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THE APPLICATION OF SIMULATION METHODOLOGY IN A HOSPITAL'S SIX SIGMA PROJECT

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ABSTRACT

Simulation was recently utilized as the key component of a Six Sigma project at a major hospital in the southeastern United States. The project team used various statistical analysis tools to assess current process performance and measure improvements with process changes. However, simulation provided the best insight into which process changes had the best opportunity to succeed and which would yield little value. This paper briefly discusses the methodology of this project and how simulation provided a better quality solution.

1 SIX SIGMA PROJECT OVERVIEW

The hospital wanted to improve its patient experience to world class levels (Miller, Ferrin and Szymanski 2003). An inherent Six Sigma team structure was developed to analyze discrete sub-processes of the overall patient experience (e.g., greet to triage, ED bed to diagnosis, etc.). These teams consisted of staff at all levels of the organization, including physicians. The overall team consisted of:

- Steering Committee/Champions
- Green Belts
- Black Belts/Master Black Belts.

The steering committee/champions were responsible for identifying the project, identifying black belts, allocating resources, monitoring progress, reviewing effectiveness, and establishing an implementation strategy and policies. Composition of the group included key management personnel who provided support and resources for the process. Their experience required an in-depth understanding of the methods used, especially the measurements and the interpretation of the process measurements (Aft 2001).

The project Green Belts were introductory participants in the Six Sigma process. They understood concepts of data collection and data interpretation, but were not full time participants.

Black Belts and Master Black Belts were thoroughly trained individuals, expert in all of the analysis tools. Usually, they teach, coach, transfer knowledge, identify opportunities, and influence the organizational use of Six Sigma methods (General Electric 2005). The project's Black Belts were leaders of teams responsible for measuring, analyzing, improving and controlling key processes that influenced patient throughput and satisfaction.

The project approach included two levels of hierarchy. The simulation project and the encompassing Six Sigma project. Critical to all projects, particularly time intensive and expensive initiatives like Six Sigma projects, requires clarity of purpose and goals (Miller, Pulgar-Vidal and Ferrin 2002). The Six Sigma team worked with the ED leadership to fully recommend Six Sigma project goals and goal tracking.

Project leadership oriented the ED teams and other key stakeholders in the Six Sigma methodology, timeline, expectations regarding assessment and execution of recommended solutions sets from the Diagnostic and Solution Set phase, and other matters important to leaders. Over time, the aim was to apprentice leaders to actually coach managers in the application of Six Sigma.

The Six Sigma project consisted of three transformational phases. Each phase's success was highly dependent upon an evidence-based, scientific analysis of historical data. This study utilized predictive statistics and regression analysis to pinpoint those Critical To Quality (CTQ) processes in the Supplier-Input-Output-Customer (SIPOC) continuous flow. Rather than focus on external, difficult to predict "best practices", SIPOC uncovers internal, already in place, best practices that can be replicated and optimized. The data are further strengthened if lab, X-Ray, CT, and bed management/inpatient admission historical data is provided, enabling the construct of constraints analysis. This final inputs into the SIPOC enabled the ED leadership to view the ED through the "eyes of the inpatient nurse", adding further clarity to a very complex and unclear patient care continuum.

All three project phases include an action plan, where teams receive results from the phase analysis. The action plans implemented several process changes in the following categories:

- NOW – teams adjourned at approximately noon, proceeded to the ED, and actually executed one or more process changes that could be accomplished immediately (e.g. relocation of charts, consolidation of materials/supplies, writing new policies, etc.)
- 30-60-90-DAY – teams commit to tasks required to achieve implementation in 30, 60 and 90 days
- Presentation to senior management – as the last activity of the 1-day or 2-day kick-off, team leaders present their action plans, including the NOW improvements made during the afternoon to senior management.

Another key component of Six Sigma projects includes Design of Experiments (DOE), whereby process improvements are planned and implemented. Traditionally, organizations will implement process improvements on varying levels of sophistication. At the lowest level, organizations "shoot from the hip" and implement what executives feel is the right thing to do. A more common approach is to implement best practices, assuming what works well for one hospital will work well for another (Advisory Board 1998).

However, not all processes should be improved in the same way (Keen 1997). There are many published examples of success stories where process redesigns caused improvements in LOS (Kleinberg 2000, Bale and Krohn 2000). Truly, these efforts were wise investments. However, it is unknown how much is invested in efforts which did not yield an improvement in LOS because these stories are typically never published. Is there a way to determine if process redesigns will improve patient LOS? This leads us to a more sophisticated approach, which is to simulate, or prototype, the proposed process improvement idea prior to implementation.

2 SIMULATION APPLICATION

Numerous improvement ideas were proposed during the 30-60-90-Day Action Plan. The most promising ideas needed detailed analysis due to the inherent risk associated with patient care. These ideas became simulation scenarios. The simulation returned quantifiable performance data, thus providing valuable input to the Six Sigma team's decision making.

Since the simulation model was used in phase 2, the simulation project therefore occurred concurrently with the project team's phase 1 implementation. The simulation project methodology included five phases of its own:

1. Develop conceptual model,
2. Programming,
3. Testing (Verification and Validation),
4. Experimentation,
5. Presentation.

The conceptual model phase included creation of process maps and documentation. The model included trigger objects to show patient arrival. It also showed activities, which describe inputs, outputs, required resources, activity durations and business rules. Finally, the model included decision points for routing patient and objects to show the end of the process.

The programming phase included coding the process model into appropriate simulation software. This simulation used actual hospital layouts as a background with entity movement and queues animated on top of the layouts (see Figure 1). Finally, a graphical user interface, or control panel, was developed to efficiently manage input parameters sent to the ED Simulation.

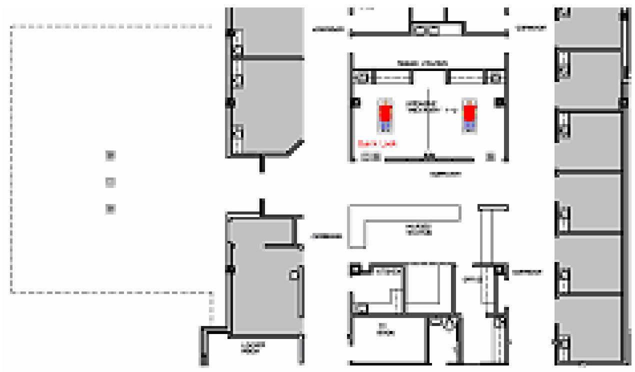

Figure 1: Animation of Hospital Emergency Department

Testing of the simulation model included verification and validation. Verification ensured the simulation behaved as intended in the conceptual model. Validation ensured the simulation model behaved similar to the actual Emergency Department.

The experimentation phase included development of specific scenarios to test. Some of these scenarios only required small changes to data, such as turnaround time for Lab or Radiology. Other scenarios required more extensive coding changes.

The simulation team presented the results during the second phase of the six sigma project. The presentation to hospital executives and staff included a review of the project scope, approach, deliverables, scenarios tested, experimentation results and recommended next steps.

3 SIMULATION BENEFITS

In regards to measuring customer satisfaction, simulation is one of the few tools capable of measuring financial indicators, operational indicators and customer satisfaction indicators in the same analysis (Ferrin, Pulgar-Vidal and Miller 2002). Moreover, in measuring CTQ attributes, sensitivity analysis performed through a valid simulation is an excellent methodology identifying the most appropriate CTQ impacting the process under review. This can usually be done quicker and more economically than using the high power statistical tools like Design of Experiments.

Simulation is appropriate for and may even be preferred for use in many of the DMAIC stages. In the Measure phase, the objective is to determine where one is relative to desired objectives, identify critical quality characteristics and estimate current capability. Traditional tools for this stage are cost of quality (appraisal, detection, failure), process capability (peSent nonconforming, capability indices), and measurement systems analysis. Simulation is likely an improved tool to determine through sensitivity analysis, the true drivers are critical to quality characteristics, CTQ. Simulation is also a superior tool to determine the capability of the current processes. Other mechanisms rely upon benchmarks that may be ill advised or even inappropriate (Advisory Board 1998).

In the Analyze phase, the objective is to show the amount of improvement that might be possible to make the critical quality characteristic "best in class." Traditional analysis tools are descriptive statistics, inferential statistics, probability, and analysiSof means. While traditional tools may be adequate to analyze and determine the future potential/capability of a process, simulation is the best way to accurately identify with statistical validity, the capability of a to-be process. It is the best tool, possibly the only analysis tool, capable of delivering Six Sigma accuracy of the to-be process.

In the Improvement phase, the objective is that possible improvements are implemented and evaluated in a logical and planned fashion. Traditional tools are project management, correlation, regression (linear, multivariate), design of experiments (ANOVA, factorial). In evaluating the value proposition of possible improvements, simulation is again the only analysis tool capable of delivering Six Sigma accuracy of the possible improvements.

In the Control phase, the objective is to ensure that measures are put into place to maintain improvements. Traditional tools are SPC, cost of quality and ISO 9000. Simulation is one of the few tools that can prototype a possible solution in an SPC format. Outputs are available that can show if a process is statistically in control or not in control as well as determine the defects outside the upper and lower control limits. It allows one to ensure that the measures chosen in fact perform as intended and reflect the correlation with the possible improvements.

4 CONCLUSION

Simulation was a good fit for this Six Sigma project. It enabled the client to better understand the patient experience, process performances and staffing inter-relationships for their proposed emergency department (Miller, Ferrin and Messer 2004). The team brought clarity to difficult internal debates and each of the deliverables was instrumental in bringing a complete solution to the client.

Simulation is used by many of the world's "best" companies when their answers must be right the first time (Crosslin 1995). Additionally, from a Six Sigma philosophical perspective, simulation is a tool capable of providing quality analytical insight. Simulation has earned a place in Six Sigma culture and will continue to be a valued tool in delivering innovative, customer focused and well defined solutions (Shapiro 2002).

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