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# ADAPTATION OF LEAN METHODOLOGIES FOR HEALTHCARE APPLICATIONS

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# ADAPTATION OF LEAN METHODOLOGIES FOR HEALTHCARE APPLICATIONS

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## Abstract

Lean and Six Sigma quality concepts and terminology have been applied in the manufacturing arena since the late 1980's and early 1990's. It has only been in recent years that healthcare administrators have identified these methods as being adaptable to their organizations so that they may realize organizational improvements for continuing success and delighting customers. Unfortunately, this is not an application that is widely taught in typical Industrial Engineering curriculum and therefore there are few educated professionals coming right out of college that are able to apply these principles to healthcare. There are however, many experienced professionals knowledgeable in the basic Lean and Six Sigma principles as applied to manufacturing. This paper presents research conducted by the IUPUI School of Engineering and Technology in partnership with Sister of St. Francis Health Services (SSFHS) which was focused on the development and implementation of a Lean Six Sigma Training Program specifically for healthcare. Through the development of this training program, Purdue faculty have adapted traditional manufacturing Lean methodologies for healthcare specific applications.

This paper will present multiple examples of successfully adapted Lean manufacturing training for Healthcare organizations. The authors will then present their findings and recommendations concerning Lean training specifically for Healthcare professionals. They will also present in-depth explanations of hands-on exercises used to demonstrate application of lean tools such as value stream mapping, 5S and visual controls that can be used to effectively train employees in most any healthcare organization.

## Lean Introduction

Lean techniques for improving organizational effectiveness are not new. Most of the techniques have been adapted from concepts that have their roots in work

that started in the mid-twentieth century with the Japanese auto making industry. Much of this work was accomplished and published by Industrial Engineers. The concepts we today associate with Lean methods are those that were in direct opposition to the early mass production concepts developed in the United States. Mass production of the early twentieth century was focused on producing high quantities of product without regard for the quality of the product, the input of the workers for improving the product or production process, or for the special needs of the individual users/customers.

What we today call Lean thinking were concepts publicized by James Womack and Daniel Jones in their research done by the International Motor Vehicle Program (IMVP) at the Massachusetts Institute of Technology in the late 1980's. This research highlighted the production system used by Toyota Motor Company in Japan from the 1960's to 1980's which gave them a competitive edge over their U.S. counterparts, Ford and General Motors. Their research highlighted that "The Lean producer, by contrast, combines the advantages of craft and mass production, while avoiding the high cost of the former and the rigidity of the latter. Toward this end, Lean producers employ teams of multi-skilled workers at all levels of the organization and use highly flexible, increasingly automated machines to produce volumes of products in enormous variety. Lean production (a term coined by IMVP researcher John Krafcik) is "lean" because it uses less of everything compared with mass production."<sup>[1]</sup>

Today, Lean methods are being applied to a varying array of organizations beyond the manufacturing arena. Healthcare is one field outside of manufacturing that has begun to use Lean methods with extremely successful results. A 2005 article from the Washington Post (June 3, 2005) titled "Toyota Assembly Line Inspires Improvements at Hospital" highlighted successful use of Lean methods being used to improve hospital operations at the Virginia Mason Medical Center in downtown Seattle. The article highlighted how Virginia Mason applied an organizational philosophy that they credited as being

pioneered at Toyota Motor Company. This was, of course, what has come to be known as Lean methods with a fundamental approach that is focused on elimination of waste – “from paperwork and inventory to waiting-room delays and extraneous surgical tools.”

When applying Lean methods or Lean thinking to an organization, upper management must instill a new Lean organizational philosophy in order to ensure success. Lean thinking is not just learning a set of “tools,” but rather it is learning a new approach to thinking about how to conduct business on a day-to-day approach. Lean thinking includes:

1. Specifying value as action steps
2. Sequencing value-created actions
3. Creating interruption-proof sequences
4. Focus on demand rather than supply sequenced operations
5. Focus on seeking ever more effective performance through learning.<sup>[2]</sup>

Whereas this organizational philosophy is valiant, for the purpose of describing what Lean thinking is to the average worker, it is often taught as the “tools” that have become known as part of Lean thinking. Some of the tools that are taught as part of most Lean curriculums include:

- Value stream mapping
- Use of Takt time and customer focus using pull systems
- Time measurement techniques and cycle time observation
- 5S for a work area
- Development of Pokayokes
- Identifying Waste and elimination techniques
- Development of Work cells
- Creating a visual workplace

It is in teaching and applying these Lean tools that many healthcare organizations have realized organizational improvements resulting in higher employee and customer satisfaction ratings.

## **Typical Lean Applications in Healthcare**

The October 16, 2006 issue of Newsweek reported the following headlines: “Fixing America’s Hospitals”<sup>[3]</sup> and “Perfect Is Possible.”<sup>[4]</sup> The first article brings attention to the urgent need within healthcare to address patient care and safety and make improvements that will save numerous lives. From this article, an underlying connection between manufacturing and healthcare is implied. “For too long, says Truesdell, hospitals have been benchmarking against the average rather than striving for perfection. When Cooley Dickinson signed up to participate in 100,000 Lives, that had to change. “There

was a day when manufacturers expected a defect rate in their products, and we were thinking that way, too.”” Healthcare has made an initiative of reducing defects in their processes and improving customer satisfaction, both signature features of Lean thinking.<sup>[5]</sup>

In “Perfect Is Possible,” the article highlights the movement to “eliminate defects” in healthcare and the programs that have been established to do this. The article begins with the efforts of the Institute for Healthcare Improvement (IHI) in 2000 with the “Pursue Perfection Project” and then details activities of the successor to this program, the “100,000 Lives Campaign.” Key concepts from Lean of “eliminating defects” and the “pursuit of perfection” are the prominent features of these healthcare programs.

During the same time as the Newsweek articles, PBS aired a special documentary series entitled “Remaking American Medicine.”<sup>[6]</sup> This four-week series examined the “quality of healthcare in the United States” and offered solutions by “showcasing the stories of individuals and institutions who are working to ensure better healthcare for everyone.” These and many other stories are forcing us to take a closer look at how we can make improvements in the healthcare delivery system throughout the United States.

Lean applications in Healthcare have recently received a considerable amount of interest and publicity. It is being realized that the tools used to “eliminate wastes” and “continuously pursue perfection” do not strictly apply to the manufacturing plant. Within healthcare, these tools can be used in nursing units, radiology departments, hospital scheduling and registration areas, the emergency department and many more. The tools are real, the benefits are real, and yet so few are exploiting these opportunities – why? Two potential reasons exist: 1) Minimal diffusion of these tools outside the traditional Engineering and Technology (E&T) academic disciplines and 2) an absence of “translation” of the manufacturing language for Lean, Process Improvement, and relevant examples into the healthcare dialect. The development of Lean Six Sigma for Healthcare addresses both issues and provides a model for disseminating the successes seen with this program nationally.

### ***SSFHS Quality Partnership***

As a result of the efforts of Professor Woodward-Hagg, IUPUI the Purdue University Regional Campuses have embarked on a state-wide venture to bring Lean Six Sigma into healthcare by partnering with the Sisters of St. Francis Health Services (SSFHS) corporation. On the academic side, more than 15 faculty members and affiliated researchers from 4 different campuses and

several different academic areas have teamed up to create Lean Six Sigma for Healthcare (LSSHC) training materials, establish a framework for implementing Lean Six Sigma in hospital organizations, and provide project support to the SSFHS hospitals. On the SSFHS side, more than 250 employees at 12 different hospitals in 4 different regions have been trained in LSSHC. They have also established a corporate-wide LSSHC infrastructure to support the program, completed 20 LSS projects throughout the 12 hospitals, and are expected to be self-sustaining by the end of 2006.

From these projects, many opportunities have arisen in which Lean tools and techniques were applied to achieve process improvements. Throughout the projects, the most commonly occurring themes within healthcare also came to the forefront. This information, coupled with the LSSHC curriculum and expertise in developing educational activities, enabled the authors to develop hands-on applied learning exercises or 'simulations' for applying lean tools within healthcare. These simulations are geared specifically toward key areas that the majority of employees could relate to. The simulation activities and intersession deliverables from the training materials also promote deeper understanding of the concepts through active, cooperative, and collaborative learning techniques used in academia.

## **Lessons Learned for Creating Effective Lean Exercises for Healthcare Applications**

### ***Lean Exercise Development***

Hands-on exercises are standard practice for Lean education and training within traditional manufacturing. Typical Lean manufacturing exercises are focused on direct application of Lean principles, such as 5S, constraint management and application of visual controls within a structured classroom setting. Often, Legos™ or other building block materials are used to simulate manufacturing processes. During these simulations, trainee participants are provided processing instructions, building blocks and dice to simulate processing times. Participants receive building blocks from previous 'processing steps' perform the required process per their processing instructions, rolling die to determine processing time prior to passing the building block to the next 'processing step'. Often multi-sided (i.e., 12 or 20 sided) die are used to simulate increased processing time and/or increased variability at specific processing steps. Multiple rounds are conducted with the application of Lean techniques between rounds used to illustrate process improvement. The impact of the Lean 'process improvements' are quantified through the monitoring of defect levels and improved processing times throughout the exercise.

The LSSHC team initially developed training for healthcare workers utilizing standard manufacturing exercises, with minor modifications, such as simplification or elimination of processing steps. The team rapidly found that healthcare professionals find it very difficult to relate to manufacturing based exercises and they were not able to translate process based flows into patient treatment processes. Additionally, it was found that the trainees had a very limited knowledge of basic tools and skills commonly used in manufacturing, including the use of direct process observation, time studies and spaghetti diagrams to identify processing deficiencies.

As a result, the LSSHC team opted to completely retool the Lean exercises to reflect actual patient care situations as well as to teach basic process assessment tools, such as performing cycle time observations, process flow charting and creation of spaghetti diagrams. Also, 'intersession deliverables' were assigned to the trainees that required immediate application of these techniques to improve existing processes. It was found that these requirements not only reinforced lean principles, but also provided immediate positive feedback to the trainees with respect to the ability to make and sustain change within their environments.

Based on the experiences of the LSSHC team, a set of recommendations for creating effective Lean exercises for healthcare applications has been developed. These principles have been tested and have been found to be effective through over 30 iterations across 16 hospitals during a 24 month period during 2005 and 2006.

### ***Recommendations for creating Lean exercises for healthcare applications:***

1. Consider your audience
  2. Introduce basic Lean tools first
  3. Baseline current processes
  4. Require immediate application
  5. Quantify improvements
  6. Recognize the team accomplishments.
- 
1. Consider your audience. This sounds obvious, but exercises should be based on processes that your audience will find easy to relate to. Do not expect your audience to bridge the gap between manufacturing and their work environment in order to understand the principles that are being demonstrated. Additionally, the LSSHC team has found that examples and exercises that more closely mimic actual workplace conditions, rather than generalized 'everyday' situations (making coffee, toast) to be the most effective.

The training goals for the project team should also be considered. Initially, the LSSHC training focused on project teams chartered with improving operational processes. As a result, the exercises that were created reinforced application of Lean tools traditionally used to optimize operational processes, such as 5S, kanbans and constraint management. Gradually, the training migrated to facilitating project teams focused on implementation of clinical practice protocols, such as bundles created for VAP, Sepsis and MRSA reduction. As a result, the LSSHC team has found that exercises should also demonstrate application of lean tools used to validate and improve adherence to these protocols. Examples of this application include the use of visual controls to simplify compliance monitoring for the Head of Bed requirement for the VAP bundle and SMED to improve compliance to barrier and contact isolation requirements.

2. Introduce basic Lean tools first The LSSHC team has consistently found that trainees that are introduced to basic tools, such as 5S and visual controls during an initial training session are much more open to 'complex' Lean tools, such as constraint management, takt time and kanbans in subsequent sessions. Additionally, it was found that the initial training sessions should be focused on identification and resolution of short duration (<10 minute impact) repetitive wastes that can be resolved through the application of the most basic Lean tools rather than extensive process modifications.
3. Baseline current processes Within the training program, the LSSHC team utilized lean exercises to introduce the concept of process improvement through the application of process observation tools such as process maps, cycle time observation, spaghetti diagrams and value stream mapping techniques. The trainees utilize these tools to identify areas of waste as well as quantify the impact of application of Lean principles following improvements.
4. Require immediate application The LSSHC team also repeatedly identified that when trainees were encouraged to apply tools introduced during the training sessions within their own work environments, they were more successful in long term retention and application of Lean tools. The LSSHC facilitator typically allowed one week between the training session and a designated 'report out' session. Each training group was

given a stop watch, multiple process observation worksheets and a digital camera.

The training groups were required to baseline their current processes, identify an area or instance of 'waste' within their processes and apply lean tools to improve the processes. The groups were then encouraged to collect processing time information for the improved process and quantify the improvement, often tying results to cost or revenue impact. The digital camera was used to record processing conditions prior to and following improvements. The groups were required to summarize their results, including pictures, in a 5-10 minute presentation for the report-out session.

5. Quantify improvements The LSSHC team encouraged the trainees to determine the positive cost or revenue impact, in terms of cost savings, productivity increase and/or additional capacity. This could only be accomplished if the trainees were able to quantify their improvements. Process observation tools such as process maps, cycle time observation, spaghetti diagrams and value stream mapping techniques were used to validate and quantify the impact of Lean applications that were made.
6. Recognize the team accomplishments: The LSSHC team found that it was important to require the training teams to bring a short, 5-10 minute presentation of the improvements that were made to the report-out. These report-out sessions are used to reinforce application of lean principles as well as to provide positive recognition of the work done by each training team. Often, if logistics allow, the training teams actually walked through and experienced the improvements on a first hand basis following the presentations.

## **Hands-on Exercises To Teach Lean Principles**

The details of how several exercises were administered are outlined below. These are exercises that have been used and tested extensively by the faculty team and local partnering hospital organizations during 2005 and 2006.

### ***Basic Lean Exercise: Critical Care Supplies/Inventory Exercise***

This exercise is used to introduce basic process observation tools such as cycle timing, process mapping, spaghetti diagrams and time value maps to the healthcare trainees.

### Exercise Setup

Participants are divided into teams. Each team consists of participants assigned to fulfill the roles of doctor, complete the process map, complete the study observation worksheet, and create the spaghetti diagram. Additionally, one participant was assigned to fill the role of Central Supply. Roles are rotated among team members during successive iterations of the exercise.

The facilitator establishes locations for each of the team 'patient rooms'. Patient rooms for a team consist of four rooms, designated by a rubber mat and a patient figurine. These rooms are configured in a hallway type format, with each team allocated 4 patient rooms. Included in each room are four patient information cards. The information cards contain the patients' name, presenting complaint and the needed medical supplies and /or equipment to treat the patient. . Typically use of a large table will work for this portion of the exercise.

Following the room setups, the facilitator establishes a central location for the Critical Care supplies and equipment room. This space should contain all needed critical care supplies and equipment to treat the presenting patients. Typically, the equipment and supplies space of the exercise is located on a smaller table, centrally located from each teams' patient rooms, but may be positioned so that it is difficult for one or both teams to access. An intended equipment constraint is simulated with the use of one thermometer for all teams to use. If the thermometer is not in the in the Critical Care supplies and equipment room it must be located by the 'doctor'.

Prior to beginning the exercise the facilitator places 24" x 36" poster paper on the walls for the team members to use who are completing the map of the process and the process flow chart (spaghetti diagram). There is also one common sheet posted which will summarize the time studies for each team. The team members fulfilling these roles are also given clipboards with paper to utilize during the observation. The time study team member is issued a stopwatch. Upon completion of the first round they are instructed to transfer the clipboard paper to the wall charts.

The exercise is run in three rounds. Team members switch roles between rounds to maximize their participation in the application of each tool. In the first round the critical care supplies and equipment space is stocked with the supplies and equipment in their original packages placed haphazardly on the table. In the second round, the supplies and equipment are still in their original

packaging but organized by type of supplies and equipment on the table. In the third round supplies and equipment are placed in bins which are consistently labeled including a sample of the supply and piece of equipment and color coded. In the third round, 5S is applied in the colored coding, consistently labeling and taping off a space of where the single thermometers should be located.

### Exercise Processing

The exercise begins when the 'doctor' is instructed to go into each patient room in succession and read the top patient card. The patient card includes the presenting complaint and needed critical care supplies and equipment to treat the patient. The 'doctor' then leaves the patient room and goes to the critical care supplies and equipment area to obtain the necessary supplies and equipment.

The 'doctor' brings the required critical care supplies and equipment back to the patient room and leaves them in the room. The 'doctor' then moves to the next patient room. Once the 'doctor' has completed the first four rooms in their 'hallway' they are to go back to room one and treat the second patient in the stack of four cards. This continues until the 'doctor' has cycled through all four rooms in succession multiple times, typically up to four iterations, depending on time constraints.

The team members completing the process map, spaghetti diagram and cycle time observation should observe the process during the first round and map the process steps through the succession of patient treatments, recording information on the poster paper. Upon completion of each round the facilitator records the cycle time observations for each team on a common poster paper on the wall. Team members then discuss the challenges of the round, with the facilitator and team members highlighting challenges, waits, bottlenecks, searching times as indicated by the process observation tools.

Upon completion of the multiple rounds the teams discuss the impact that the changes in the critical care supplies and equipment room would have to the staff satisfaction, work process, work flow and cycle times. Constraint management and lean techniques such as visual controls, and 5S techniques are applied to the exercise process to reduce or eliminate the impact of constraints, reduce the amount of waste and correspondingly increase productivity.

### ***Advanced Lean Exercise: ED patient throughput exercise***

This is a second example of a hands-on exercise that introduces healthcare professionals to more complex lean

tools such as constraint management, kanbans and WIP management.

### Exercise Setup

Team members are given instruction cards representing the roles typically found in a hospital Emergency Department (ED), including registration and admission, triage, charge nurse, ED nurse, ED doctor, specialist, patient transporter, and ancillary services, such as laboratory and radiology. A minimum of 6 team members and a maximum of 15 team members can participate in parallel. Discussion between team members with respect to their assigned role in the exercise is limited to communication between the ED doctor and ED nurse and the patient transporter and charge nurse. Instruction cards also include information about required patient processing, including follow-on processing steps.

Team members are given two die to roll during the exercise, with the average of the roll representing the patient treatment time. Multi-sided die (up to 26 sided die) are also distributed to simulate increased processing time and process variability. A timer is used to track overall patient cycle time.

Cards with a picture of a gingerbread cookie are used to represent 'patients'. Gingerbread cookie cards are multi-colored to represent different patient acuity and processing requirements. A stack of cards is placed near the registration clerk to represent the patient entry point into the process.

Prior to commencing the exercise, the maximum capacity of the ED 'waiting room' and ED 'beds' are set to 6 patients. The players are instructed that once the ED 'waiting room' and ED 'beds' are filled, patients must be held at the previous processing steps.

### Exercise processing

The exercise begins with the 'registration clerk' rolling and averaging the die to simulate patient registration time. Once the processing time has completed, the registration clerk calls the 'patient transporter' to transport the patient to the 'triage nurse'. The 'triage nurse' then rolls the die and averages to simulate processing time and calls the patient transporter to transport the patient to either the ED waiting room or to an ED bed, based on the color of the 'patient' card (patient acuity) and 'bed' availability. The 'patient' card is processed through each step of the ED flow, per the station instructions, until 'discharged'. Upon discharge, the 'discharge clerk' validates that the patient has completed the required processing steps per the gingerbread cookie color and evaluates whether the patient has qualified for 're-imburement'. The team is 'reimbursed' \$1000 for each patient that successfully completes the required processing steps and is debited \$750 for each patient that does not successfully complete each required processing step.

Typically, the 1<sup>st</sup> round ends when 5 patients have been 'discharged' and the processing time as well as the number of patients successfully processed are recorded. The team is also asked to identify the processing constraints, the amount of WIP in queue and cycle time. Additionally, to improve overall understanding of the patient processing requirements, the team is asked to create a process map of the patient flow process.

Constraint management, WIP management and lean techniques such as kanban and SMED are applied to the exercise process to reduce or eliminate the impact of constraints, reduce the amount of WIP and correspondingly increase cycle time. Additionally, visual controls, and 5S techniques are applied to increase the number of 'patients' qualifying for 're-imburement'.

Multiple rounds are conducted with improvements made and quantified through evaluation of cycle time improvements and an increase in re-imburements.

## **Conclusions**

Lean is an effective tool for identifying and eliminating waste from processes. Through our partnership with local healthcare providers, we have adapted traditional lean training and exercises specifically for use in a healthcare setting. Through this process, we have developed a set of recommendations for other Lean trainers interested in adapting and creating healthcare based exercises. We have also described two healthcare based exercises that have been extensively tested with local healthcare partners.

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## **Biographical Sketch**

Heather Woodward-Hagg is an assistant Professor of Industrial Engineering Technology at the Indiana University-Purdue University Indianapolis. She is a Certified Six Sigma Black Belt and a Certified Quality Engineer, . Professor Woodward spent 9 years at Intel as a process and quality engineer and manufacturing statistician within semiconductor manufacturing, specifically in the areas of Photolithography, Plasma-Enhanced and High Density Chemical Vapor Deposition. Prof. Woodward's areas of expertise include in the development and implementation of closed-loop process control systems within high volume manufacturing. Professor Woodward's departmental research concentration involves adapting the quality and continuous improvement methodologies and tools (i.e. Six Sigma, Lean) used within high volume manufacturing for the service and healthcare industries, as well as small businesses. An additional research concentration is the optimization of a performance based predictive cost model for high volume manufacturing of Solid Oxide Fuel Cells. Professor Woodward is currently the director for the Laboratory for Enterprise Excellence at IUPUI (LEE-IUPUI) and leading the effort for development of a statewide, regional campus Healthcare based Lean Six Sigma initiative.

Deanna Suskovich is an Affiliated Researcher at Indiana University Purdue University Indianapolis and a Certified Six Sigma Master Black Belt (CSSMBB). Deanna educates and facilitates Healthcare worker teams in Lean Six Sigma methodology and project execution. Deanna has applied Six Sigma and Lean methodologies in other markets and has worked to adapt them to Healthcare over the last six years.

Jamie Workman-Germann is an Associate Professor of Mechanical Engineering Technology at Indiana University – Purdue University, Indianapolis (IUPUI) and Foundry Educational Foundation Key Professor. She teaches courses in Materials Science, Manufacturing Processes, and Metallurgy. Prior to teaching at the university, Jamie spent 4 years at Allison Transmission Division of General Motors as a Reliability Engineer and Test Engineer for

heavy duty transmissions. Her efforts at Allison Transmission included quality, reliability, and cost reduction studies and the comparison of duty cycles to analyze the effectiveness of in-house simulated transmission testing vs. actual vehicle testing. At IUPUI, Jamie's most recent area of applied research centers around the adaptation and implementation of Lean Six Sigma processes from the manufacturing industry into the hospital healthcare environment and the development of discrete event simulation models for operations within the hospital healthcare system.

Susan Scachitti is an Associate Professor of Industrial Engineering Technology at Purdue University Calumet. Professor Scachitti consults and teaches in traditional areas of Industrial Engineering which include Total Quality Management techniques and organizational change, Six Sigma methodologies, methods engineering, Lean thinking, facility layout, process improvement, and ergonomics. She holds degrees in Industrial Engineering Technology from the University of Dayton and a Master of Business Administration in Management from North Central College. Recent grant work has focused her current research on applications of Lean and Six Sigma principles in Healthcare environments. Prior to working in education, she spent ten years in various engineering and supervisory roles in the telecommunications industry which focused on high volume electronics manufacturing. Her accomplishments include implementation of Total Quality principles including Lean Manufacturing concepts, Demand Flow Technology, self-directed work teams and various other techniques that improve overall process efficiencies within the organization. Also, she held key roles in successfully attaining ISO9001 certification, establishing a benchmark for a self-directed workforce, conducting economic analysis and cost justifications for new manufacturing technologies as well as utilizing various other industrial engineering concepts to reduce cycle times and increase production efficiencies.