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Methods and Skills for Improving Health Care Processes: A Lean Engineering Approach

Marek Gebicki, Amanda Andrikopoulos, Matthew Hume
Department of Mechanical and Industrial Engineering
Montana State University
Bozeman, MT 59717, USA

Lukasz Mazur
Industrial Extension Service (IES)
North Carolina State University (NCSU)
Raleigh, NC 27695, USA

Shi-Jie (Gary) Chen
Department of Industrial and Systems Engineering
Northern Illinois University
DeKalb, IL 60115, USA

Abstract

A need exists for specialists to address the issues of inefficiencies and quality of health care. Industrial engineers might be the best candidates to improve health care systems, but they lack some necessary skills to deal with a hospital's unique environment. This paper describes a process improvement study guided by Toyota Production System (TPS) approach to process improvement at one community hospital's inpatient pharmacy by industrial engineering students. Additionally, this paper reflects on skills of industrial engineers crucial to successful analysis and improvement of hospital operations and skills needed by hospital personnel to improve their own processes.

Keywords
Healthcare, Process Improvement, Industrial Engineering, Lean, Systems Engineering

1. Introduction

For the last several years, the quality and cost of health care have become very important issues. Even though much effort has been put into improving care, statistics show that worrisome problems still exist. The Institute of Medicine estimates that at least 1.5 million preventable adverse drug events (ADEs) occur in United States annually, costing the nation $3.5 billion annually [1]. The true issue is that the price of medical services is continuing to rise and the quality of care provided is not keeping pace [2]. The authors suspect that the fundamental problem is grounded in a shortage of well-trained professionals that possess skills and knowledge required to scientifically analyze and improve health care delivery systems. This paper will present a study performed at one community hospital (CH) with 98 beds by three senior industrial engineering students (Andrikopoulos, Gebicki, and Hume) under the guidance of Dr. Lukasz Mazur and Dr. Gary Chen.

The study was aimed at improving medication delivery processes in the inpatient pharmacy using TPS or 'lean' methodology for process improvement [3-5]. Following the process improvement methodology of lean, students conducted a study about skills helpful to the successful completion of the project and those that they felt they lacked. Finally, skills needed by the hospital staff to maintain changes and make their own improvements are discussed. The skills identified in the paper come from the observations collected during the process improvement study using the participant-observer method [6] and qualitative data analysis using ad-hoc focus group meetings with content experts.

2. Study at Community Hospital

The practical objective of this project was to determine the root causes of medication errors through observation and analysis of the medication delivery system at CH and to suggest process improvements to mitigate errors as well as address efficiency deficiencies and waste. The medication delivery process describes the progression of a medication from prescribing to administrating. The Joint Commission on Accreditation of Healthcare Organizations' (JCAHO) recommendations and the 5 R's of medication delivery (right dose, right medication, right patient, right time, and right route) guided the main focus of the observations and subsequent improvement suggestions. In order to analyze and understand the current medication delivery system and pharmacy operations, approximately 60 hours of observation and conversation with the CH pharmacy staff were spent collecting data. Value stream mapping [3] and problem solving methodology based on Toyota's A3 method [7] were used to visualize, quantify, present, analyze, and consequently identify root causes of process inefficiencies to assemble suggested process improvements. Table 1 describes the results of the study, presenting both the problems recognized, the solutions proposed, and their intended effects. Following the table is a detailed discussion. One important fact confirmed through observation is that mistakes and inefficiencies often result from faults in the process, not the worker [8].

Table 1: Improvement Summary

Problem	Solution	Impact
Lack of standardization	Document standard procedure consisting of current best methods and suggestions based on the study	Less variability between workers, standard time to perform tasks, and fewer errors
High search time when picking	Standard and clear organization of drugs on the shelves; specify shelf location of drugs on a pick list; bigger font on labels	Shorter time and less stress in the medication picking task
Lack of/inefficient use of space	Bigger bins and carts; designated counter space for newly picked medications	Organized picking area and fewer errors in picking and checking medications
Often violated FIFO	Managers communicating the importance of FIFO in pharmacy settings	Fewer drugs wasted due to expiration
No specific afternoon duties	Afternoon duties checklist	More utilized technician and better prepared/organized workplace
Little feedback from co-workers	Feedback incorporated in the standard procedure (e.g. between pharmacists and technicians)	Fewer repetitive errors; faster learning curve for employees

First of all, the lack of standardization in the process manifested itself when technicians picked the drugs to be restocked in a different manner and every pharmacist checked these drugs in his/her own unique way. These dissimilar work methods can cause variability and increase potential for error. As a solution to the non-standardized processes, best practice procedures were collected for certain steps and suggestions were made for others. These procedures were documented and provided the basis for a training session. For example, one best practice documented was that picking should be done alphabetically and drugs kept in this order to facilitate sorting and subsequent checking. Implementation of the recommended standard processes should increase efficiency, decrease variability, and consequently, improve patient safety. Additionally, doing the process the same way each time will provide a starting point for continuous process improvement and quality control.

The volume of pills on the shelves resulted in a large search area when picking and thus, non-value added search time. Small font on the labels for each bin of pills compounded this problem. To combat this issue, students recommended labeling sections of the shelves and indicating the location of the drugs on the pick list in addition to increasing label font size. Time to pick decreased and the potential for picking errors decreased.

Space constraints also affected the picking area. Drugs sat in small bins on crowded shelves. In addition, the working area to pick to and on which to sort drugs was small resulting in difficulty performing

necessary tasks. Crowding of this sorting area was leading to errors and inefficiencies. Students recommended a facility layout redesign to accommodate larger bins and more counter space to facilitate picking and sorting.

In observations, students noted that technicians did not always pick following a first-in-first-out (FIFO) discipline. FIFO is important in pharmacy settings to prevent drugs from expiring before use and being wasted. As a solution, students recommended that management explain the importance of FIFO to technicians and enforce the concept. Once technicians know that FIFO prevents medications from expiring and subsequent waste, they will likely take more care to follow it.

Observations revealed that while the morning duties were specified, afternoon duties were not. The lack of structure resulted in idle time because technicians did not know what else they could do. As a solution, afternoon duties were made into a standard daily checklist that technicians initial as they finish tasks to minimize idle time and keep the pharmacy running as smoothly as possible. CH employees are motivated to work but need guidance about what to do.

Finally, communication and feedback were not common when errors occurred. For example, when pills were not in the correct place on the shelves or a pharmacist discovered an error when checking, the discoverer of the error often solved the immediate problem with no further investigation or communication. The standard procedure developed incorporates some feedback steps to ensure that communication occurs. The communication is intended to reduce repeating errors and raise awareness about their prevalence.

3. Industrial Engineering Skills

The study had a positive response from CH management and can be perceived as a success. Consequently, the data analysis based on ad-hoc focus group meetings with content experts led to the reflection on skills that allowed the students to complete the study and on those that the students did not possess but would have improved the study's outcome.

3.1 Helpful Skills that Industrial Engineers Students Possess

As industrial engineers, students following the TPS methodology for process improvement possessed three helpful skills: systematic thinking, visualizing, and systems thinking. First of all, industrial engineers learn to think systematically. They are taught to break problems into small pieces and identify objectives. Engineers develop problem-solving skills throughout their curriculum. The lean methodology was used in the process improvement study to facilitate systematic thinking. Paralleling value stream mapping methodology but tailored to the hospital industry, it breaks the system into manageable pieces for low level, standardized data collection and then places these manageable pieces into a high-level visual map. Apart from using the lean methods and tools, which guides systematic thinking, the students inherently possess this skill. As demonstrated in this study, the students used it to iteratively progress through the improvement process. For example, students met weekly to discuss progress and update next steps in view of an overall project plan.

The data collected via observation and conversations at the front line was used to map the entire process. Mapping employs a second useful skill to a person trying to improve the hospital operations, the ability to visualize a system and its subcomponents. Visualization includes understanding the flow of a process from start to finish by means of diagrams, maps, and flowcharts. Throughout the study, students drew flowcharts of the drug flow in and out of the pharmacy separate from the maps in order to understand inventory issues.

Systems thinking is the set of technical skills that allows one to most knowledgably make improvements in light of the big picture (i.e. the entire system). When decisions are made to improve specific tasks, a systems thinker must understand how the suggestion would affect other interrelated tasks. Decisions should be made that will improve the entire system. For example, systems thinking was used when scheduling restocking times for the restricted access drug vending machines on the hospital floor. When optimizing the pharmacy schedule without considering other departments, the restocking process conflicts with nurses who are administering medications and heavily utilizing the machines. By restocking at a different time, congestion is drastically reduced. Therefore, a schedule that is suboptimal for the pharmacy is optimal for the whole system.

3.2 Skills that Industrial Engineers Students Interested in Health Care Should Develop

There are two categories of skills found to be potentially underdeveloped in industrial engineers: qualitative research techniques and cultural/people observation skills. There is little mentioned about qualitative research or, more precisely, obtaining and analyzing qualitative data in most undergraduate industrial engineering programs, as engineers are mostly comfortable with quantitative data. Knowledge of qualitative research techniques is important in process improvement because the process to be observed includes not only equipment and products, but also people. In order to improve the process, good data must be gathered, and to obtain reliable data, qualitative research techniques must be used.

In the hospital study, students were told to participate in and observe the process using the guidance proposed by Atkinson and Hammersly [6] to obtain needed information such as the flow, batch sizes, time it takes to complete a particular task, or type and number of errors occurring during the process. This task proved to be very difficult without comprehensive training on the participant-observer method. All three students had different approaches to carrying out interviews and collecting data from observation which resulted in varying responses. For example, questions were phrased dissimilarly and asked in a different order by each student causing responses that could not be compared. The lean method and tools helped to organize data so that it could be combined, but because much of the information was subjective, there were many discrepancies between the students and additional effort had to be made in order to arrive at the reliable result. What is more, much of the analysis was done on the quantitative data, while the qualitative data was only discussed, but not formally analyzed, thus making conclusions on the qualitative part weaker.

The previous paragraph describes some difficulties and shortcomings of the study which came from a lack of knowledge about gathering and analyzing data on and from people. The analysis of data from weekly ad-hoc focus group meetings with content experts showed how observations and analysis should have been performed to get reliable data and correctly analyze it. First, students feel that the initial period of the study (a pilot study) should have been more participative in order to build a relationship with the observed person and become acquainted with the process and environment. Then gradually, the observer should move toward a direct observation technique where the observer does not disrupt the process so that the natural process emerges. Secondly, good preparation is needed before observing in order to capture the most important facts. After the pilot study, there must be an agreement on the verbiage of questions, criteria for evaluation, and the boundaries of the tasks. Finally, qualitative data analysis differs from the quantitative analysis and requires training so that valid conclusions can be drawn. For instance, data on employee attitudes about the process could have been better analyzed by categorizing responses. Doing this analysis correctly would result in better conclusions and stronger recommendations.

The second important skill in the CH study was the talent to notice, understand, and be able to describe people and the culture within CH and more specifically in the inpatient pharmacy. While part of this deficiency comes from the inability to perform good qualitative research, perhaps part is the insufficient practice in industrial/organizational psychology. While it is not necessary to get a psychology degree to be able to improve processes within the hospital, it may help to understand several concepts such as health care organizational structure, attitudes and behavior, work motivation, teamwork, training or leadership. Without this knowledge, it was difficult to understand differences in people's mentality and conflicts within them, and how they affected their performance. It was also difficult to clearly define communication networks and flaws in them.

4. Health Care Process Improvement Necessities

While trained professionals can suggest improvements, recommendations must be implemented and maintained in order to have a significant impact. Ingredients required to implement and sustain improvements by hospital staff include two categories of components: foundational elements (e.g. organizational culture) and skills that hospital staff should develop for continuous process improvement.

4.1 Foundational Elements

Organization cultural and foundational elements must exist for lasting improvements. These elements include emphasis on reporting improvement suggestions over errors within clear communication channels, understanding and accepting standardized processes, and management involvement.

Clear communication channels for error and improvement suggestion reporting require psychological safety. Edmondson [9] showed that psychological safety enables willingness to engage in problem solving behavior because improvement efforts are inherently risky and can have negative consequences for the person who raises the concerns. Nembhart and Edmondson [10] showed that leader inclusiveness – words and actions exhibited by leaders that invite and appreciate others' contributions – can help health care people and teams overcome the inhibiting effects of psychological safety, allowing members to collaborate in process improvement. At the time of the study in the CH, there was no clear standard for reporting errors or improvements. For example, pharmacists checked technicians' work before delivering drugs to the hospital floor, but did not always inform the technicians of mistakes. Clear communication channels would encourage constructive feedback in this situation.

Another foundational element is creating a culture that understands and accepts standardized processes. Lack of standards or no standards makes it difficult to pinpoint system inefficiencies. Standards also ensure safer systems, since employees would be sharing the safest and most efficient way to do things. If best practices are not standardized, they will be lost when employees leave or management changes. However, standards are useless if not followed. Institute of Medicine found that one of the main reasons for medication errors was not following standard procedures [11].

Finally, management involvement is necessary for encouraging continuous improvement of the system. To find improvement opportunities also requires management to be in touch with the process and to be able to relate to employees when opportunity for improvement may be presented. One suggestion for keeping management in touch with the process taken from the TPS is termed "Go See." Management should take initiative to look at the process. Students suggest that management participate in the process routinely in order to identify potential improvements. Tucker and Edmonson [12], one of the leading researchers in the field of health care process improvement, suggests that health care professionals are likely to engage in improvement efforts if managers are physically present on the floor, have a reputation for "safety" and "improvement" and have the time needed to devote to such efforts.

4.2 Skills that Hospital Staff Should Develop for Continuous Process Improvement

Ideally, hospital staff would introduce the improvements themselves. In order for hospital staff to conduct their own improvement efforts, they need the following: problem solving training, mapping training, the skill to approach problems at different levels of detail, and management skills.

Currently, problem solving is focused on the problem of the moment. For instance, one student observed a technician discovering an unidentified pill mixed into a box for another pill. To solve the problem, she simply put it where it belonged. While solving the problem at hand, no one else was notified of the problem. It should be noted that the technician was correct in solving the immediate problem but should have taken the issue one step further to identify root cause and prevent the issue from reappearing. Therefore, employees need problem solving training which would include a crash course in problem solving techniques, such as the five why's, and a discussion of the proper communication channels when solving problems.

Mapping training encourages the use of a standardized tool to communicate and investigate problems and guide improvement efforts [13]. A powerful tool for managers, mapping enables approaching problems at different levels of detail which is important because issues often affect different areas. Without mapping, one area might solve a problem in a way that negatively affects other areas. Looking at the big picture and zooming in and out for levels of detail facilitates a deeper understanding of the general process.

As in all organizational changes, support from management is essential for success. However, management must have management skills in order to provide the correct support. These skills include leadership, the ability to communicate effectively with different types of employees, and the ability to develop workplace networks and bonds among employees. Management skills also help to create the atmosphere for the foundational elements discussed earlier and are therefore indispensable to improvement efforts.

5. Conclusion

This paper presented a study performed at a community hospital aimed at improving medication delivery processes in the inpatient pharmacy. Based on qualitative data analysis guided by the expert on this particular process improvement study and research, students were able to suggest a set of skills of industrial engineers needed to successfully improve this hospital's operations. This set includes systematic thinking, visualizing, systems thinking, qualitative research techniques, and cultural observation skills. Additionally, foundational elements and hospital staff skills were identified to help sustain improvements. Foundational elements include emphasis on reporting improvement suggestions over errors within clear communication channels, understanding and accepting standardized processes, and management involvement, which are aligned with research findings from extensive data collection by Mazur and Chen [14].

Following obstacles were identified. First, this study was conducted in one organizational with small sample size of students. Second, data collection using direct observation by students presented several difficulties: 1) direct observation has been shown to alter behavior (also known as Hawthorne effect), particularly motivating subjects to perform at higher levels than they would if unobserved; 2) the fact that the students had limited experience in hospital settings possibly hindered their abilities to understand some of the events witnessed; and 3) the unknown bias of the researchers, which could influence what was recorded, coded and analyzed, could be present in this research. Therefore, based on the limitations of this study, generalization of the findings to the entire population of industrial engineering students can not be ascertained. However, results of this study might be applicable to other health care facilities.

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