Lean Six Sigma Supply Chain Case Study: Breakthrough in Trailer Utilization

Elizabeth Cudney, Ph.D. and Rodney Kestle
Missouri University of Science and Technology
Rolla, MO, USA

Abstract

Real world examples and hands on experience are invaluable resources when instructing the use of methods and tools in a classroom. The instructor may not have access to these resources, thus they can teach only theory and basic examples. Another solution is the use of case studies. Case studies can help enhance the learning experience by allowing the student a role in a real scenario. The "story" of the case study adds life to a seemingly lifeless group of tools. With this understanding, Six Sigma and Lean methods taught with the aid of case studies may help some students better assimilate the tools, since they are presented as a whole. The primary objective of this research is to develop a Lean Six Sigma case study following the DMAIC process in the retail industry. The purpose is to facilitate Lean Six Sigma instruction by providing an interactive case study. The case study will enable the training participants to apply the DMAIC phases by providing data and information on a distribution center.

Introduction

Lean and Six Sigma are powerful philosophies backed by several tools for improving quality, productivity, profitability and market competitiveness for any corporation in a holistic manner. Lean focuses on eliminating waste and improving flow using various proven methods initially pioneered by the Toyota Manufacturing Company under the banner of the Toyota Production System (TPS). Six Sigma methods were first perfected by the Motorola Company and deployed with ferocious gusto by Jack Welch while he was the CEO of General Electric. Six Sigma is focused on reducing process variation using problem solving and statistical tools.

Six Sigma is focused on reducing variation using a problem solving approach and statistical tools. Six Sigma is a customer focused continuous improvement strategy and discipline that minimizes defects and variation towards an achievement of 3.4 defects per million opportunities in product design, production, and administrative processes. It is focused on customer satisfaction and cost reduction by reducing variation in processes. Six Sigma is also a methodology using a metric based on standard deviation. The goals of Six Sigma include developing a world-class culture, developing leaders, and supporting long-range objectives. There are numerous benefits of Six Sigma including stronger knowledge of products and processes, a reduction in defects, an increased customer satisfaction level that generates business growth and improves profitability, an increased communication and teamwork, and a common set of tools.

Six Sigma is commonly credited to Bill Smith, an engineer at Motorola, who coined the term in 1984 [1]. The concept was originally developed as a safety margin of fifty percent in design for product performance specifications. This safety margin was equivalent to a Six Sigma level of capability. Since it's first introduction, Six Sigma has continued to evolve over time and has been adopted throughout the world as a standard business practice.

Lean emphasizes the elimination of waste and creation of flow within an enterprise. Lean's primary focus is on the customer, to address value-added and non-value added tasks. Value-added tasks are the only operations for which the customer is ready to pay. The idea in creating flow in lean manufacturing is to deliver products and services just-in-time, in the right amounts, and at the right quality levels at the right place. This necessitates that products and services are produced and delivered only when a pull is exerted by the customer through a signal in the form of a purchase. A well-designed lean system allows for an immediate and effective response to fluctuating customer demands and requirements. Lean tools that are most commonly used to eliminate waste and achieve flow are: value stream mapping, standard work, 5-S housekeeping, single minute exchange of dies (SMED), and visual management.

When Lean or Six Sigma is deployed independently, only a few companies have shown strong improvements. This paper proposes a synergistic merger of the tools in a Lean Six Sigma case study for course instruction, using the very basic Six Sigma tool of DMAIC process to merge the implementation of both philosophies. An integrated approach to process improvement using Lean and Six Sigma principles is required since both Lean and Six Sigma are more of a cultural change meant to be the way a company does business rather than a one time tool to be used for quick improvement. Without a model to allow merging of the tools, companies will falter in the search of a new quick-fix.

Instructional Method

The growth and recognition of the Lean Six Sigma methodology has led to the need for students to have experience in this area. The development of Lean Manufacturing and Six Sigma courses at Missouri University of Science and Technology was in direct response from companies seeking Lean and Six Sigma experienced graduates. The Lean course is a graduate level course open to masters and doctoral students. The Six Sigma course was developed as a graduate course also available to seniors. In the spring of 2007, Design for Six Sigma was also added to the curriculum as a graduate course with Six Sigma as a prerequisite. All of the courses require a semester team project which employs the course topics. These courses are offered during the course of one semester each which is equivalent to sixteen weeks.

A major disconnect, however, is any congruency between the Lean and Six Sigma courses. The two areas were taught with little overlap to tie the concepts together. For the Lean course there are manageable projects (i.e. 5S, standard work, VSM) that could be performed in conjunction with local manufacturing companies. The tools for a Six Sigma project require considerably more time to collect data and analyze. Therefore, it is extremely difficult to assign a hands-on project for the semester course. This led us to the conclusion that a fully integrated case study would be the most appropriate path considering the short time frame.

The main deliverable of this research is a comprehensive case study in retail which utilizes the Lean Six Sigma methodology. To aid the instruction of Six Sigma and Lean for the supply chain industry, a case study has been constructed that focuses on a breakthrough in trailer utilization. The case study begins with an introduction of the need for the breakthrough and then steps through the Define-Measure-Analyze-Improve-Control (DMAIC) process. Table 1 shows the DMAIC phases and the respective tools. Each phase of the process is discussed along with each tool used. Supporting calculations demonstrate how to use each tool while achieving the breakthrough solution. To help further facilitate the learning process, a table was also created that documents the line between tools from phase to phase, see Appendix. This showed the linkage between the different tools and how decisions flowed throughout the case study.

Table 1. DMAIC Process and Tools

Define	Measure	Analyze	Improve	Control
• Project Charter • Stakeholder Analysis • SIPOC • Process Map • Project Plan • Responsibilities Matrix • Ground Rules • CTS tree	• VOC • Data collection plan • Pareto Chart • Histogram • Scatter Diagram • Process Capability • Process Statistics • Benchmarking • Gauge R&R • Cost of Poor Quality • Current State Map	• Cause & Effect Diagram • 5 Whys • Test for Normality • FMEA • Correlation Analysis • Regression Analysis • Hypothesis Tests • 8 Wastes • 5S • Kaizen	• Quality Function Deployment • Action Plan • Cost/benefit Analysis • Future State Map • Design of Experiments • Main effects and interaction plots • Dashboards/ Scorecards	• Control Plan • Mistake Proofing • Standard Work • FMEA • Training Plan • Process Capability • Statistical Process • Control (SPC) • Standard work • SOP • Lessons Learned

In developing the case study there were three goals. First, the case study will follow the DMAIC framework and will utilize data from a distribution center throughout the case. Next, the case study will be interactive to allow training participants to analyze the given information and apply the DMAIC tools. Finally, the case study will include a facilitator guide and participant questions.

The main learning objective for developing the case study was to facilitate the student in applying the tools demonstrated throughout the Lean Six Sigma case study to perform a project. In developing the case study, several key points for instruction were considered including:

1. write the case study story in a sequential fashion, telling the story how it happened.
2. provide information in the case study story that can be used to complete the tools and simulate the process.
3. provide templates for the student to use the tools.
4. create an instructor guide with definitions, methods, and examples of the tools.
5. provide discussion notes that show completed tools from the case study.

In developing the case study, the key focus was to make the case study both believable and interconnected. To achieve this, a table was created which outlined each phase, tool, template, reference, and deliverable. This was critical to ensuring the case study built off previous tools and tied together. The remainder of the paper is outlined following the DMAIC process, particularly as it relates to the developed case study. Key tools and deliverables will be highlighted to illustrate the effectiveness of the instructional technique. This is followed by a summary of the case study and recommendations for further work in instructional techniques.

Case Study

Define

The purpose of the first phase of the DMAIC process is to identify and refine a process in order to meet or exceed the customer's expectations. The Define phase includes developing the team charter, critical to quality characteristics, problem statement, communication plan, project scope, and goal statements.

The case study was developed to drive down the main learning objective into each of the DMAIC phases. In the define phase, the learning objective is to develop a project charter given the details in the case study.

In this stage the following questions are addressed:

- Who are the team members?
- Have the team members been properly trained?
- Is the team adequately staffed with the desired cross-functionality?
- Has the customer(s) been identified?
- Has the team collected the voice of the customer?
- Have the customer needs been translated into measurable requirements?
- Has the team developed and communicated the project charter?
- What specifically is the problem?
- What is the project scope?

An interesting point to note in the case study is that it is of little use if you ask students to only pull information from the case. The case study had to be constructed so that the students would need to infer some key information and use their judgment based on what they were learning. This stemmed to using Bloom's Taxonomy for selecting the appropriate level of cognition. These levels include knowledge, comprehension, application, analysis, synthesis, and evaluation [2].

The first activity in the case study is for the students to prepare the project charter. At this point in the case study, the students have been provided the background and reasoning for the project, the key individuals involved, the customers, and overall goals. This is a considerable amount of information which requires the students to pull out the critical information and use their judgment since extraneous information has been included. The completed project charter is shown in Figure 1.

Project Name: Trailer Utilization Optimization
Project Overview: In alignment with the company's strategic goals, the Distribution and Transportation Executive team has jointly set an achievable objective to reduce their internal operating costs by 25%. This has translated to a 35% reduction of operating costs in the Midwest

Distribution and Transportation (D&T) region. The Midwest D&T region's Six Sigma team has examined multiple projects that may impact the breakthrough goal and has identified optimizing trailer utilization as a high priority.
Problem Statement: The Midwest Distribution and Transportation (D&T) region needs to reduce operating costs by 35%. Improving trailer utilization has been identified as the quickest way to reduce costs within their direct control. The Six Sigma team needs to analyze the current state of trailer utilization and then suggest improvements based on an optimized process. If the Midwest D&T region fails to show an opportunity to reduce operating costs as directed by the company's strategic plans, the company may not be able to meet its predicted growth.
Customer/Stakeholders: Transportation Personnel, Warehouse Receiving Personnel, Warehouse Shipping Personnel, Driver, Store Receiving Personnel, Vendor Shipping Personnel
What is important to these customers – CTS: Up to date trailer status, Optimized trailer dispatch plan, Open communication of critical or jeopardy events, Realistic process time estimates
Goal of the Project: Reduce trailer use costs by 20-35%
Scope Statement : The project is limited to the Midwest region which Anita Baker and Joe Thompson are responsible. The Lean Six Sigma team will examine and recommend changes to the major process steps for the use of a trailer: dispatch, load, transport, dispatch update, unload. The investigation is limited to the two methods of live unload and drop and hook, which may occur at a vendor, distribution center, or store.
Projected Financial Benefit (s): Based on an operating budget of \$1.5 million, this project will attempt to avoid costs connected with trailer use. The avoidance target is \$0.3 – 0.525 million.

Figure 1. Project Charter

Measure

The purpose of the Measure phase is to develop, execute and verify a data collection plan. Tools that are typically used in the Measure phase are Process Flow Diagrams, Process Failure Mode and Effects Analysis (FMEA), and Measurement System Analysis. The learning objectives in the measure phase include:

1. students should be able to select the necessary tool, and
2. students should recognize the importance of the sequential flow of the method.

In this stage the following questions are addressed:

- What processes are involved?
- Who is the process owner?
- Who are the team members?
- Which processes are the highest priority to improve?
- What data supports the decision? (Metric)
- How is the process performed?
- How is the process performance measured?

- Is your measurement system accurate and precise?
- What are the customer driven specifications for the performance measures?
- What are the improvement goals?
- What are the sources of variation in the process?
- What sources of variability are controlled and how?

In this phase, the students must understand what to measure or validate in order to gather the Voice of the Customer (VOC) and identify Critical to Satisfaction (CTS) characteristics. The students should see that the method uses facts and data to build knowledge which will be used to make decisions.

One of the key tools used in the Measure phase is the Supplier-Inputs-Process-Outputs-Customer (SIPOC) diagram. Further discussion is given in the material such that the students can create the diagram themselves. Using this interactive structure, the students would develop a SIPOC similar to that given in Figure 2.

Suppliers	Inputs	Processes		Outputs	Customers	
(Providers of the required resources)	(Resources required by the process)	(Top level description of the activity)		(Deliverables from the process)	(Anyone w ho receives a deliverable from the process)	
		Requirements			Requirements	
Driver Coord.	Dispatch Plan, Phone, Tractor, Trailer, Driver		Dispatch to Shipping Dock	Dock Location, Trailer at Dock		Driver, Shipping Personnel
Shipping Personnel	Product		Load Product	Trailer Ready to Transport	Leave On Schedule (LOS)	Driver
Driver			Transport Trailer			
Driver	Cell phone	30 min. before arriving at rec. dock	Driver Reports Status	verbal communication		Driver Coord.
Driver Coord.	Dispatch Plan, phone	before product is unloaded	Driver Receives Dispatch Update	verbal communication		Driver
Driver		Arrive On Schedule (AOS)	Arrives at Receiving Dock			Receiving Personnel
Receiving Personnel		LOS	Product Unloaded	Product		Driver, Warehouse or Store

Figure 2. SIPOC Diagram

Analyze

The purpose of the Analyze phase is to develop and test hypotheses about the causes of process defects. Therefore, Hypothesis Testing is a common tool in this phase. In the Analyze stage there are three main questions:

- What are the key variables affecting the average and variation of the performance measures?
- What are the relationships between the key variables and the process output?
- Is there interaction between any of the key variables?

In the Analyze phase, the case study provides sufficient information for the student to 1) decide on the appropriate type of study, and 2) run the necessary experiments. For example, a hypothesis test is necessary to compare the difference in means between to samples. Based on the information given up to this point from other tools such as the cause and effect diagram and process failure modes and effects analysis, the student should decide to run a hypothesis test. Also given in the case study is ample data for the student to pull out the necessary data and perform the calculations. The learning objectives in the analyze phase include:

1. students should be able to design an experiment,
2. students should analytically determine the key variables, and
3. students should develop mathematical relationships between the variables.

An example of how Lean tools are applied in the Analyze phase is with the use of the eight wastes. Throughout the case study the distribution's process flows in terms of information and material have been discussed. Particularly in this section, more discussion is placed on the areas that have waste. The students are asked to complete a table listing the various forms of waste and develop recommended actions to eliminate the waste. Table 2 shows the table the students must complete.

Table 2. Forms of Waste

Type of Waste	Examples in the Case	Recommended Actions
Transportation	Movement to inspection	Perform inspection during unload
Inventory	Excessive inventory	Level load deliveries
Motion	Excessive lifting to reach labels	5S labeling bench
Waiting	Drivers waiting on orders	Kaizen event on shipping order process
Overproduction	Containers pre-shrink wrapped and may not be needed as grouped	Only package when the order is received
Overprocessing	Extra padding added to protect certain products	Determine padding requirement
Defects	Incorrect shipping orders	Auto-populate cells in shipping order
Skill	Dispatch team underutilized in scheduling	Update job roles and provide training

A second example from the case study is the flow in the distribution center. The students are given information in the case study to develop a process flow diagram that can be used later for analysis. The process flow diagram is given in Figure 3.

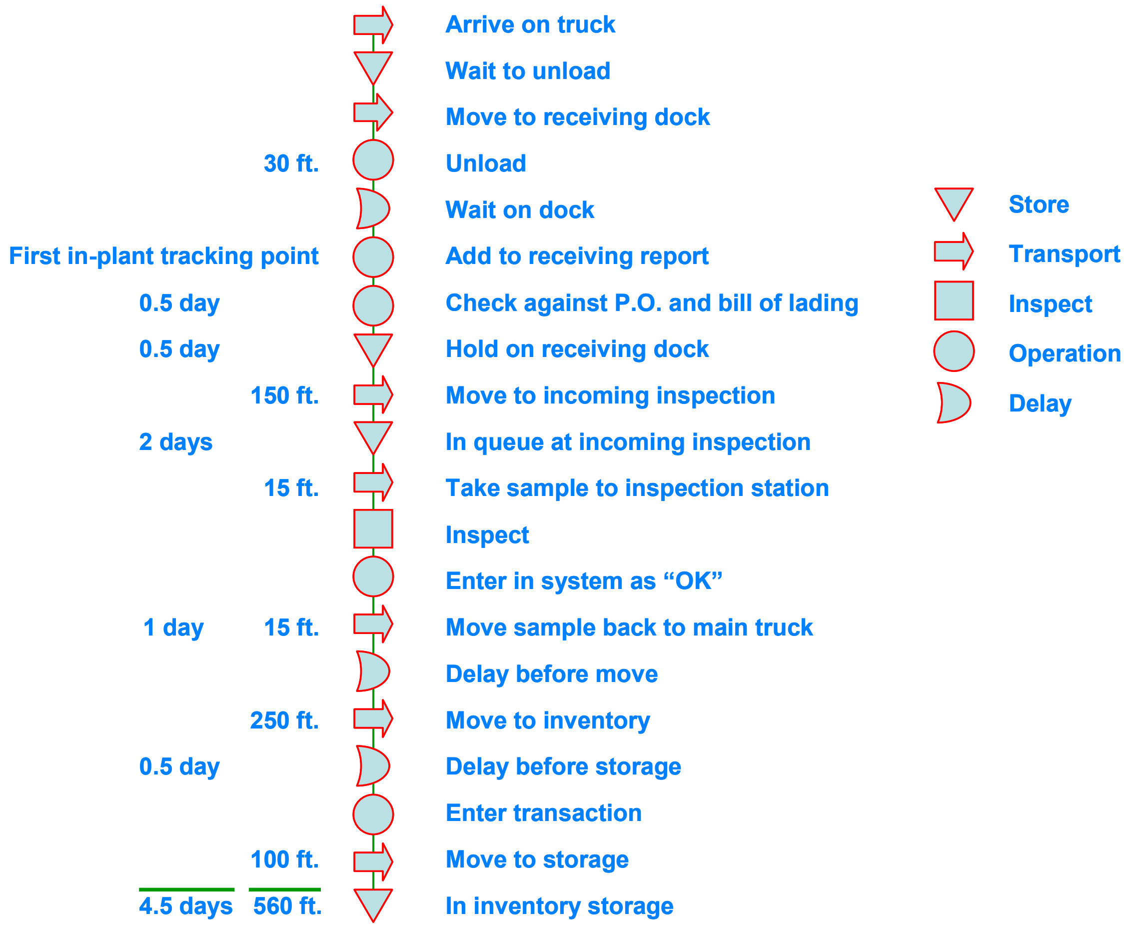

Figure 3. Process Flow Diagram

Improve

The Improve phase focuses on formulating and implementing process improvement ideas. Tools in this stage include Multiple Regression and Design of Experiments. In the Improve phase the following questions are addressed:

- What are the key variable settings that optimize the performance measures?
- At the optimal setting for the key variables, what variability is in the performance measure?

The Improve phase is set up similar to the Analyze phase in that it is imperative for the student to fully comprehend all of the tools at this point to formulate the proper design of experiments. The case study builds upon itself to provide the foundation for the students to utilize the tools for determining the key variable settings. Again, the case study provides the necessary data to perform the calculations. The learning objectives in the improve phase include:

1. students should be able to determine the key variables, and
2. students should analytically determine the optimal setting of the key variables.

In addition to the basic quality tools used in the DMAIC methodology, Lean tools such as the future state value stream map and visual management are critical. The students focusing on reducing variation not only in the process setting but also in the overall process flow. This provides a more holistic approach to the improvement process. Examples of tools from the improve phase are given in Figures 3 and 4.

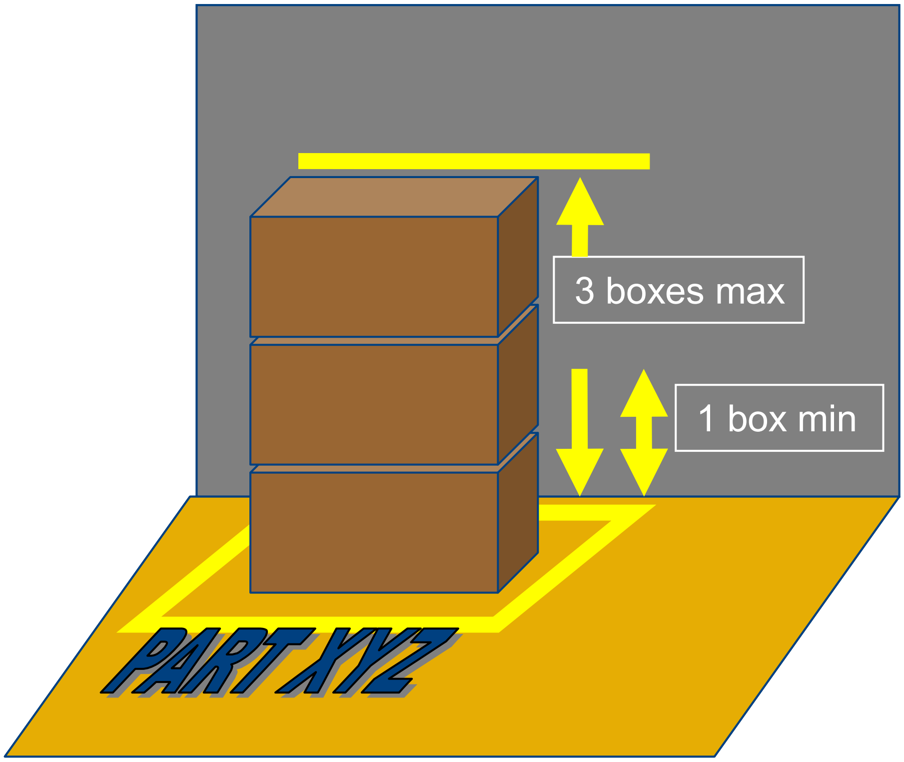

Figure 3. Visual Management Example

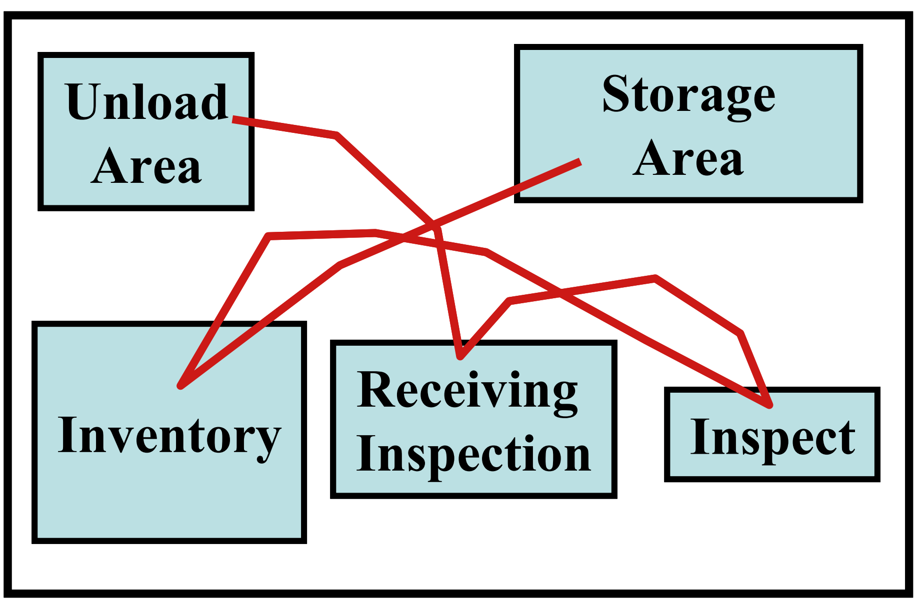

Figure 4. Spaghetti Chart Example

Control

The final phase of the DMAIC process includes controlling and monitoring the process. This stage addresses:

- How much improvement has the process shown?
- How much time and/or money was saved?
- Long term metric.

In the control phase, a strategic approach is taken to ensure the long-term success of the improvements as outlined and developed throughout the case study. Information is given on various costs and times; however, it is up to the student to interpret the results. This final phase is set up as a culmination of the previous phases to finalize the case study. The learning objectives in the control phase include:

1. students should be able to quantify the savings, and
2. students should develop process monitors.

At this phase in the case study the process has been improved. The students now must assimilate their learning to sustain the improvements. Tools such as statistical process control, standard work, and mistake proofing are focused on in the case study to ensure the process continues operating as expected. Additional areas that are highlighted at this point are training plans and lessons learned.

Finally, the case study is summarized and the Lean Six Sigma team move on to their next continuous improvement endeavor. In order to illustrate the nature of continuous improvement, the case study closes by ending this project and briefly showing how the team would move on to their next project. Deming's Plan-Do-Check-Act cycle is utilized to show the importance of continuous improvement.

Summary

Lean Six Sigma is a growing methodology throughout all industries. As such, it is necessary to add the methodology to university curriculums. However, due to the semester time length restrictions and manageability of Lean Six Sigma projects, it is necessary to develop fully supportive case studies to facilitate the instruction. Case studies can be used either throughout the course to further reinforce concepts or as semester projects.

The research outlined in this paper highlights the work performed to develop a Lean Six Sigma case study for classroom instruction. The primary objective was to develop a fully integrated and self-contained case study that would enhance student's learning of the Lean Six Sigma methodology.

References

1. Harry, M., and Schroeder, R., Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations, Doubleday, 2000.
2. Bloom, B., Taxonomy of Educational Objectives, Handbook 1, Addison Wesley, 1956.