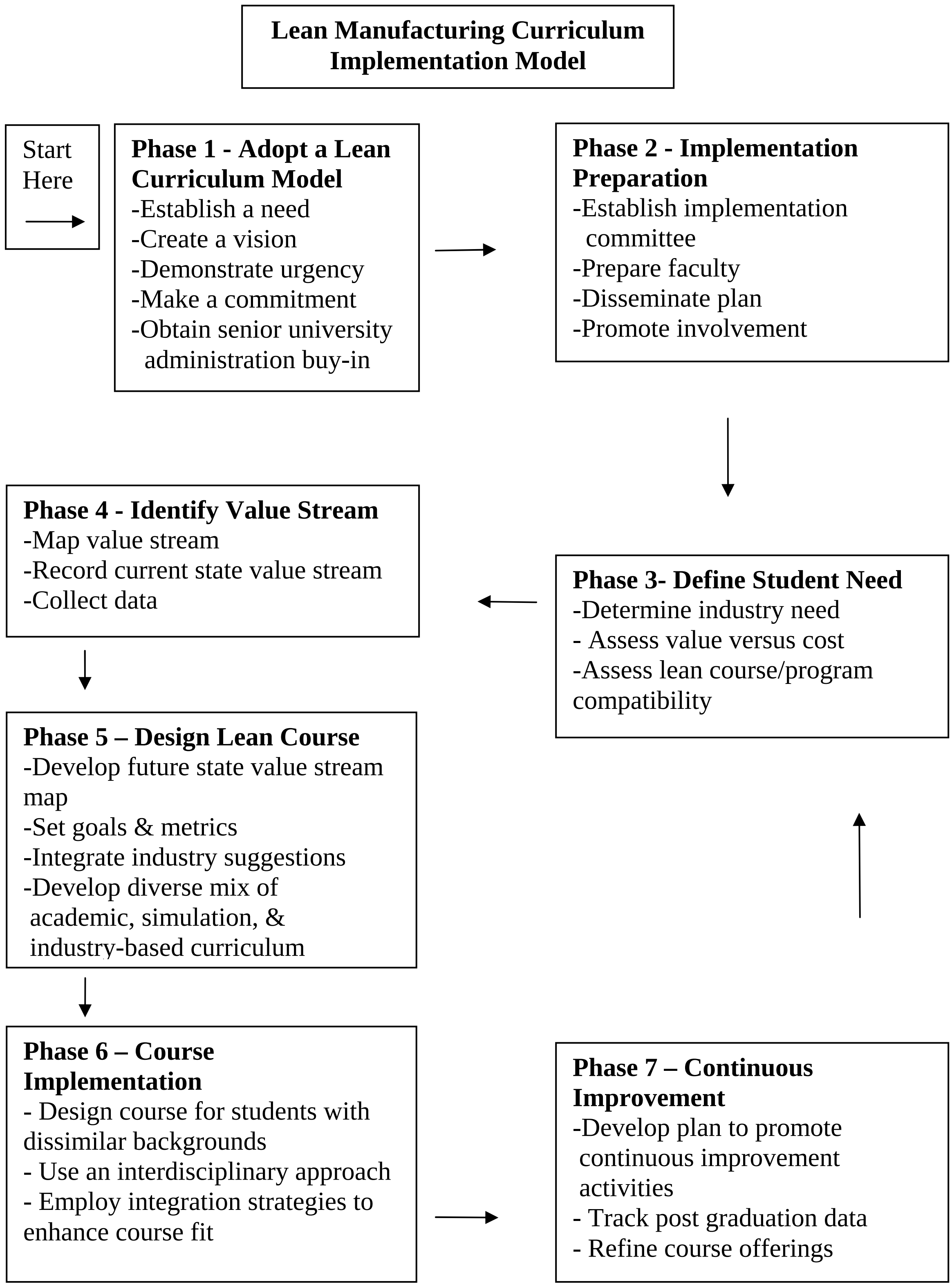

Figure 1 Lean Manufacturing Curriculum Implementation Model

Once the conceptualized model has been established, it becomes the foundation for teaching lean philosophies that serve to complement the traditional batch production ideologies. It may be helpful to see the internal structure of the model to in order to better comprehend the mechanisms of change. The transition is accomplished in a series of phases, each containing multiple steps. This internal structure of the model is now explained by the following list of phases and subsequent steps detailing the intended course of action.

Implementation Model

Phase 1

Adopt a Lean curriculum Model

- Establish a need – survey area manufacturers to establish a rational for implementing this type of course
- Create a vision – describe how lean can be incorporated, in a complementary fashion, into the existing curriculum
- Demonstrate urgency – show why it must be done immediately, i.e., loss of area manufacturing jobs due to global competition
- Make a commitment – allocate resources to see the project through
- Obtain senior university administration buy-in-get a consensus from senior-level administrators to commit to the project

Phase 2

Implementation Preparation

- Establish implementation committee – select faculty members in the manufacturing program to facilitate the project
- Prepare faculty - provide education and training for faculty to teach new course
- Disseminate plan – see that implementation information is distributed to everyone involved in a timely manner
- Promote involvement – encourage participation from all members involved in the implementation process

Phase 3

Define Student Need

- Determine industry need – get specific information from the manufacturing industry as to what type of educational courses will be the most valuable for the student when preparing for a career in this field
- Assess value versus cost – do an analysis comparing the *value of the course* to the *cost for the student*
- Assess lean course/program compatibility – make sure a lean course would be an appropriate addition to the program

Phase 4

Identify Value Stream

- Map value stream – determine the route a student must go in order to complete program requirements

- Record current state value stream – document current order of program requirements
- Collect data - develop longitudinal database on graduation/employment rates, salaries, etc. to support/direct decision-making process

Phase 5

Design Lean Course

- Develop a future state value stream map – generate new student program route that incorporates a lean course
- Set goals and metrics – establish new program parameters to coincide with shifting industry demands
- Integrate industry suggestions – utilize industry management ideas in the development of a lean course
- Develop diverse mix of academic, simulation, and industry curriculum – design a lean course that incorporates a variety of sources and instructional techniques

Phase 6

Course Implementation

- Design course for students with dissimilar backgrounds – develop course that is enhanced by learner diversity
- Use an interdisciplinary approach – utilize implementation strategies that draw from a variety of academic backgrounds
- Employ integration strategies to enhance course fit – the new lean course should complement the existing program courses

Phase 7

Continuous Improvement

- Develop plan to promote continuous improvement activities – create system to identify/advance continuous improvement needs (student surveys, exit-interviews, shifting industry requirements, etc.)
- Track post graduation data - monitor longitudinal database, originally developed in Phase 4, of graduate employment rates, salaries, employer feedback, etc.
- Refine course offerings – based on changing industry conditions, return to Phase 3 and modify lean course as necessary to attain program goals

Using the new lean manufacturing model, senior university administrators would begin at the Adopt a Lean Model phase and work to accomplish each of those goals for a successful implementation. Senior administrative involvement is key to bringing the implementation to fruition. Some attempts at adopting lean fail because of the lack of understanding by the very people responsible for promoting it. This leads to an ineffective promotional effort and lack of support for the idea and consequently poor or failed lean implementation attempts, so early involvement is crucial to success.

Course Survey and Evaluation

Once implementation the lean course has been completed, it is important to assess the status of the lean performance. The lean assessment metrics should have properties similar to the ones listed below (Hallam, 2003):

1. They should be measurable and in-line with the strategic objectives of the student.
2. They should enable control and evaluation of performance.
3. They should aid in understanding the current scenario and help in identifying improvement opportunities.
4. They should be up-to-date and realistic.
5. They should promote students' fundamental knowledge and understanding of lean manufacturing practices.
6. They should help students develop skills with which to provide solutions to problems in the workplace.
7. They should provide give students the capability to be competent in numerous areas relevant to the manufacturing industry.

One of the primary objectives of the course should be for students to gain knowledge comparable to that which they will encounter in their careers. The courses should also be designed to be team-based with the goal of transforming a traditional batch manufacturing operation to a lean-based operation where practical. The intention is to form teams with diverse skill sets like would be assembled in a typical workplace setting. It is important that students understand the traditional manufacturing methodology before they can accurately envision the conceptual framework of the lean philosophy. The course would begin with students learning traditional manufacturing techniques and producing a product in the manufacturing laboratory using these means. Once a thorough evaluation of the current state of the value stream and a baseline had been determined, the lean strategies could be implemented. Student teams would be required to post their observations in a log book as they progressed through the course. Their analysis of the situation, their findings, and recommendations would all be recorded. Evaluation of the team's comprehensive report and final presentation would account for a percentage of their grade and would be based on the following criteria (Til, Sengupta, Fliedner, Tracey, & Yamada, 2005):

- Quality of the current state value stream map generated by the team.
- Value analysis as well as wastes identified, quantified and documented by the team.
- Lean principles incorporated in the team's solution.
- Quality of team's presentation and ability to intelligently address questions and concerns.

Evaluations should come from both the students and industry. The student course evaluation will provide a sense of whether they feel the education they are receiving is going to be useful in their overall career goals, and if not what needs to be changed about the program to make it better. Industry evaluations could provide invaluable feedback as to whether the program is educating students in a manner that meet their needs as potential future employees. Managers in industry have first-hand knowledge of what it takes to be competitive in the global marketplace and are an important source of what the curriculum needs are in this field.

Conclusion

Although some semblance of lean has been around for nearly a century, lean manufacturing concepts are now beginning to be embraced worldwide. Toyota's success in the tough automotive market has proven the strategies of lean to be more than just another passing management fad. The true value of lean is being recognized and there is a genuine need for educational opportunities promoting this management philosophy in the field of manufacturing. Using the implementation model developed in this research will aid in the integration of a lean course into any manufacturing oriented program.

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