Introducing Lean Manufacturing Course to Enhance Undergraduate Curriculum

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Abstract

This paper discusses the development of a new undergraduate engineering course in order to emphasize the subject of lean manufacturing. This course helps students in developing a product in whatever way the customer needs, while at the same time decreasing time and reducing product cost. Such a system teaches the engineer an efficient way to handle product development, while keeping market strategies in view, starting right from inventory until the product is packed off to customers. Finally, it examines all means of reducing costs, and specifically concentrates on eliminating wastes and process improvements, which in turn leads to great profits in the organization.

Key words: Lean Manufacturing, Productivity, and Continuous Improvement.

Introduction

In manufacturing, the ultimate goal of any industry is to compete in the market with higher quality goods that also offer reduced cost. Meanwhile, the specific profit of any given manufacturing industry depends on hundreds of factors, starting from the design engineers, selection of raw material and inventory, and proceeding to the supplier and customer. Continuous improvement of the product is the most important factor in improving overall productivity. The major problem faced by industry today is overall product development, especially relating to how production time affects budget. Continuous improvement is achieved only by implementing lean manufacturing principles into industry.

Attention to lean manufacturing in an undergraduate curriculum will emphasize a cross-functional team effort with better quality, reduced time to market, and higher profits. Lean manufacturing by definition is "a systematic approach to identifying and eliminating waste through continuous improvement by flowing the product at the pull of the customer's pursuit of perfection." The philosophy is to improve the product continuously throughout the factory set up. Overall, lean manufacturing is an integrated process that systematically eliminates waste throughout a given company. [1]

The main objective of this paper is to present an overview of the development of a new engineering course wherein lean manufacturing and product realization are organized sequentially to invent a new program in lean manufacturing. The course helps in the cross-functional, team-based approach and shows how lean manufacturing helps to cut waste, right from the conceptual design up until customer satisfaction is achieved. [3]

The program teaches the student an efficient way to perceive the product, to work with the design component and process line, and then to create the most suitable production process—one that provides a perfect marketing issue for that particular product. Since the internships usually last only one semester, however, there is not enough time for a student to grasp the concepts of lean manufacturing simply through one course of their internships. That is the reason that students should be taught these lean concepts

progressively throughout their undergraduate education so that they can use the concept in other courses such as manufacturing process and Design. The result is rigorous engineering programs that produces well-rounded students who are very useful to industries thus receive better employment upon graduation. [2]

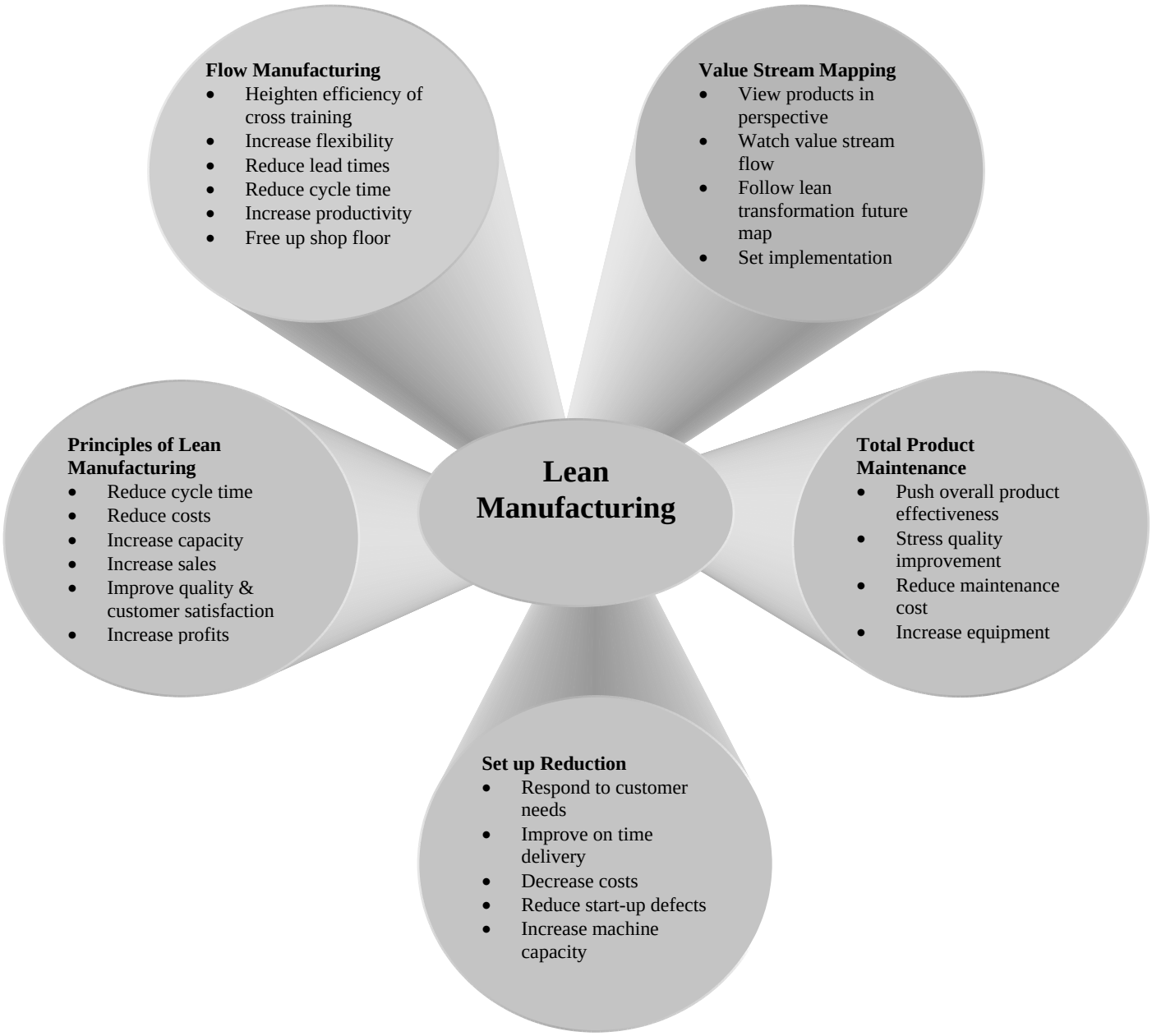

Figure 1: Various Parameters Involved in Lean Manufacturing.

Goals of Lean Manufacturing

The paper recommends implementation of lean manufacturing into an engineering curriculum in order to achieve the following:

- To provide highly skilled employees to the industry and thereby make the companies that hire them competitive in the global market;
- To promote in students a team-based approach in solving problems;
- To provide a given company and its customers a systematic approach by eliminating waste and increasing lead time;
- To enable students exposure to real-time projects in advanced manufacturing fields by providing them the deep concepts in higher levels of lean manufacturing; and
- To allow students to apply the knowledge they gained from these courses in real experience, which in turn reduces on-the-job training.

Presently, a significant number of mechanical engineering students obtain industry experience through the internship program. This opportunity in itself is a valuable tool in exposing students to the working environment. Since these internships usually last only one semester, however, the students lack enough time to grasp the concepts of lean manufacturing simply through their internships. That is the reason for suggesting that students should be taught these concepts progressively throughout their undergraduate career.

The Education Infrastructure

There are several topics covered in the 'Lean Manufacturing and Implementation course'. The objectives of first topic are defining Lean, Lean Enterprise, 5s system, and recognizing lean as a journey and discussing the importance of Lean.

In the second topic some Lean terms, tools, and principles are taught. Some obstacles in implementing the lean and benefits to the organization through the lean journey are summarized. Lean Manufacturing is a transition from a performing process to a

continuously improving process. This requires specific consideration of process flow and bottlenecks, and implicit consideration through “modernization” of process.

The third topic is to recognize the difficulties inherent in a relative uncontrolled process, identifying the process in the simulation, and practice the mechanics and rules of the simulation. At the end of this segment of lean simulation all the bottlenecks and transport complexities are identified. Before starting the next segment of lean simulation, the principles of lean, key concepts, terms such as value, value stream, value stream mapping (VSM), mistake proofing, pull, push flow used when talking about lean are explained. This topic consists of understanding the process, process maps. Learning the five lean fundamentals: Specifying the value, Identifying the value stream by mapping out all the processes and functions necessary for transforming inputs to outputs to eliminate waste, Making value flow continuously after eliminating waste, letting customers ‘pull’ value and pursue perfection by continuous process improvement. The lean simulation second segment consists of mapping the value stream, team discussion to strategize improvements, implementing the changes, and measuring the benefits.

The third segment of lean simulation consists of identifying the real constraints in the system, recognizing the difficulties inherent in the improvement effort, and improving the performance of the system.

The 5S System

In topic 1, students get the fundamentals about how the workplace differs before and after the application of the 5S system.

The whole course is divided into several topics, in which students are taught how to reorganize and resolve real issues occurring in a live workplace. Initially, students are taught within the engineering department, they gradually learn how to apply the concepts, they have learned, within an assigned workplace setting. Specific concepts that are applied include 5s: sort, set in order, standardize, shine and sustain. All the attempts are made to eliminate waste, clean up the given work site, standardize the procedures, and at the same time create a system in which the atmosphere thenceforth can be maintained, controlled and organized properly.

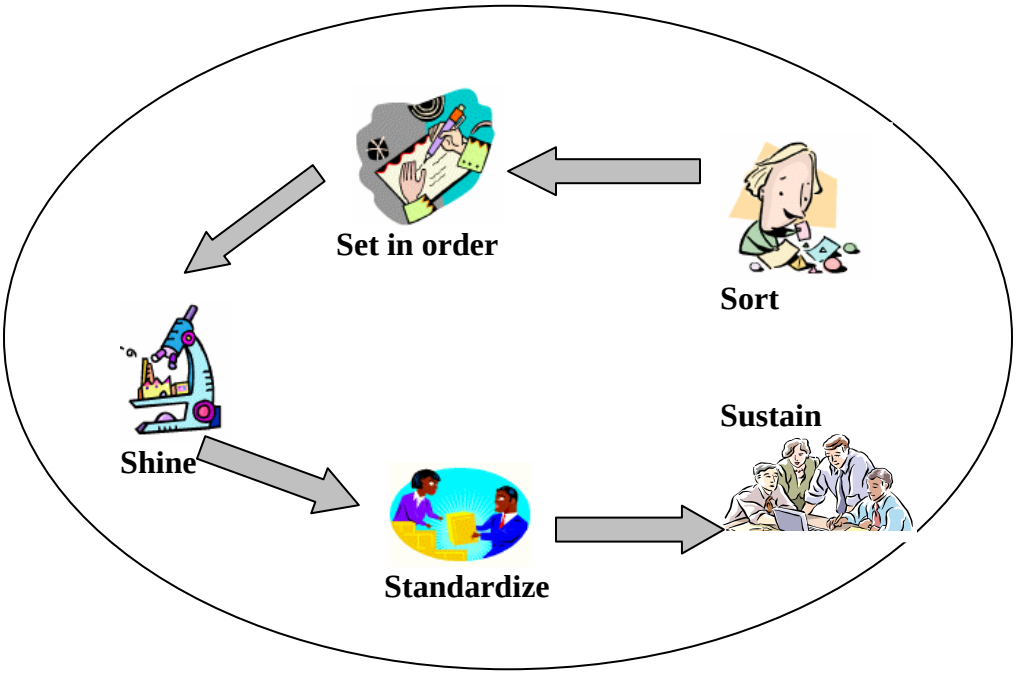

Figure 2: Illustration of the 5s System. [7]

Implementation of Lean Manufacturing

In topic 2, students are trained more in-depth regarding implementation of lean manufacturing principles of real-world problems. In the first phase, students are taught fundamental principles, as well as the significance of the 5s system within industry. Each individual is assigned a particular job, and a one-day workshop is organized, with attention to the principles of lean manufacturing and how to apply them. The workshop include lean concepts such as standardized work, visual signals, continuous process improvement, pull systems, dynamic scheduling, and more Consulting and Value Stream Mapping analysis. [4]

In the workshop, engineers and production workers work hand in hand on the shop floor to implement lean manufacturing while training students to implement lean manufacturing fully and successfully. [5]

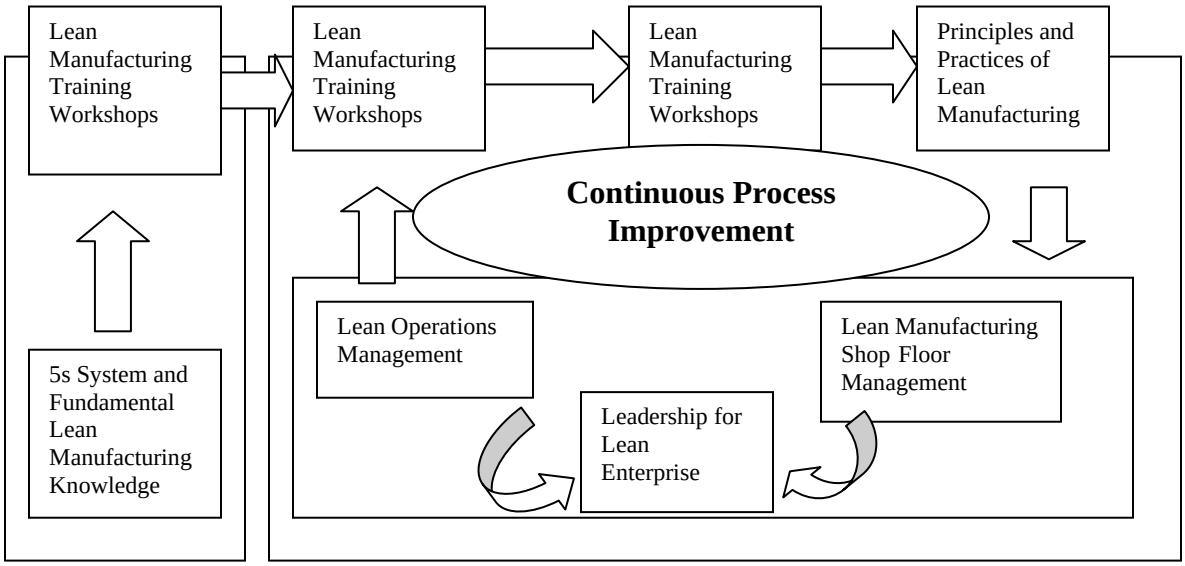

Figure 3: Implementation of Lean Manufacturing.

Value Stream Mapping

Students are trained in value streaming. During this phase, students are required to create a map of an entire value stream. In related workshops, students learn the present or current scenario of the workflow, identify the given places, improve the flow, and eliminate waste. Each team is asked to create its own workflow and to determine its own ways to eliminate waste.

Value streaming is a major step that includes information about flows and wastes. It concentrates on reducing set-up time and increasing lead time, while reducing wait time. The teams now are asked to work cross-functionally and to cooperate and discuss each team's unique way of applying lean principles. The plan then is implemented without disturbing the existing process. [6]

The Implementation Plan outlines what tools need to be applied, when the tools should be applied, who should apply tools, and who will be responsible for ensuring follow-through and completion.

Teamwork and Collaboration

Students will complete the lean manufacturing objectives and will be able to apply all of the concepts and techniques taught to them in an organization. Students will learn how to integrate all the lean manufacturing tools they learned in previous courses and will be capable of acting as team players within any given teams relating to factory design, engineering, marketing, and production

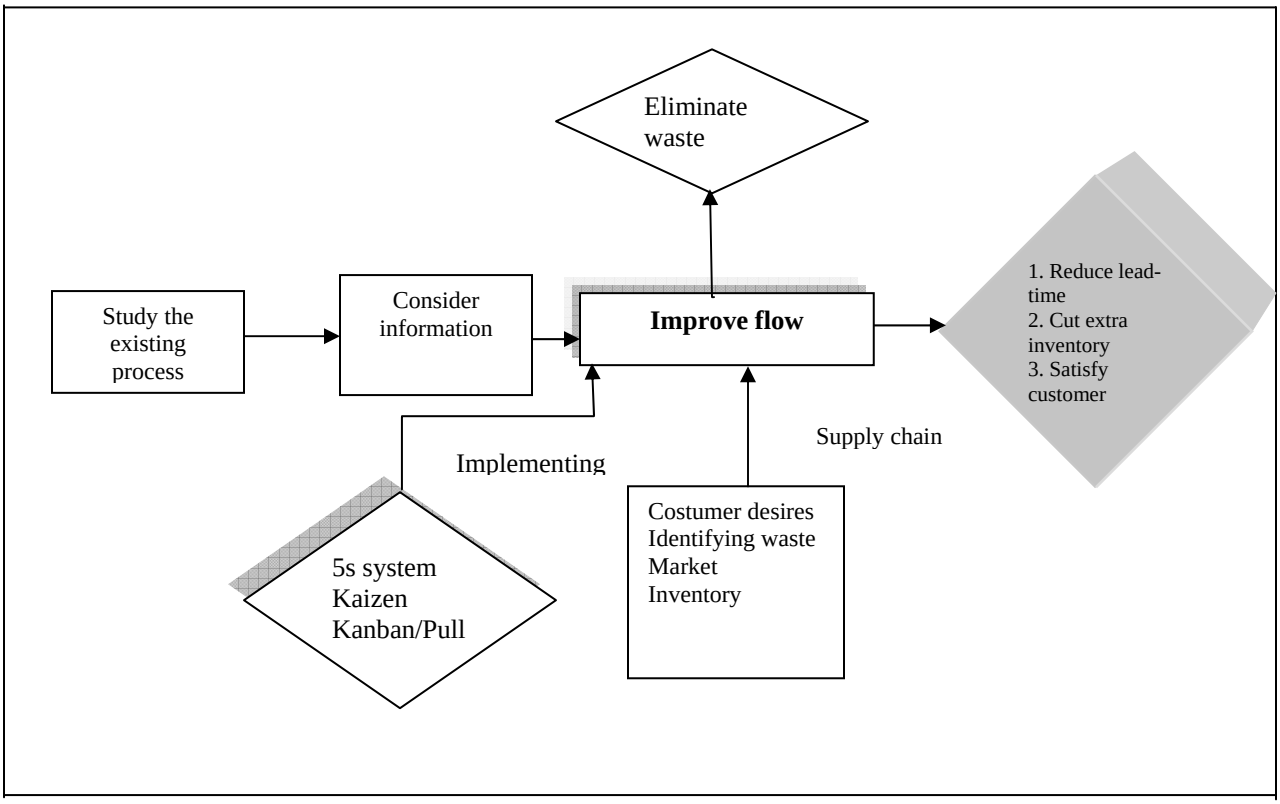

Figure 4: Implementation of Value Streaming.

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The result of new rigorous engineering program developed within the department, produces well-rounded students with a great chances of employment, in an organization, upon graduation. Given this fact, introducing lean concepts into the curriculum is another

step the department has taken in order to better prepare our graduates for a successful future.

Methodology

Lean Simulation

Students are divided into groups, and teams will be exchanged for every simulation. Each team is assigned certain duties such as set-up time reduction, line balancing, flexibility, and bottlenecks are observed, along with the cause for the bottlenecks. The simulations are conducted as a part of the curriculum. This process will help them continuously build the lean concept. Basic lean techniques are introduced in the workshops, and simulation exercises play the most efficient role therein. These simulations give students the real-world experience in which they learn for themselves how to apply the concept.

Using simple examples, such as 'Lean Simulation using Plastic Brick Aero plane model', in this simulation plastic bricks like Lego® are used to create the model of aero plane. The students are divided into groups of four. Each group conducts the simulation separately. In the simulation project each group assembles the plastic group to create the model. Once all the team conducts the simulation, they discuss the bottleneck in the process, sequence of operation, and other factors in order to improve the process. When the simulation was conducted second time the groups were able to come up with more assemblies. In this process of simulation the students learn various concepts of lean manufacturing, DFA. Simulation process makes the students learn by doing the things, finding problem associated with the system and thus improves the system.

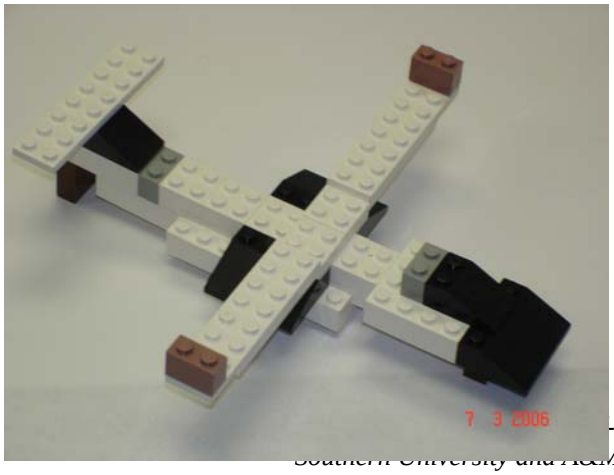

Figure 5: Plastic Brick Aero plane Model

Another simple example is of Lean Factory Simulation Car Kit [8], students learn various ways of manufacturing and analyzing the best and fastest way, the customer gets the delivery. This encourages the team to move from a traditional push big batch, slow response environment, with limited flexibility, to a lean pull, the best practice environment, wherein techniques such as kanban, continuous improvement, set-up time reduction, line balancing, flexibility, quality and low batch size are introduced and tested. After each simulation, the mistakes are discussed in order that the same mistakes are not repeated. Hence, such simulations build overall teamwork capabilities and also create a fun environment. Students learn more and more and at the same time enjoy the work and the course while their skills improve steadily.

Figure 6: The Workshop Simulation Kit. [8]

Now, the designed part can be simplified further and the assembly operation involved can be reduced further, in order to improve productivity vastly, thereby reducing lead-time and eliminating waste. Students are given a particular part being produced, so that they can design the part design software; the various designs then are taken into account and

the best design is selected. The part then is prototyped, using the rapid prototyping machine in the product realization lab. It then is studied in thermal analysis, and the various problems involved in manufacturing the part are discussed.

Conclusion

Introducing students to one of the leading concepts currently being practiced in the industry and therein involves the development of a new course. Presently, a significant number of mechanical engineering students obtain industry experience through the internship program. This is proving to be a valuable tool for exposing students to the working environment. Introducing lean concepts into the curriculum will enhance the internship program by getting students out into the real world faster. If students are provided exposure to lean manufacturing concepts prior to their graduation, the industries hiring them will not need to invest in expert training to educate their new employees. The final result will be more successful graduates and happier employers.

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Mr. Rahul Kulkarni is currently pursuing his M.S. degree in Mechanical Engineering Department of University of Louisiana- Lafayette. He is working on his thesis in the area of Lean Manufacturing.

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Dr. Suren N. Dwivedi is the Professor of Manufacturing in UL Lafayette's College of Engineering. Dr. Dwivedi has been a senior member of SME from 1975. He has worked in various areas of product realization and concurrent engineering for more than 25 years. He was one of the investigators of the Concurrent Engineering Research Center, established in the Department of Computer Science at West Virginia University, and served for seven years as director of the Manufacturing Process Laboratory at Birla Institute of Technology in India.

Dr. Dwivedi teaches the Lean Manufacturing and Lean Enterprise course (MCHE 578). Apart from teaching modern manufacturing techniques, this course gives student a comprehensive look at Lean fundamental of Manufacturing. Dr. Dwivedi will pioneer the enhancement of undergraduate engineering curriculum, solutions and methodologies, as part of the project. He will serve as the Project Director, and the following personnel have agreed to assist him.