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Six Sigma in a Large-Scale Social and Statistical Science Research Organization: Some Lessons Learned on Getting Started

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Abstract

RTI is pilot testing a structured quality improvement process based on the Six Sigma quality improvement approach. Expert consulting staff trained a group of internal Green Belts to lead process improvement projects. We defined and implemented a pilot project with organization-wide impact. This paper outlines the development of an RTI-specific quality improvement methodology adapted from Six Sigma techniques and reports on the results of this pilot project. We address the challenges of adapting a methodology first developed for manufacturing-oriented processes to the research contract environment. The paper reports on the successes and failures of the pilot project and the strategic decisions about steps to be taken based on these results.

1. Introduction

RTI is a multidisciplinary nonprofit contract research organization serving government, academic, and commercial clients worldwide. Representing a diverse set of scientific and technical capabilities, RTI staff members conduct research in many areas including health, environment, education, survey, statistics, and economic and social development. The Social, Statistical and Environmental Sciences (SSES) unit of RTI has about 1,200 individuals conducting about $300M of research contracts and grants annually. SSES, the focus of this paper, represents about 40%, by revenue, of the RTI organization.

2. Quality Management at RTI

SSES/RTI distinguishes itself as a provider of high-quality research and technical assistance. Our contracts often require a set of quality-related products and metrics that demonstrate the integrity and value of the research being conducted. Some contracts rely on regulated quality requirements (National Institutes of Health good clinical practice, for example) but most are governed by client-provided and often contract-specific quality guidelines. RTI has developed an overarching quality policy that underlines the importance of providing high-quality products and services to our clients. Historically, however, the methods and approaches for achieving quality standards are determined by each business unit and, to a large extent, by the contract project team.

Although SSES work products are generally of high quality, internal performance and quality metrics indicate considerable variation for some products. To remain competitive we recognize the need to reduce the costs and effects of poor quality. As such, SSES leaders have invested in several organization-driven quality improvement initiatives over the years to bolster the quality of products across all of our contracts. In the early 1990s, the survey research unit established a quality assurance group under the direction of a research vice president, and staff members were trained on the Total Quality Management (TQM) principles taught by Deming, Scholtes, Juran, and others. The quality unit supported the examination and redesign of some survey processes during this period and recorded some efficiency gains and quality improvements. The TQM movement was

criticized as expensive and the investment returns were not apparent to a new leadership team installed in the mid-1990s who curtailed the effort.

From 2001 to 2005, SSES leaders, particularly in the survey research unit, established a quality assurance approach based on principles often associated with regulated quality frameworks. Standard operating procedures (SOPs) were developed for all research (primarily survey) activities and an audit function was established to assure compliance. A quality assurance office was established to help write all of the SOPs and to audit project teams.

Research staff did not enthusiastically support the regulated quality model; they felt encumbered by the financial burden of the quality office without seeing tangible benefits. Research teams complained that SOPs were too rigid to describe the complexity and nuances of social science research activities and that a central audit function could not effectively appraise the vast amount and type of research conducted in the organization. In addition, the SOPs were written in such generalities (partly because of the difficulties in describing complex activities and partly to avoid negative audit findings) that even processes of questionable standards could be compliant under the SOPs. By 2005, the extensive set of SOPs that had been developed was largely not maintained, and the audit function was not adequately funded and rarely implemented. Eventually only the system framework existed; project teams claimed to be following the SOPs but actually defined their own methods for assuring quality.

2.1. Quality Management System

In recent years SSES has developed a quality management system (QMS) designed for all unit activities, research, and technical support services. The system diverges from the regulatory model described above and instead is based on a foundation of current best practices (Morganstein and Marker, 1997) and a peer-review system. Quality has been redefined to include accuracy (as before) and many interrelated goals, similar to the quality framework defined by Statistics Canada and other similar organizations (StatCanada, 2002; Eurostat, 2005). The quality system is designed to encompass all unit activities, not just survey-related activities, including business and proposal development, scientific and technical design and processes, and project management.

The current quality framework categorizes quality management activities into three broad areas: quality planning, quality control, and quality improvement. Maintaining and improving the system are part of the QMS quality planning component and represent the organization's commitment to and support for the system. The quality control component establishes the quality standards critical to RTI's work and the quality assurance steps implemented to ensure that these standards are met. Quality improvement is continuously pursued and achieved through management driven activities designed to improve products and services and to exceed current standards.

The initial focus of the quality planning team was to define the elements of the quality control component of the system. The team developed comprehensive quality standards, guidelines, and supporting documents, and published them in a quality handbook. Designed to be more flexible than the prior SOPs that had guided project teams, the handbook provided multiple best practices for achieving quality standards. (The structure was patterned after the Office of Management and Budget set of survey standards (OMB, 2006).) Quality assurance protocols, including independent scientific, technical, and project reviews, were defined, but notably no formal audits were required. Training and administrative support were provided to help ensure that the quality control protocols were followed and were effective.

The process of establishing the quality framework and developing the handbook was a time-consuming, 2-year effort. To be sure, many protocols and processes were already documented; otherwise the process might have taken longer to accomplish. Now, the quality framework provides

a cohesive quality assurance and improvement plan that can be articulated to clients, staff, and other stakeholders. The handbook serves as a guide to staff and includes a more comprehensive definition of quality. Quality assurance protocols focus on high-risk contracts and provide early warnings about performance and quality issues. These objectives were all good, but as the core quality team reviewed progress, they found little evidence that the system significantly affected behaviors, was fully integrated into the daily activities of contract project teams, or improved quality.

At RTI, project teams have wide latitude to develop client-oriented solutions, and these solutions can vary significantly while still meeting general quality standards and guidelines. Project teams routinely implement a broad and complex set of research-oriented activities; thus, it is difficult to codify standards for all of the research and technical approaches. The SSES quality committee recognized these limitations to the QMS quality control and quality assurance processes and realized that the existing foundation was a necessary but not sufficient step to improve quality.

2.2 Quality Improvement Strategy

The handbook describes the quality improvement component of the QMS as "…the identification of improvement opportunities and coordinated activities to improve quality" but these activities were not fully defined. In practice, the SSES leadership team focused on improving quality. Typically quality improvement efforts were reactions to quality problems and took the form of an ad hoc committee to research and develop improvement recommendations. Ad hoc committees followed common-sense approaches to identify causes of problems and to develop practical solutions. These solutions were communicated and implemented in most situations. The improvement process was not organized, however, and the improvement targets were not necessarily prioritized or tied to business strategies—although these efforts and the required investment were largely driven by management.

The committee set out to develop a more rigorous quality improvement strategy in the spring of 2008. As they considered strategies, the quality committee reviewed a number of classic approaches and was especially drawn to the teachings of Joseph Juran (for example, Juran on Leadership for Quality). The core principles about organizing for quality improvement, focusing on strategic quality goals, and the exhortation that real improvement was achieved "project by project and no other way" resonated with our group and seemed to fit our organization and culture. The essential elements of Juran's ideas were adapted to fit RTI and were presented as a plan to the SSES leadership team. As a first step in the process, nominations were accepted for a formal Quality Council from among senior leaders and a search was initiated for a consulting group to assist with the process.

In the summer of 2008, the Juran Institute was hired and senior consultants from this group interviewed a cross-section of RTI managers in a 2-day organization assessment. The assessment was followed by a 1-day executive training session conducted in July 2008 for all SSES senior leaders. This session was designed to underscore the financial and organizational benefits of developing a quality management strategy. The argument was relatively straightforward: the management team had to organize and support the investments in improving processes, Time and financial investments were substantial but the payoff was likely significantly greater. The Juran Institute introduced the concepts of Six Sigma as a framework for organizing quality improvement efforts and provided relevant examples to demonstrate the power of the approach.

The rationale for developing a quality improvement strategy was clear and the approach made sense. The core quality committee organized a discussion shortly after the executive training to debrief attendees and develop consensus for initiating a pilot or test project. To prepare for this discussion the team developed a model and a multi-step process for nominating and prioritizing

potential process improvement projects that would take weeks or a few months to complete. The leadership team needed far less time, and during a 1-hour discussion, they decided to pilot the Six Sigma improvement process; proposal development at RTI was nominated as the first process to be evaluated and improved.

3. Six Sigma Project Approach and Implementation

3.1 Six Sigma Overview

In the mid-1980s Motorola developed (and copyrighted) the Six Sigma approach to improving quality (Motorola, 2008). The term Six Sigma, on one level, is a goal to reduce or eliminate defects. Motorola engineers defined the mathematical term Six Sigma to represent a process that produces fewer than 3.4 defects per million opportunities (DPMO). More importantly, Six Sigma is also an established and, in many cases, successful methodology for examining and improving processes. The methodology requires the identification of process outcomes critical to quality as determined by customers and includes process mapping and data analysis steps designed to identify root causes for problems, reduce process variation, and increase quality.

Six Sigma techniques were first implemented in manufacturing, product creation applications. The methodology has been applied in non-manufacturing or "softer" environments, as some case studies have demonstrated (see BLS case study, for example), but very little has been written about applying the techniques to processes in a research contract organization. Indeed, at the beginning of the project we were sufficiently concerned about the manufacturing-oriented reputation of Six Sigma principles—and how these concepts would be received by our research/academic-oriented staff—that we asked the Juran Institute to modify training materials to deemphasize common Six Sigma terms such as DPMO, Green Belts, and Black Belts.

The steps that teams follow in the Six Sigma process have been modified to address different process improvement objectives. In this paper when we refer to the Six Sigma approach (or process), we mean activities organized around five essential steps: Define; Measure; Analyze; Improve; and Control. The steps are carried out by a multifunctional team who understand and can represent the critical parts of the process being examined. A trained process improvement expert (Green Belt or Black Belt) leads the team. In the Define and Measure steps the team dissects the process, develops an understanding of the key quality issues as perceived by customers, and establishes improvement goals. In the Analyze stage the group examines process metrics to identify root cause problems and then designs potential improvements. The team follows a series of steps to implement these improvements and "hold the gains" in the Improve and Control phases (Lean Six Sigma, Transactional Green Belt training reference) of the improvement project.

The Six Sigma process shares many of the same techniques and tools advocated in TQM (Deming and Walton, (1986)) teachings. The process is designed to help expert teams identify, prioritize, and resolve competing root cause issues. The Six Sigma approach is differentiated by its conscious and overt tie to strategic and business goals. Developed by business leaders, the process is purposely a more concrete roadmap with explicit return-on-investment expectations for process improvement teams. Additionally, although other quality improvement approaches (e.g., TQM and process reengineering) emphasize data-driven decision making, the path from analysis to redesign is more arduous and rigorous in the Six Sigma framework. The Six Sigma process requires more analyses and process examination steps before improvement recommendations are developed than TQM prescribes.

3.2 Pilot Project

The SSES organization invests significant resources developing research contract proposals. Invariably, more opportunities are available than the organization has funds to pursue. In 2008, the leadership team had been wrestling with this problem, sometimes turning down good opportunities so as to ensure adequate funds for others. When executive training took place, solving this problem was a very high priority and it was widely accepted that improving the efficiency and effectiveness of our proposal development process would stretch our proposal development budget and allow us to write more, and we hope, more winning, proposals.

Many elements of the proposal development process made it a good first process improvement project. The success of the process is important to everyone and, therefore, everyone on the leadership team has "skin in the game." The impact from improvements to this process could be significant and benefit everyone. Lastly, addressing the problem was a high priority for the management team and was clearly tied to business and strategic goals.

The proposal development process is complex, involving hundreds of steps and scores of people. RTI has defined a standardized process with practices that teams must follow and activity milestones that must be accomplished. These steps are documented and participants are trained to follow them. Notwithstanding, significant variability remains in how proposal development teams are staffed and in how well the steps are implemented. Improving such a complex process is difficult, and is a significant obstacle for the pilot project. Although the benefits that can accrue from improving the proposal development process are clear, making significant changes to such an established process is also difficult.

The process owner and research and financial vice presidents drafted the project charter that included a problem statement, set of goals and operating plan. The charter statement restricted the scope of investigation, for simplicity, to all of the activities that occur after the decision was made to bid for a research contract. Pre-bid activities influence proposal outcomes and taking these activities out of the scope of this effort complicated our ability to measure improvement. The compromise seemed reasonable, however, because the process steps that occur after the bid decision are extensive, costly, and significantly impact the outcome of the bid. The charter statement was quickly approved and monies were allocated for the pilot project at the beginning of the RTI fiscal year (October 2008).

3.3 Project Implementation

The plan was ambitious. The Juran Institute provided a master Black Belt to train Green Belt staff (and others that were to receive some basic training) and to direct a complex process improvement project. Approximately 10 RTI staff members were selected to be trained as Green Belts; half would participate in the pilot project and the other half would direct later projects. An additional set of RTI staff, selected as process experts, were assigned to the project team and would receive a subset of Green Belt training while participating in the project. The Green Belt training, which required 10 full days, was broken into four 2.5 day sessions and scheduled over a 7-month period. The first training and project kickoff were scheduled for early December 2008, by October 2009 training was to be finished and the project completed.

After the first training and assisted by the project Black Belt trainer, the pilot team began working on the discovery and measurement steps of the Six-Sigma process. The team, which included some very senior researchers, concluded that many of the analytic approaches offered in the Green Belt training for analyzing and discovering process problems were too simplistic. (At the same time, some of the technical demands of the Green Belt training were beyond the reach of some trainees.) Several senior statisticians conducted a multivariate analysis (classification and regression tree-

CART) of over 1,500 RTI proposals written over the last 3 years to identify significant factors associated with the variation in effectiveness and efficiency of proposal efforts. (Interestingly, the CART analysis produced similar results to the more simplistic approaches that were taught in the training but provided more confidence in the findings.) Eventually, a revised charter statement was developed that clarified the goals of the project and combined the concepts of improving the effectiveness and efficiency of the proposal development process for medium to large research contracts.

The team identified significant stakeholders in the proposal development process and developed a high-level SIPOC (suppliers, inputs, process, outputs, and customer) process chart. They then surveyed major customers at each point in the process to identify critical-to-quality (CTQ) elements. A cost-of-poor quality (COPQ) analysis was completed to identify the significant impacts that stem from problems that occur through the process. They prepared a "fat" fishbone diagram listing all process inputs and potential failure points, and developed a process PERT chart that incorporated the CTQ findings. By April 2009 the team had dissected the process and identified hundreds of potential areas for improvement.

The team summarized their findings and shared their insights in a 45-minute overview session for the entire management team. At the end of the briefing senior leaders were disappointed that the pilot project team did not offer any improvement recommendations. The leadership team thought that many of the insights the pilot project team offered were intuitive and largely already known. Some in the group were happy to make recommendations for process changes based on the information presented and disappointed that these recommendations would be delayed to collect process performance metrics. The Executive Vice President (SSES chief) volunteered to help steer the group and asked for more frequent debriefings, and the meeting was adjourned.

After developing a common understanding of the process and inputs, the team took the next step to analyze the data and establish leading improvement hypotheses. They used a Failure Mode Effects Analysis (FMEA) to identify likely common failures that have the highest impact on process quality. A subgroup of the project team sifted through hundreds of potential hypotheses and developed about 30 for consideration; the project leader then whittled this set to nine hypotheses for further testing.

Although outcomes of the proposal development process are tracked, RTI has very few (if any) proposal development process metrics. This lack of data led the pilot team to conclude that testing the hypotheses was impossible without collecting new information. In response, the team developed a questionnaire to capture the frequency and severity of problems in the proposal development process related to the leading hypotheses. The survey was administered to all staff who participated in the development of about 50 proposals for medium to large research contracts over 2 months. The instrument was customized based on the role that each person played on the proposal team to capture multiple perspectives from different team members. The leading hypotheses, data collection plan, and survey instruments were developed and presented to the SSES management team in July and the survey was administered through September 2009.

In one year we had traversed through just half of the Six Sigma process. No improvement recommendations had been developed and implementation plans had not been contemplated. Tepid support for finishing the project continued but senior leaders lost patience with the process and significantly lowered their expectations for its overall impact. The remaining section of this paper presents lessons learned from the experience. These lessons might change and will no doubt be updated as we progress through the final steps of the improvement project but they serve us well as we consider next steps to complete this initiative.

4. Lessons Learned

Expect difficulties when translating the concepts embedded in the Six Sigma approach into a research and contract/service organization.

The Lean Six Sigma approach emphasizes lean, or more efficient, processes and a reduction in errors that are critical to quality. The concepts work well in manufacturing and production-oriented environments in which cycle times are routinely measured, the value of efficient operations is widely accepted, and causes of error in the production process are relatively easily identified. In RTI's environment, translating the "Lean" related goals of the improvement project to our research staff's common goals and beliefs was much more difficult. Our stated goal when we initiated the pilot project was to increase efficiency and effectiveness of the proposal development process. As the pilot project team progressed, team members questioned whether improving the efficiency of the process would improve the success rates of the proposals. Connecting the relationship between process efficiency and ultimate effectiveness consumed significant time. Ultimately, we decided to de-emphasize efficiency goals and focus on identifying deficiencies in our processes that were leading to proposal losses.

Six Sigma analytic approaches are designed to be conducted by people with a strong interest in the process being improved but not necessarily strong analytic or statistical backgrounds. The data gathering, process mapping, and data analysis steps are rigorous but the statistical tools are relatively simple and packaged into easy-to-use computer-based modules. It proved difficult, and somewhat pointless, to train statisticians and other research professionals to follow these tools because these staff had long before developed their own analytic approaches and developed an affinity to different statistical packages. (On the other hand, many individuals in the training group did not have extensive statistical training and these tools were very helpful to them.) Further, project staff also felt that their findings would be subject to a fairly sophisticated level of scientific review meriting a more rigorous and time consuming approach.

The initial (or demonstration) project should have high importance to management and have high and measurable potential impacts on the organization.

Our pilot project was an ambitious undertaking given the size and complexity of the process, and the selection was made without careful consideration of other alternatives. However, the proposal development process is very visible, its success is important to everyone in the unit, and improvements can have a large impact. Improving the proposal development process has significant business and strategic benefits and is, therefore, a prime candidate for a Six Sigma-based improvement project. We were rightfully fearful that its size, scope, and complexity would slow us down, but remain unconvinced that we would have selected a better process to analyze if we had spent more time considering alternatives.

At the same time, the scope and difficulty of the project may have been underestimated by both the SSES quality committee and the SSES leadership team. When this was realized, there were some attempts to scale back on the scope of the project, but there were also pressures to implement major improvements for proposal development. It was finally decided to keep most of the original objectives in tact. However, the original deadlines for producing measurement results were not revised to reflect this new understanding of the scope of the project.

The demonstration, and most all other, process improvement projects should be completed within a relatively short (6–9 month) time frame.

Most people, especially managers, want to see tangible benefits from investments made within a short period of time. We learned a few critical lessons about keeping the demonstration Six Sigma project to a reasonable schedule.

Project scope. Project scope is driven by two multiplicative factors: number of process steps and number of customers. The scope of the initial project should be limited to a process (or part of a process) that has a manageable number of steps and a group of customers that can be easily accessed. Project complexity increases and the chance of completing all of the Six Sigma steps within a reasonable period of time decreases as the number of steps and customers grow. For reasons noted above, we were reluctant to short-cut the Six Sigma process to fit a tighter schedule but we were also unable to rescale the scope of our project as it became apparent that the 6–9-month schedule was infeasible.

Staff availability. Key stakeholders and experts for important business processes are busy people without a lot of available time. Our process improvement project was just one more project to which team members were assigned, and although the leadership team emphasized the importance of the quality improvement project, very little if any effort was made to transfer other assignments or to divert attention to this one. We could not impose priorities and it was impossible to suggest that the process improvement effort was more important than time spent on a project paid for by a client, even if improving the proposal development process might have greater impact on the growth of our business. The project director (or lead Green Belt) seldom had more than 6 hours a week to dedicate to the process improvement effort. Other team members had, in most cases, even less time.

The pilot process improvement team was also too large. We included too many people and thus had difficulty scheduling meetings, assigning clear responsibilities, and making progress. Some people had to be replaced because they could not devote enough attention and time to the project. The lesson is clear: a small and dedicated team works best. However, with a large project, there are many stakeholders and this usually leads to more team members. This also emphasizes the need to keep the project scope manageable.

Availability of process performance metrics. RTI tracks proposal development efforts very carefully; a unique identifier is assigned to every proposal and, over time, a significant amount of information is attached to the record related to the client, type of research, proposal budget, proposal cost, and eventual outcome of the bid. Surprisingly, however, descriptive data about how well the proposal writing process works are not available and had to be created for our pilot project so the team could develop improvement recommendations. Although primary data collection is a necessary part of many Six Sigma efforts, it adds significant time to the schedule and makes it difficult to complete within a 6–9-month period.

The project must have the full support of the process owner.

RTI's proposal development process is "owned" by a very influential stakeholder and member of the management team. Although there is widespread belief that improvements to the process will benefit outcomes, no evidence indicates that the process is broken and some people feel that modifying the process might do more harm than good. The process owner participated in the development of the process improvement project charter, Green Belt training sessions, and in project meetings but remained skeptical that meaningful improvements to the process could be made. In this environment it was difficult for the process improvement team to dramatically change the steps in the process and instead the focus switched to how it could be tweaked to perform better. This subtle but important change in focus occurred after the project started and significantly limited its effectiveness.

The project should have intimate involvement of the highest level manager over the unit encompassing all the work to be performed. This might be the company president if the work is company-wide. This includes some form of Green Belt-like training if this person is not familiar with Six Sigma techniques.

Improving complicated processes requires strong senior leadership regardless of the techniques or methods that are followed. The Six Sigma approach requires significant resources and investment; theoretically, the teams using these methods are trying to improve significant strategic and operational issues. In addition to these reasons for close involvement of the highest level manager, senior leaders help establish the necessary environment and support for the team(s) to be successful. In our pilot project we lost connection with the leadership group after the project was approved and, as a result, did a poor job managing their expectations. As an example, in April 2009, the project lead Green Belt provided a mid-course presentation on the results to date. The leadership group expressed disappointment that insights regarding needed improvements and progress towards project completion was much less than they anticipated. As a result, their confidence in the Six Sigma approach and the prospects for a successful outcome were lowered.

"Just in time" training of project staff has pros and cons.

We combined training with project execution, which significantly slowed progress. We wanted to train Green Belts while implementing the pilot project so that we could more quickly launch additional improvement projects at its conclusion. Alternatively, we could have hired a Black Belt to lead a process improvement team without concurrent training on the Six Sigma principles. This would have cut significant time from the process, allowing the process improvement team to demonstrate results earlier and thereby develop the confidence of the management team. This confidence would have translated into more commitment for the Six Sigma program and for training additional process improvement project leaders.

Green Belt training should be completed in a short timeframe prior to launching a process improvement project. A small training project should be used during training to adapt the training to the organization.

Our Green Belt trainees (who were to lead future projects) had difficulty understanding and fully appreciating the concepts without the opportunity to apply the principles they were learning. Green Belt certification requires that a trainee complete a training project. We should have required trainees to work on a small training project in addition or instead of the pilot project.

5. Next Steps

As our pilot project proceeded, another unit at RTI launched a Six Sigma-based process improvement initiative targeting back office corporate services. The unit followed a very different strategy, deciding to hire Black Belt trained staff to lead process improvement teams and projects. These teams made relatively quick progress largely because they were unencumbered with training sessions and because they focused on improving much smaller processes. In addition, the on-staff Black Belts were absorbed much more quickly into the RTI culture and since they were on-site, they could direct the teams more effectively and efficiently. This team also has the advantage of applying Six Sigma within an RTI administrative unit rather than a research environment. It is too soon to tell whether their approach is sustainable or that it will achieve important gains in quality. However, it currently appears to have greater support in the organization.

Our pilot project was intended to test the Six Sigma approach for improving processes and before completing it and measuring its return on investment, it is difficult to predict the future of Six

Sigma at RTI. Assuming that we demonstrate value with the Six Sigma approach and nominate other processes for improvement, we are likely to leverage existing on-staff Black Belts to lead these efforts. As likely, we could fall back to improving processes by following a more ad-hoc and less-structured approach. In both cases the organization is committed to defining the improvement strategy; the steps that we take to identify improvement opportunities, the formation of the right team to fix the problem, and the training and support that is provided for the team to be successful. It is this last part of the strategy that, as we are learning in the pilot, is more difficult than anticipated.

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