2006-1504: LEAN SIX SIGMA AS AN IMPROVEMENT TOOL IN ACADEMIA

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Lean Six Sigma as an Improvement Tool in Academia

Abstract

Six Sigma is a quality management philosophy, problem solving approach, and statistical measure that helps organizations improve processes, reduce variation, and eliminate waste. It has been used successfully in the automotive, chemical, healthcare, high-tech, financial and retail industries. The Industrial Engineering and Management Systems Department at the University of Central Florida has incorporated service experiential learning opportunities into the curriculum within a Total Quality Improvement course. This course teaches the Six Sigma body of knowledge together with Lean Principles and provides hands-on Six Sigma project experience. This paper describes how a team of faculty and students used the Lean Six Sigma Technology to document and improve the pre-application process used by the College of Engineering and Computer Science at the University of Central Florida.

1. Introduction

In the Fall of 2004, the College of Engineering and Computer Science at the University of Central Florida (UCF) started the implementation of a graduate pre-application process. The process was designed to serve as a screening tool to weed out unqualified applicants and as an early identification tool for top recruits. The college could then offer incentives for attending UCF, including but not limited to scholarships, fellowships and waived fees for students. The pre-application tool was designed and the database programmed by a Computer Science student within a month. End-users such as faculty, academic program administrators and prospective students were not involved in the process. In addition, the database went live without any beta testing. Complications such as inaccurate data, incomplete applications, and unpredictable system shutdowns ensued.

The Six Sigma Team from the Total Quality Improvement Course taught by Dr. S. Furterer at UCF used the Lean Six Sigma Technology to document the current process, identify opportunities for improvement, develop metrics for continuous improvement and finally document the revised process.

1.1 Problem Statement

Traditionally, a prospective graduate student, interested in applying to the College, would apply to the University Graduate Admissions Office. This office would then forward the information to the College. The College ended up processing thousands of applications despite the fact that hundreds of students did not meet basic qualifications.

In an effort to increase the efficiency of Graduate Coordinators and the College Graduate Admissions staff, the Graduate Programs Coordinator implemented the pre-application process. This tool was designed for two reasons:

1. It would serve as a screening tool to weed out unqualified applicants and would also be used in the early identifications for top recruits. The college could then offer incentives for attending UCF, including but not limited to scholarships, fellowships and waived fees for these students.
2. Faculty could list select institutions from which UCF was interested in recruiting. Any student's pre-application from those select institutions would be flagged, and correspondence with the potential student could begin immediately.

1.2 Project Objectives

The objectives were developed, and outlined within the Project Charter and those were:

1. Document the current process
2. Develop some metrics for continuous improvement
3. Suggest improvements on usability (more user friendly system)
4. Improve the existing application process time
5. Survey the users to determine the perceived problems with the current process
6. Identify indicators to measure if client needs and expectations are being met
7. Document the revised process

2. Methodology

In the Lean Six Sigma approach, usually lean manufacturing principles are used to eliminate unnecessary process steps and unnecessary processes and the DMAIC activities are used to reduce variations in the process and improve the process capability. The DMAIC acronym stands for Define, Measure, Analyze, Improve and Control. It is a very structured, disciplined and rigorous approach to problem solving and process improvement. (Harry and Schroeder, 2000)[1]. It is a five-phase process and a brief description of each phase as well as the tools that were used during each phase follows.

2.1 Define Phase

The Define Phase describes the customers, their needs and expectations. Through the project charter, the project goals and scope were determined as well as the key deliverables. A responsibility matrix, identifying the role of each of the team members and a work plan with assigned completion dates and milestones were created.

As a key step in improving the current pre-application process, the team developed a detailed stakeholder or customer analysis. Stakeholders can be identified as managers of the process, people in the process, customers, suppliers, upstream people in the process and downstream people in the process (Rath and Strong, 2000)[2]. Five major participants within the pre-application procedure were identified, consisting of domestic applicants, international applicants, the Office of Graduate Affairs staff, the departmental graduate coordinators, and the technical support team designated to the pre-application database. All of the inputs and outputs of the system, as well as all administrative and maintenance tasks for the system, were either supplied, received or performed by one or more of the above mentioned participants. As a second step of the analysis, the team identified the roles, needs and concerns of each stakeholder. This information enabled the team to measure how well the current pre-application process was

satisfying the needs of its customers, and to designate key areas for improvement in order to increase the level of satisfaction. A communications chart and an initial process flowchart were also developed.

2.2 Measure Phase

The goal of the Measure Phase is to investigate the problem in detail, more specifically what is happening, when it is happening and where it is happening. The Measure Phase concentrates on capturing the voice of the customer in order to identify the root cause of process problems. It is also intended to create an accurate picture of how the pre-application process currently performs in order to identify opportunities for improvement. During this phase, data is collected to create a performance baseline that may be used later to compare the process performance after it has been improved.

Surveys of applicants and face-to-face interviews with the graduate coordinators, the graduate office staff, technical support and the associate dean were used to identify the voice of the customers (VOC). The customer data was analyzed to uncover concerns and the characteristics that had to be met to satisfy the customer requirements. The tools used to analyze the customer data are listed below:

1. Detailed process map.
2. SIPOC (Suppliers, Inputs, Process, Outputs, Customers) identified the suppliers, inputs, process, output and customers.
3. Data Analysis from the applicants' survey.
4. A CTQ (Critical to Quality) tree diagram was used to determine the metrics necessary for an efficient pre-application process.
5. A Balanced Scorecard was used to monitor results from the financial, customer, internal and learning perspectives.
6. A House of Quality was used to translate customer requirements into technical requirements and prioritize them.
7. Benchmarking provided the data to show what could be achieved and how to achieve them.

2.2.1 SIPOC

The SIPOC diagram can be placed in the define stage (Rath and Strong, 2000)[2] or in the measure stage (Simon, 2001)[3,4]. This process map helps the team view the project from a higher level. This tool focuses on suppliers, inputs, process, outputs and customers. The screening process started once a prospective student filled out a pre-application and ended once the pre-application process was completed. The process depended on whether the applicant was domestic or international. The suppliers and customers were the same in this project and they were identified as internal and external. Internal suppliers or customers were the stakeholders who owned the process and made it work everyday. On the other hand, external suppliers or customers were the end users of the process.

2.2.2 CTQ & Metrics

This tool focuses on the critical drivers and metrics of the project. The critical to quality tree helps transform the general objectives of the project into specific goals. The basic metrics were selected taking into consideration the suppliers, internal process and customer feedback. These metrics should be similar for other organizations that measure a similar process. Accuracy, cycle time, and usability were the critical drivers selected.
The CTQ tree is shown in Figure 1.

2.2.3 Balanced Scorecard

Kaplan and Norton (1996)[4] introduced the balanced scorecard for business level management metrics in the following areas.

- Financial Perspective
- Customer Perspective
- Internal Perspective
- Learning Perspective

The Six Sigma team used the balanced scorecard to represent the relationships between the long-term business objectives, the short-term process objectives, and the necessary metrics for the College pre-application process. This tool identified the following:

- Business objectives for the College
- Immediate pre-application process objectives
- Measures necessary to evaluate accomplishment of the process objectives
- Desired targets for the measures

It also defined the relationships between the various objectives and metrics necessary for the fulfillment of the College's vision. It focused on business-level management metrics in the areas of customer satisfaction, quality, organizational growth, employee satisfaction and organizational learning and involvement. The tool identified lower level objectives for the pre-application process and a corresponding relationship with each of the five previously mentioned areas. The measures displayed in the scorecard represented measurable aspects of each of the process objectives that must be continuously measured in order to track the level at which the process was meeting its objectives. These measures also indicated the need for improvement in certain areas of the process. Lastly, the targets shown within the scorecard were simply the desired outcomes for those aspects of the process that were to be measured. The Balanced Scorecard for the project is shown in Figure 2.

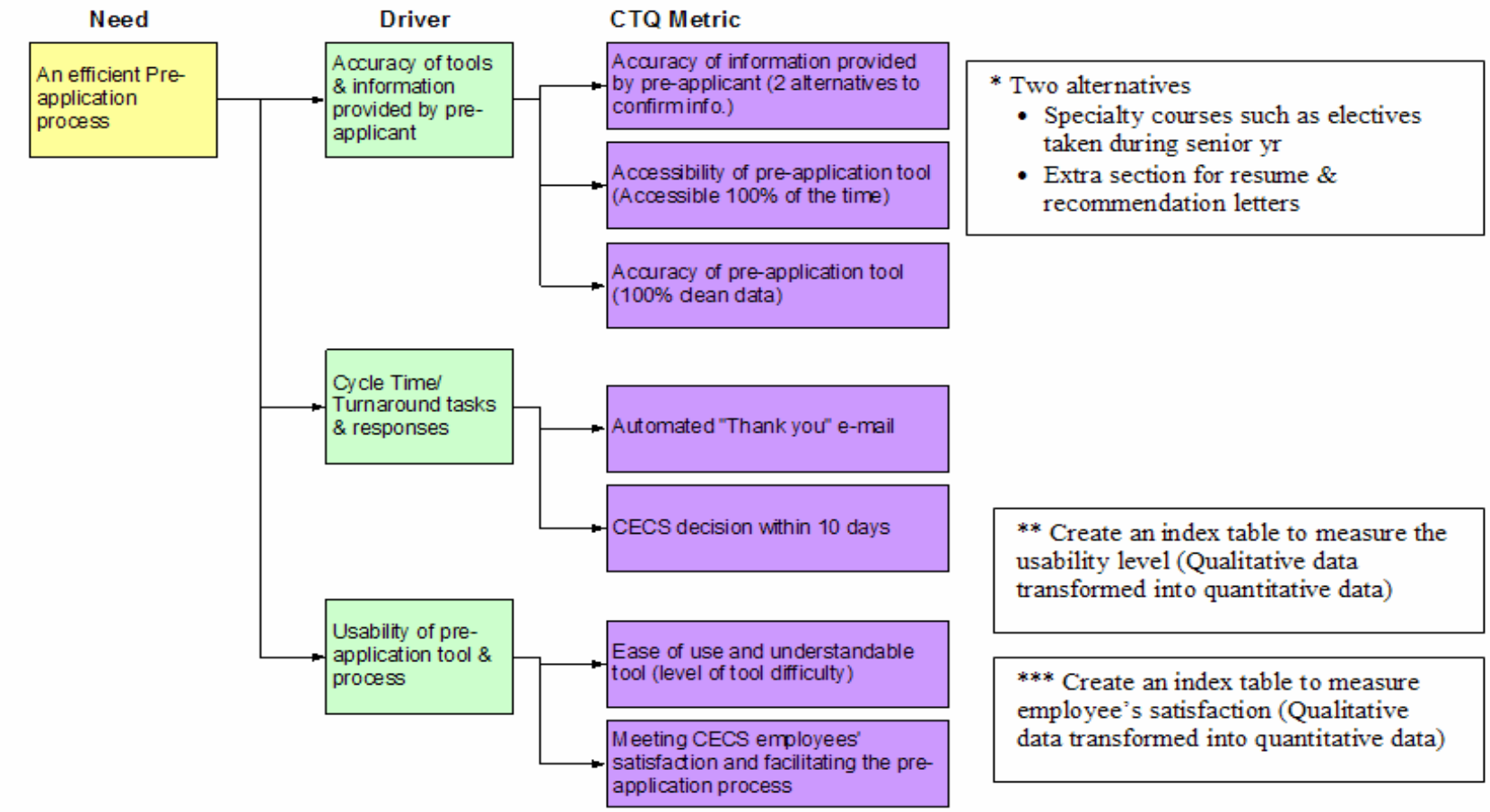

Figure 1: Critical to Quality Tree

2.2.4 House of Quality

One of the tools of QFD (Quality Function Deployment) is the House of Quality. It is a graphic technique for defining the relationship between the customer desires and the product or service. By defining this relationship in a rigorous way, managers are able to build products and processes with features desired by the customers. "The House of Quality" is a conceptual map that provides the means for inter-functional planning and communications"(Hauser, 1998)[6].
The information necessary to build a House of Quality for the screening project was obtained from the students' survey, the interviews with the graduate coordinators, technical support, graduate office staff and the technical support from the College of Optics and Photonics (CREOL). CREOL was used for benchmarking since they had a pre-application process that worked really well.
The final output from the HOQ was a set of technical target values to be met by the new process design. Those were:

1. Simple Data Structure
2. Full Time Technical Support Person
3. The Use of a Tracking Number for each pre-applicant.

The House of Quality for the pre-application improvement project is shown in Figure 3.

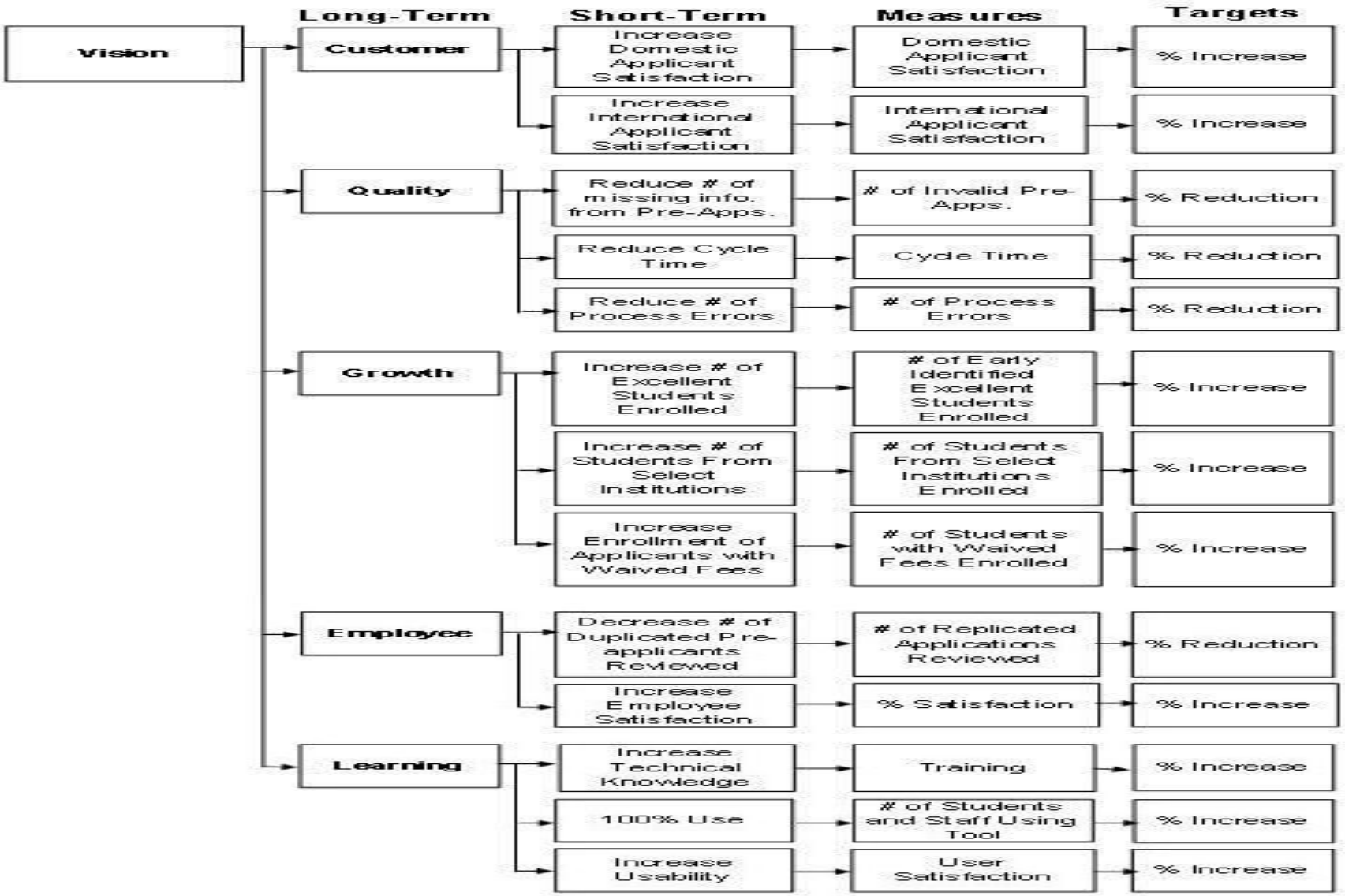

Figure 2; Balanced Scorecard

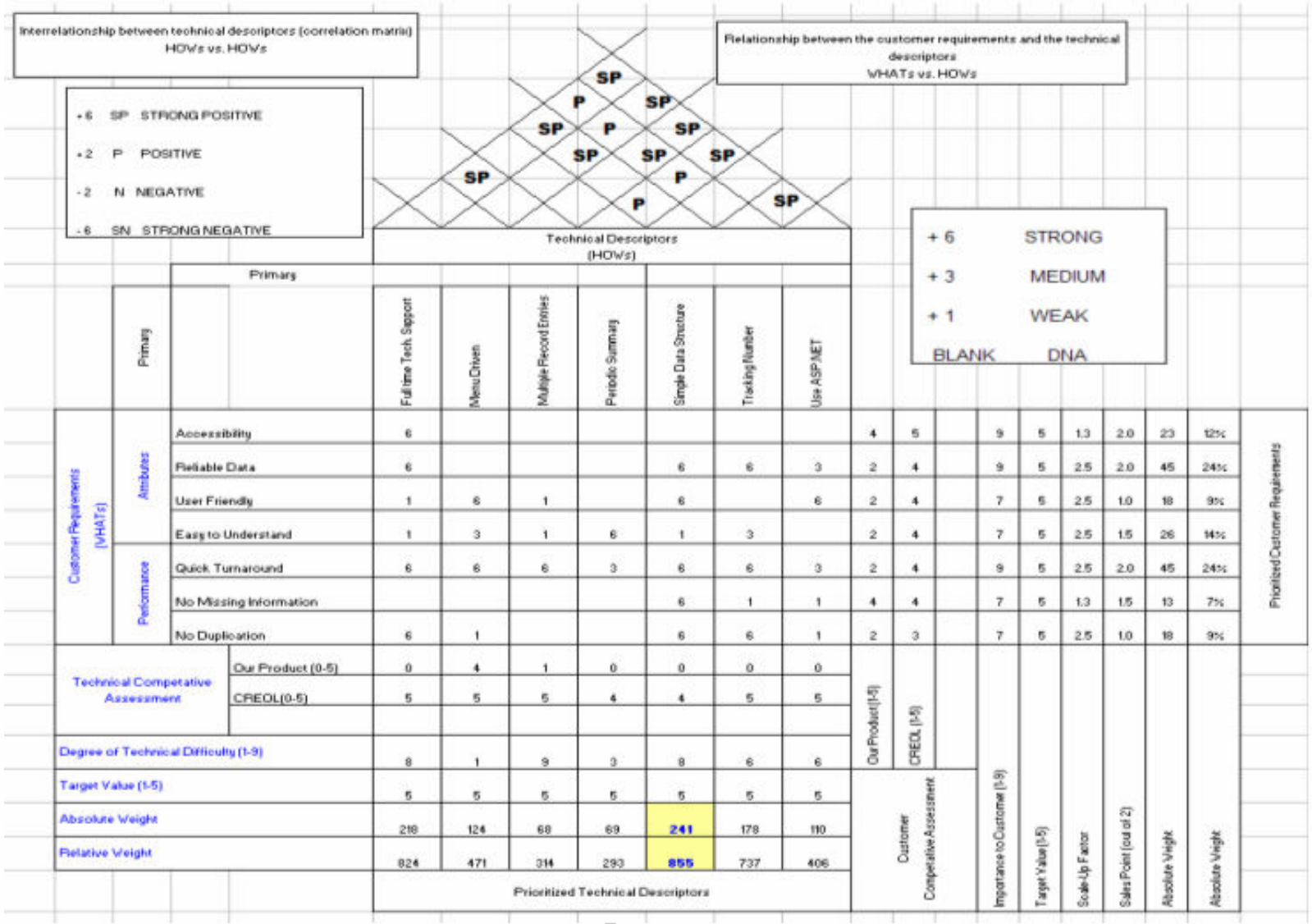

Figure 3: House of Quality

2.2.5 Benchmarking

Benchmarking is defined by Omdahl (1997)[7] as a continuous improvement process in which a company measures the most relevant specific attributes of its products, services and practices. It compares its performance against the best in class and against companies recognized as industry leaders. The greatest advantage of Benchmarking is that it provides measurements of a company's performance compared to the competition, and is an essential part of Six Sigma projects during the Measure and Analyze phases. The information obtained during the benchmarking process is used to improve the company's performance.
As part of the Measure Phase, the Six Sigma team identified the College of Optics and Photonics as a potential organization/department at UCF for benchmarking because they had a pre-application process that was very successful. The Computer Support Administrator from that college was interviewed and the important features of their pre-application process were captured. This information was later used to develop the short and long-term improvement plans.

2.3 Analyze Phase

In the Analyze Phase, the causes for inefficiency in the pre-application process were researched in detail. The Analyze Phase was dedicated to answering the following questions:

1. Is the current state the best state?
2. Who will help make the changes?
3. What resources will be required?
4. What could cause this change effort to fail?
5. What major obstacles will be faced in completing the project?

The following tools were used to facilitate the analysis process:

- Statistical Data Analysis
- Cause & Effect Analysis (Fishbone diagrams).
- Improvement Plans.
- Cost of Quality.
- FMEA (Failure Mode and Effect Analysis).

2.3.1 Data Analysis

Data analysis was conducted on a sample of 83 randomly selected records from the pre-application database. The sample is a distillation of the data – this is essentially a random sampling of the 'good data' available. The fields used were:

1. The pre-applicant's name
2. The department to which they were applying, e.g. Electrical Engineering, Computer Science etc.
3. The date the pre-application was received

4. The graduate coordinator who reviewed the pre-application
5. The date the decision was made by the graduate coordinator
6. The decision:
    a. Invite to apply with waived fees
    b. Invite to apply without waived fees
    c. Not invite to apply
    d. Conditional approval
    e. Decision Pending

The results indicated that 40% of the pre-applicants had been invited to submit an application with fees waived and 19% had been invited without fees waived.
See Figure 4.

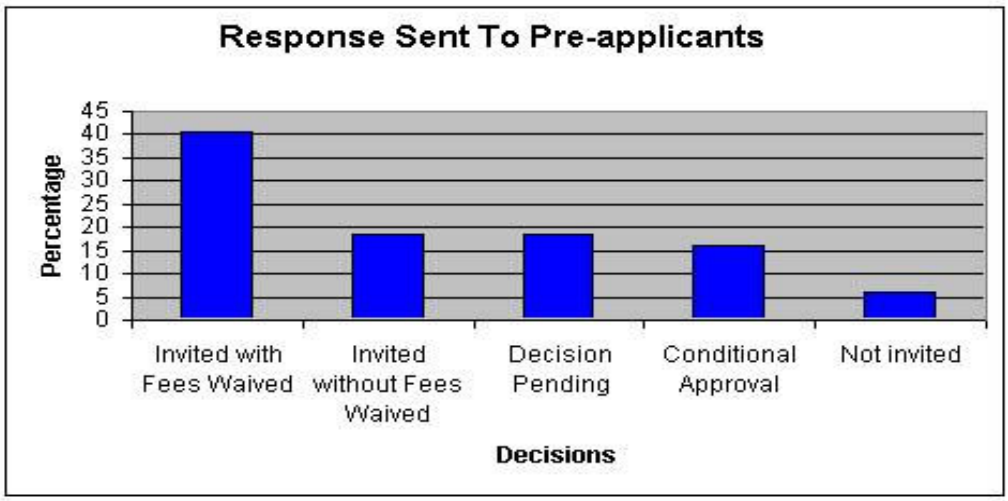

Figure 4: Decision Distribution

The time taken for a graduate coordinator to make a decision was calculated by taking the difference between the date the pre-application was submitted and the date on which the decision was made, taking into consideration only working days and disregarding semester breaks. The results are shown in Figure 5. The longest time taken by any graduate coordinator to process a pre-application was 168 days. The shortest time was 1 day. The mean processing time was 56 days, with a standard deviation of 46 days.

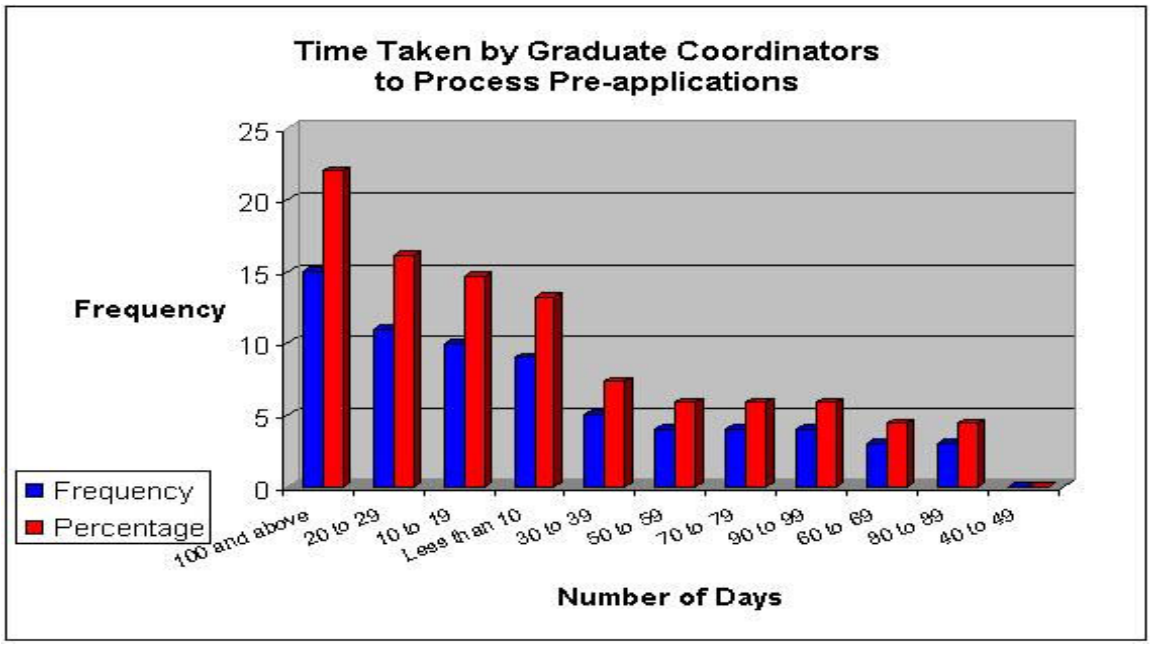

Figure 5: Time Taken to Process Pre-applications

It took more than 100 days for 22% of the pre-applicants to obtain a decision. Only 13% of the pre-applicants received a decision in 10 days, as specified in the pre-application form.

A comparison was made between all departments and only one department processed all their pre-applications in less than 20 days. Most of the pre-applicants who were invited to apply with fees waived still had to wait for more than 100 days for a decision (Figure 6).

40% of applicants were invited to submit an application with fees waived, however only 23% of those who were invited to apply with fees waived were currently attending the College.

To put everything into perspective, it was important to know the distribution of pre-applicants by department (Figure 7).

It was evident from the data analysis that the pre-application tool was not being used effectively – for each use (or misuse) of a tool there is an opportunity cost. The next section discusses how the College could eventually reduce expenses by implementing key changes with minimal economic effects – the cost of quality.

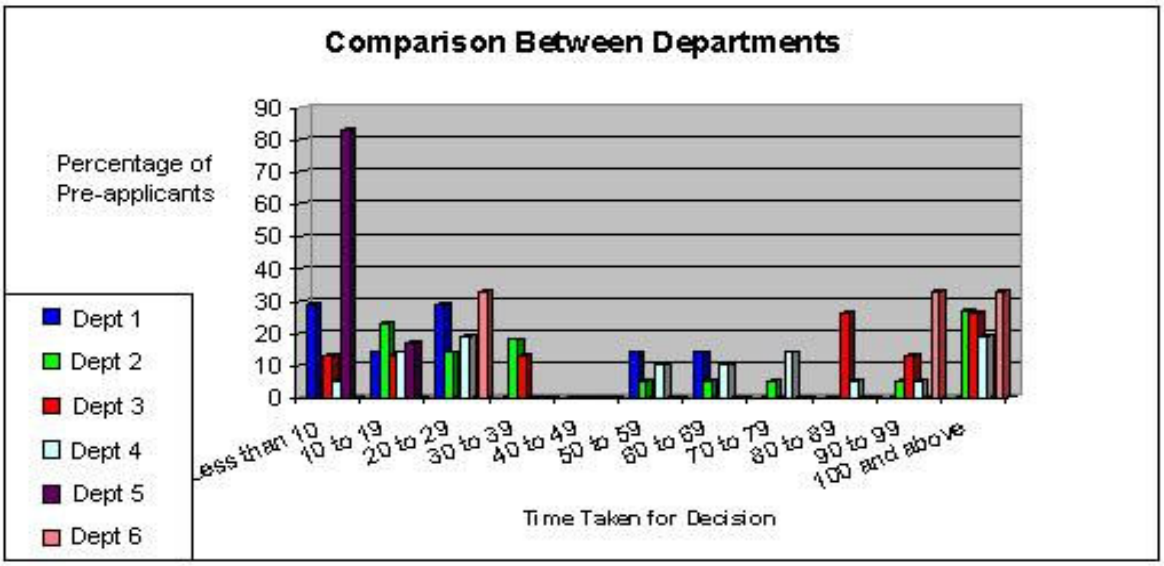

Figure 6: Comparison between Departments

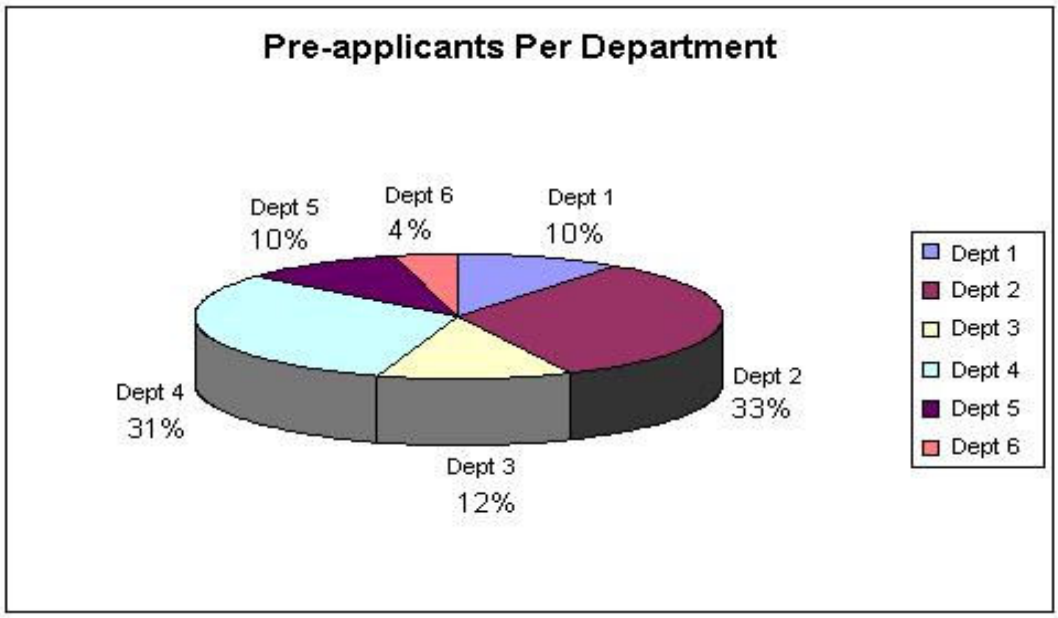

Figure 7: Pre-applicants per Department

2.3.2 Cost of Quality

The cost of quality represents the cost of preventing, finding and correcting defective work. Campanella(1999)[8] defines the following quality costs :

- Prevention Costs: Costs of activities specifically designed to prevent poor quality in products and services.

- Appraisal Costs: Costs associated with the measurement, evaluation or audit of products or services to assure conformance to quality standards and performance requirements.
- Internal Failure Costs: Costs which occur prior to delivery or shipment of the product, or the furnishing of a service to the customer.
- External Failure Costs: Costs which occur after the shipment of the product or during or after furnishing a service to a customer.

The costs of quality can range from 20% to 40% of sales; therefore an early identification can help the business performance significantly. The Six Sigma team focused on the most critical tasks from each of the sections mentioned above. Certain assumptions were made in order to estimate the costs and those were:

- $15 was assigned as the hourly rate for a UCF doctoral student assistant.
- Certain tasks could be performed without hiring a graduate assistant. For instance, the quality data acquisition could be preformed by the Assistant Director of Assessment and Accreditation and procedure reviews could be performed by all the internal customers.

The total cost of quality was estimated to be $15,225 for the first month of implementation. A $7,725 reduction in expenses would be observed during subsequent months of implementation. During the first month, it was assumed that more time would be spent because the process was not under control. Once the process stabilized, the variability of cost from month to month would be minimal.

2.3.3 Process Failure Mode and Effect Analysis (PFMEA)

PFMEA is a systematic technique used to analyze a system, subsystem or item for all potential or possible failures. It can help identify and eliminate concerns early in the development of a process. The process is examined for possible ways in which failure can occur and then the processes can be redesigned so that the new model eliminates the possibility of failure. This tool helps to develop countermeasures to prevent failures. The Six Sigma Team developed a Process FMEA that generated a prioritized root-cause identification list. Those are listed by order of importance.

- Database design and integrity were identified the major concerns or root-causes of numerous problems. The redesign of the pre-application software tool would solve many of the problems associated with the pre-application process.
- Cycle time was determined to be the second major concern. The time consumed on non-value added tasks during the process could be eliminated enabling applicants to receive responses within the specified 10-day time frame and generating a lean process that increases productivity and the level of efficiency.
- Communications between stakeholders was a big problem. A systematic approach for reducing communication barriers was suggested.

- Accountability was another concern. Graduate coordinators are faculty members whose main responsibilities were teaching and research. The necessity of processing the pre-application in a timely fashion had to be impressed on them. That would be a challenge.
- The process had to be properly documented else process standardization cannot be achieved. Documenting the procedure for the process would decrease both the cycle time and the opportunities for mistakes.

A short-term and long-term improvement plans were developed based on the results from the Analyze Phase.

2.4 Improve and Control Phases

During the Improve Phase, additional data analysis was conducted. The short and long-term improvement plans were finalized. In addition a process control plan was developed to perform an ongoing monitoring of the process.

The team chose to create four cause and effect diagrams, one for each of the stakeholders identified in the Define Phase. The tool was used in this manner in order to detail the unique issues experienced by each stakeholder as they performed their individual roles within the pre-application process. Each diagram identified the major issues that contributed to an inefficient process for each the users. The major issues were then collectively considered as the root causes for the inefficiency of the pre-application process, which then became the basis for the improvement plans. The improvement plans suggested both short and long-term actions that contribute to a successful plan that enabled change and improvement. The improvement plans for the graduate coordinators and technical support parts of the process are shown below.

2.4.1 Improvement Plan for Graduate Coordinators Part of the screening process

Short Term:

- The staff from the graduate office should track the pre-applications on a weekly basis and inform the graduate coordinators when those become delinquent.
- Automated email should be sent to the graduate coordinators just before the ten-day period has expired.
- The importance of reviewing the pre-applications in a timely fashion should be made clear to the graduate coordinators.
- Only the applications with complete information would be forwarded to the graduate coordinators.

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- Graduate coordinators should get an automated email once a week to inform them about the status of "their" students.
- The database should be redesigned so as to automate the short-term plan.
- The part of the tool, used by the graduate coordinators, should be redesigned to be more user-friendly.

- There should be some statistical analysis conducted on the data from the pre-application database to monitor its performance periodically. As the performance improves, the frequency of the analysis could be relaxed.

2.4.2 Improvement Plan for the Technical Support Part of Screening Process

Short Term:

- Obtain feedback from users (Students).
- Redesign interface (e.g: Menu driven, Eliminate excess information, Reduce the verbiage on the site)
- Simplify the tool.
- Partner with the College of Optics and Photonics.
- Develop a team from all departments to re-document procedures.
- Have a phone number listed on the website for applicants to call if response exceeds 10 days.
- Send an automated email to the graduate coordinators just before the ten-day period has expired.
- Move historic data into a separate location.
- Remove duplicate and irrelevant data into a separate location.
- List and prioritize applications by precedence.
- Follow-up on people responsible to complete information provided.

Long Term:

- Conduct periodic maintenance services through a technical specialist.
- Continuously update and enhance the documentation to align with tool improvements.
- Assign a full-time expert in software development and maintenance

2.4.3 Control Methods

The control methods recommended by the project team to ensure the objectives set forth in the usage of this tool were met, were surveys, the utilization of the PDCA (Plan, Do, Check and Act) continuous improvement tool, statistical analysis, standardization and storyboard .

Surveys
With the use of Internet surveys immediately after the use of the tool, the College Academic Affairs Office can determine if the usability of the tool meets or exceeds the students' standards. Also, conducting entrance surveys among the entering graduate students and those not accepted, will allow the department to gain a strong understanding to the extent of this tool is convenient and cost efficient.

PDCA (Plan, Do, Check, Act)
PDCA is a continuous improvement tool developed by Shewhart and is also known as the Deming's cycle. It is a helpful procedure to follow for improvement at any stage of the process

(Gee, 2000)[9]. Its implementation in the Control Phase is ideal because it maintains a continuous improvement cycle throughout the life of the process.

Statistical Analysis
Finally, statistical analysis of the number of students using the tool, the number of students that accept the invitation offer, the number of students that enroll, and the number of students that attend the university is necessary to validate the extensive usage of the tool. If the 'bottom line' is to maximize the money spent on recruiting and retaining talented students, it is imperative for the academic affairs office to set up tracking systems, which enable them to see how efficiently they are spending their money.

Standardization
Standardization is a desirable stage for any process. In order to accomplish standardization, the outliers must be eliminated. Once that has been done, the next target is to minimize the process variability, creating a controlled and stable process. Once a process is stable, the potential failures within the processes can be forecasted and anticipated. The CTQ metrics, as well as the Balanced Scorecard metrics, will help the team achieve this stage.

Storyboard
Storyboard is a method used to encourage continuous process improvement by spreading the success stories of accomplished goals within organizations. Its main purpose is to motivate improvement.

4. Conclusion

The Lean Six Sigma methodology proved to be an excellent choice in the implementation of the pre-application project. The benefits were two-fold. First, the team learned a lot about teamwork, accountability, how to establish a Six Sigma project, the different roles within a Six Sigma project, the DMAIC process and the choice of the right tools during each phase of the project. They learned how to integrate lean concepts into a project and how to use a very structured approach to solve problems. They also saw first hand the application of the Six Sigma methodology in the service industry. Surely, those are skills that will serve them well in the future. Second, the project was of benefit to the College of Engineering and Computer Science. Breakthrough improvements were made in the cycle time. The following steps were identified as necessary for the successful improvement of the pre-application process.

- Implement suggested improvements.
- Train users in accordance to changes that will be made in the system.
- Measure and control the process through the use of surveys, PDCA (Plan, Do, Check, Act) and statistical analysis to ensure that the process is operating at the desired level.
- Continuously seek process improvements.

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