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Six Sigma Analysis: The Design and Implementation

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Abstract

The purpose of this project was to gain a strong understanding of Six Sigma management philosophy, concepts, and practices and to apply this knowledge to creating a Six Sigma academic course or training program. This was done through three main methods: preliminary research and data collection, the creation of a design model for Six Sigma academic course/training program establishment, and the creation of a Six Sigma academic course/training program syllabus. The preliminary research consisted of conducting a Six Sigma knowledge survey with the students of Worcester Polytechnic Institute, interviewing a Six Sigma expert, and examining current Six Sigma educational programs in other universities, businesses, and organizations. As a result of our observations, we determined that Six Sigma has become a large part of many companies and should be implemented into more engineering programs at universities nation-wide, including Worcester Polytechnic Institute. This can be done through a project based course, as well as more Six Sigma based Interactive and/ or Major Qualifying Projects.

Acknowledgements

First and foremost, we would like to thank Professor Joe Zhu for guiding our progress and advising this project. His encouragement and interest in our project assisted in the smooth operation and timeliness of our activities. We would also like to thank Alison Howett, Six Sigma Expert from Raytheon, for taking time to answer on questions and offer our team a considerable amount of information regarding Six Sigma in a corporate entity. Our team also thanks and acknowledges the student body of Worcester Polytechnic Institute, for taking the time to address our survey and answer our questions thoroughly. Thank to you all other individuals that aided in the completion of this project, we greatly appreciated your help.

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Executive Summary

Six Sigma is a continuous quality improvement methodology created by Motorola in the 1980s, and developed from the concepts of Total Quality Management. The Six Sigma architects at Motorola focused on making improvements in all operations within a process in order to eliminate wastefulness and defects, producing results far more rapidly and effectively than traditional strategies offered. Today, this strategy can be seen in companies all around the world. Customer satisfaction is the underlying concern of companies, and Six Sigma is a way to ensure that customer satisfaction is being met. Despite the attention given to Six Sigma, there is still not enough proper training. There are a small number of universities that offer Six Sigma training. Worcester Polytechnic Institute does not have a formal Six Sigma course or training program.

The overlying goal of this project was to create a training program/academic course template at the university level that can be used in the creation of a Six Sigma academic course, resulting in a larger student participation level and knowledge base of Six Sigma. Before a new strategy could be created, our group had to increase our knowledge about the topic. This was accomplished by researching the fundamentals and background of Six Sigma as well as existing Six Sigma training programs and academic courses used by successful universities and corporations. Literature written by Six Sigma experts provided our group with solid foundation to build our design model. In order to gauge the current knowledge of WPI students in the area of Six Sigma, a survey questionnaire was sent out to the entire student body at Worcester Polytechnic Institute. Due to the fact that neither group member had gone through formal Six Sigma training, interviews of Six Sigma experts were conducted to gain information about the different Six Sigma approaches. Effective use of existent resources was an important aspect of this project.

Assessment of the current Six Sigma courses and training programs began with conducting evaluations of five current Six Sigma academic programs and three independent Six Sigma training programs. Through these evaluations, the group was able to determine the important aspects covered in all of the programs. It was also noted that each of these programs tended to be different and cover different aspects more than others, due to difference in

certification level or program intent. This gave the group a solid understanding of Six Sigma through many different perspectives.

This preliminary research prepared the project group to create the Six Sigma training program/academic course design model. The main focus of this model was to observe the critical components of Six Sigma, determined by the group through their research. This was broken down into six steps: 1) The Training Mission, 2) Structural Design, 3) Staffing Design, 4) Educational and Industrial Resources, 5) Participant Performance Evaluation Measures, and 6) Training Program Evaluation Measures. This led to the creation of the Six Sigma training program/academic course syllabus. This included the complete blueprint of the course, including structure, course books, and organization of the program.

Furthermore, a set of recommendations was provided to aid in process of creating a Six Sigma academic course or training program at Worcester Polytechnic Institute. The recommendations were primarily based on our observations and interpretation of the results gathered via the questionnaires, interview, and current program evaluations. These recommendations summarize the conclusions that can be drawn from the information obtained.

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Quality

Quality is a necessary characteristic for Industrial Engineers to observe, study, and understand. Process improvements often begin at an analysis of the level of quality in a system or organization. For organizations that offer products and services to customers, a system within this company is a process that produces, maintains, or supports a product or service. According to Kirkpatrick (1970), "a system is a physical or conceptual entity comprised of interdependent parts that interact within boundaries established to achieve some common goal or goals." Outputs of systems include products, services, or components to create products and services. An example of a system would be a manufacturing line that produces the raw materials for product prototyping, or the process at a hospital that supports incoming emergency patients. In both examples, the quality of each system can be analyzed independently from its contribution to the whole facility of organization. This definition of system aids a proper definition of quality within the realm of Industrial Engineering topics. According to El-Haik (2005), quality can be defined as "the degree to which the design vulnerabilities do not adversely affect product performance." It is important to note that this definition is universally applicable to not simply products and product design, but also service and service process design. Also, the design vulnerabilities of a product or service can either be inherit in the type of product or services being created, or perhaps established by improper conceptual design. Regardless of which type of vulnerability may exist, the quality of a product or service is only decreased when it affects either the process that creates it by increasing costs, time, and constraints, or by affecting the end product or service that a customer uses. This implies that quality is not merely achieving the perfection of a product or service, but rather, high quality is achieving perfection of product or service performance, or getting as close to it as possible.

In spite of this definition of quality, it is also necessary to identify the determinant of quality for a product or service. In some situations, the quality of a product or service is determined by the individuals in the design sector. Often, decisions of product characteristics are decided by top management, and these decisions are based on their view of how well a product or service should perform, as well as what types of functionalities the product or service should have. From a total quality management perspective, the quality of a product should have many determinants, other than opinions of top management and the designer intention.

> According to Charbonneau and Webster (1978), to properly understand a concept such as the quality control function, it is important to understand the concept of quality in a broader perspective. Essentially, quality is established by the customer, and the product or service designed and manufactured for sale is intended to meet these customer requirements. Inferior quality, as indicated by the appearance or performance, is ultimately reflected in its relation to the customer. This includes sales increases, declines, and if not corrected, can potentially lead to the termination of a product, service, or organization altogether.

As quality is approached from a customer satisfaction perspective and an organizational ideal, rather than a simple product requirement, it can be conceptualized as a product or service characteristic that is affected by several types of organizational processes, from production processes and manufacturing concerns, to managerial implementations of quality assurance and company mind-states. According to Charbonneau and Webster (1978), "the total quality control concept was originated by Dr A.V. Feigenbaum in the 1950's, and is difficult to teach because it is much a "state of mind" as it is a "course of action." It involves all organizational members—from top management to hourly workers—with the concept that product quality should be the first and foremost initiative in everyone's mind. More specifically, product quality is defined as "the composite product characteristics of engineering and manufacturing that determine the degree to which the product in use will meet the expectations of the customer." When the quality of a product or service is understood to be affected by components beyond manufacturing, philosophical concepts and managerial theories are developed and become methods for organizations to improve on the quality of a product in addition to pure mathematical calculations, applicable to all processes within all systems. This evolution of quality as understood in Industrial Engineering disciplines has paved the way for theories and concepts such as Total Quality Management, Six Sigma, Just-In-Time (JIT), and other managerial process and quality improvement methods established around the premise of customer satisfaction by continuous quality improvements.

It is important to note a primary figure to the total quality management approach, before addressing its major components. This figure established the fundamental theories that form the base for the quality management programs, requirements, and initiatives of today. The philosophies of William Edwards Deming focus on the same notion stated earlier, which is that quality is the main determinant of a company's success, and is influenced by several components of an organization and its systems. In addition to this, Deming went against the popular business conception of quality and its relationship to a company. Deming, a college statistician and pioneer of total quality management theories and practices, used this concept of quality as an instrument to increase the productivity and success of organizations throughout Japan in the 1950s, as well as production improvements during World War II here in the United States. The varieties of methods in which this quality concept can be implemented into an organization are solely dependent on the organizational mind-state. According to Aguayo (1990), "one of the most fascinating aspects of Deming's teachings, one that radically departs from conventional thinking, is his treatment of the relationships among quality, costs, productivity, and profit. According to Deming, as quality is increased, costs decrease." This is fundamentally different than the typical business concepts taught in many management majors, which insist that an increase in quality comes at a cost to the company as a decrease in profits. According to Aguayo (1990), Deming's philosophy of quality can be broken down into four axioms:

1. Quality and costs are not opposites, or trades-offs, with one being improved at the expense of the other. Instead both can be constantly improved.

2. The meaning of quality is different from conventional views that mistake exotic materials and fail-safe designs for quality. In Deming's view, quality is best understood from the point of view of the customer, but one important component of quality is improvement of uniformity.

3. Variation is a naturally occurring phenomenon. It is not an exception or fault. Variation is treated differently depending on whether we are dealing with a stable or unstable system. A stable system creates both success and failures. Lowering the number of defects in a stable system can only be achieved by working on the system

4. Cooperation is a fundamental ingredient that leads to improvement. Competition is often at work and helps determine which products and which companies survive, but there are times when competition is irrelevant and times when competition is inappropriate

Quality Control & the Quality Control Function

Quality has a rather distinct definition when related to engineering fields and processes. An understanding the fundamental properties of quality and its relation to Industrial Engineering bridges the gap between what quality is and the quality improvement methods that have been developed in many Industrial Engineering disciplines over the years. Traditional views of quality control led to the development of statistical and mathematical models that may directly increase the quality of production for a product. These models focused on increasing quality after design specifications and requirements were made. This approach focuses on maintaining a desired variability range for a product as it is produced. This acceptable range is usually determined by the design engineers prior to the initiation of production. According to El-Haik (2005), quality loss has two ingredients: quality loss due to unwanted variability within a production process and loss due to deviation from the original target design specifications and requirements. Maintenance of the quality level for a product was originally focused on the production process for a product. Methods to achieve high quality involve mathematical and statistical calculations to produce a desired variability range in the production process and maintain a low level of defects and complications. These methods are post-production oriented, and involve catching problems after they occur. Although these processes maintain the level of quality in a product, the benefits of these processes are limited, mainly because this view of quality control is restricted to the scope of production, and after all design parameters have been determined.

Before the beginning stages of the production process, engineers are focused on creating and designing a product, and there are certain characteristics and guidelines that a production process would have to meet in order to ensure that the product operates as it is supposed to. These guidelines are related to safety of production, defect levels in a product, and variation parameters, which are all set by the engineers prior to production initiation. The processes that engineers go through in order to set these parameters for a product can be tied into quality control if done properly and efficiently. Even within the manufacturing realm, the idea of quality is still related to the customer, because these products still have to meet customer needs and desires. According to Kirkpatrick (1970), "the control of product quality is a function of two related activities of the production system." The first activity involves the development of the general and technical specifications for the product. The second activity is the assurance of product conformance to the technical specifications. Quality control begins at establishing the specifications, technical properties, and functionality requirements of a product. This step allows for engineers to focus on creating a product that their system can support and maintain. This maintenance is limited by the financial and technical resources allocated and willing to be allocated for a product by an organization. Future resource allocations for product quality should also be considered during this first stage. High quality can be achieved at low costs if all dimensions of the product can be controlled by the resources an organization already has. In addition, if this control is initiated prior to the production of a product, the control level is greater and more effective. Quality becomes a complication and potentially a cost liability for a product when resources outside of the company have to be gathered in order to raise the quality of a product to an acceptable level. This means that before initiating the production of a product, it is important to assess how well the current system can support the product's quality, and whether or not this is sufficient for the customer. This beginning process can define how difficult or how easy it is to maintain the quality of a product after production is initiated. Quality models such as inspection programs are more of supplementary criteria to quality enhancement rather than a determinant of it. After the proper considerations are taken by an organization, quality control can be most efficient and successful.

As previously mentioned, traditional quality control strategies focused on the production aspects of a product, and mostly involved processes in the manufacturing industry. The quality control processes used to maintain the quality of a product during the production process include, but are not limited to, routine inspections, defect analysis, product reworking, materials handling, and production process control. These activities focus on maintaining the predetermined quality specifications made by the creators of the product or service. The frequency of these activities in manufacturing facilities led them to be incorporated into a combination of uniform mathematical and statistical analysis techniques applicable to many different manufacturing environments. These techniques, when combined, create an engineering principle called the Quality Control Function. This function has the following characteristics:

> According to Charbonneau and Webster (1978), “the quality control function exists primarily as a service organization, interpreting specifications established by the product engineering and assisting the manufacturing department in producing to meet these specifications. As such, the function is responsible for collecting and analyzing vast quantities of data and presenting the findings to various other departments for appropriate corrective action.”

The quality control function can be properly viewed as a set of quality maintenance activities, and not necessarily a set of quality enhancement activities. It is important to stress this observation because it highlights the limitation of traditional quality control activities as process improvement strategies that occur mostly after product design and production initiation. This is a limitation because the quality of a product is largely determined prior to its production initiation. According to El-Haik (2005), “traditional quality practice is devoted primarily to the downstream portion of the design process, with emphasis placed on inspection schemes. The concentration is currently shifting upstream to the concept design stage.”

According to Kirkpatrick (1970), the quality control function is a collection of activities within a production system. Sales, purchasing, product design, process development, manufacturing, inspection, are all functions of the production line, with sub-activities directly related and devoted to the quality of a product. The quality function focuses on the technical activities that support the quality of a product. These mathematical and statistical models support such decisions as the calibration of the tools and machines used to create a product, methods of handling the materials used to create a product, the manufacturing process used to compose the product, and the inspection techniques used to ensure the product is meeting the intended quality specifications during production and post-production. Included in the quality control function are several variance analysis techniques for certain variance parameters and requirements. According to Aguayo (1990), “when Walter A. Shewhart, the father of statistical quality control, first began to track the problem of quality at Bell Laboratories in the 1920s, he emphasized the need to minimize variation and understand the sources behind variation.” As previously stated, a certain level of variation may be beyond the control of quality maintenance strategies, and it is important for a quality analyst to identify the sources of variation that can be controlled within the production process, and make the necessary decisions to maintain this control.

Contrary to the traditional quality control techniques is a problem prevention approach as a means to reach high quality in products. This concept and process stresses the importance of product control from the beginning of the product life cycle to the end, as a method to ensure that the quality of a product meets its intended desire and specifications of the organization, as interpreted from the customer. This involves not only the quality of the product or service, but the quality of the entire process leading to the product's production, and including all activities after the product's production. According to El-Haik (2005), "design decision making has a significant impact on lead time, function and form, quality, and cost of the end result. Studies suggest that decisions made during the early stages of the design phase commit 80% of the total costs associated with developing and manufacturing a product." Quality is related to all aspects of a product, and not simply what occurs on the production line after parameters have been decided. The early stages of product design and specification affect the costs related to quality far in the future, so many successful quality increasing implementations begin at the design stage, before the product enters production. This also allows production and inspection quality analysts to focus on the dimensions of quality specific to the production process, and not worry about design related quality issues, because they were previously addressed accordingly. This also assists the technical focus of the statistical models for the production aspects.

True quality control involves all stages of a product, and this gives light to the theory that quality is not simply affected by production processes, but all activities before and after the production process as well. According to Kirkpatrick (1970), "quality control is a staff function, whose objective is to coordinate the production facilities to produce a product at the quality level defined by the design specifications. In addition, the quality control department should not attempt to assume the individual quality responsibilities that are integral parts of the day-to-day work of the line, staff, and function groups which hold them." Statistical and mathematical processes only reinforce the improvement of quality, but alone, do not achieve the total quality requirements for a product. This definition of quality control transforms the traditional outlook of quality in production and broadens it to involve all organizational decisions for a product. This involves all planning, inspections, defect analysis, manufacturing processes, and post product production operations related to the product. More importantly, this involves all of the organizational strategies taken to increase the level of quality in a product, such as training, team-building, and management leadership. The concept of addressing factors outside of the production line for a product as contributors to quality improvements comes from this understanding of quality control. Developed from this understanding is a theoretical and practical concept that has shifted the way the industrial world views quality, and its relation to products and services.

Total Quality Management

Industrial Engineering focuses on process improvement in both the engineering and managerial aspects of an organization achieved primarily by mathematical models, quality control functions, and management techniques applicable to many engineering products, services, systems, and organizations. There exists a management topic within the Industrial Engineering field ties together process improvement, philosophies of quality & quality control, best practices in engineering and management, and several other components related to the quality output of an organization as a whole. This concept is called Total Quality Management, or TQM. According to Sakthival (2007), "the TQM model is considered as an integrated system of principles, methods and best practices that will provide a framework for organizations to strive for excellence in everything they do. The concepts and principles of TQM, which are effectively used in today's competitive production and business environments, have become indispensable in today's business of higher education." Total Quality Management is a method for an organization to effectively implement quality enhancing strategies into their functional systems, as well as their managerial departments, in order to maintain continuous improvements of quality for all products and services. This implementation of quality improving initiatives can be facilitated not only by mathematical processes and models, but organizational consistency and excellence. Total Quality Management involves theories and practices that are crucial to quality improvement in a variety of organizational systems, and these systems range from manufacturing systems producing medical components for a medicine distributor, to modifications in patient query processes in hospitals to ensure that the hospital is supporting its community as efficiently and as effectively as possible. According to Lo and Sculli (1996), "during the last decade or so, the world has also seen considerable developments in the pursuit of quality; the concepts of total quality management have evolved and standards such as the ISO 9000 series have been established. These quality concepts cover a wide range of operations, ranging from final product inspection to the inspection of purchased parts and raw materials, and even personnel selection." The development of TQM concepts into international standards such as ISO 9000 is one of the many examples of TQM concepts influencing the design and practices of an organization. Within these standards and other quality management material are several variations of the original principles of Total Quality Management, created by William Edwards Deming. Total Quality Management as a theory was developed from Deming's 14 Points for Management.

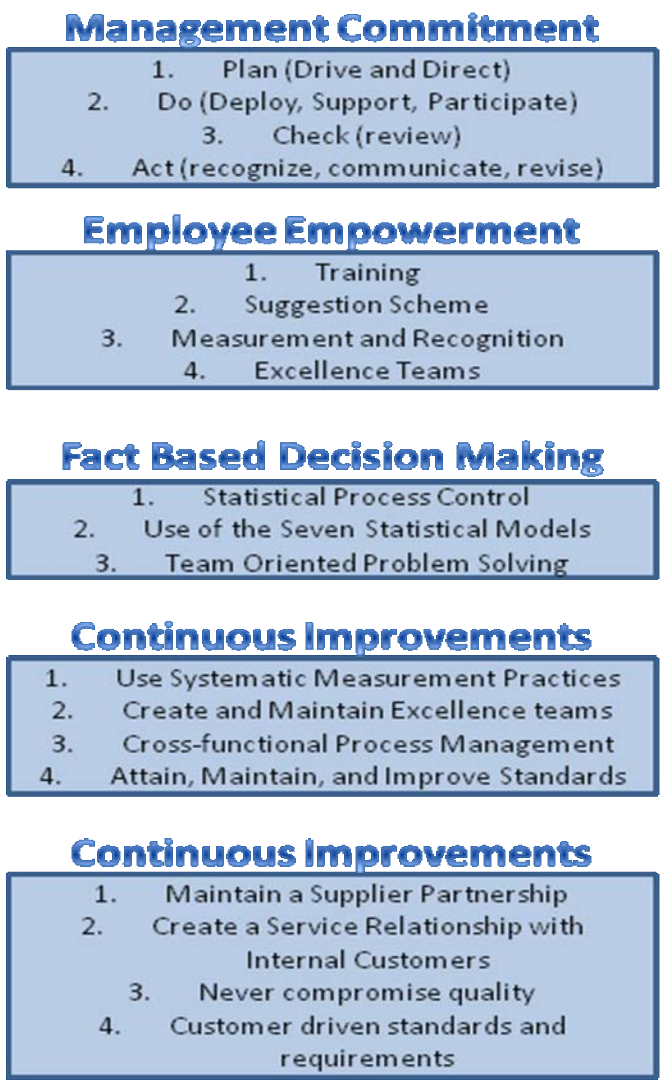

Figure 1 – Principles of Total Quality Management, Martin (1993)

Figure 1 is a summarization of this theory into a set of Total Quality Management principles, applicable to many types of organizations. These principles combine all aspects of quality management, from mathematical processes, to organizational management tasks. Such mathematical processes included in the Total Quality Management principles are the seven statistical models for quality assessment. According to the Tague (2005), these seven basic models are:

1. Cause-and-effect diagram (Ishikawa or Fishbone chart): Identifies many possible causes for an effect or problem and sorts ideas into useful categories. Good management brainstorming technique for identifying root causes of an issue.
2. Check sheet: A structured, prepared form for collecting and analyzing data; a generic tool that can be adapted for a wide variety of purposes.
3. Control charts: Graphs used to study how a process changes over time.
4. Histogram: The most commonly used graph for showing frequency distributions, or how often each different value in a set of data occurs.
5. Pareto chart: Displays on a bar graph which factors are more significant.
6. Scatter diagram: Graphs pairs of numerical data, one variable on each axis, to look for relationships between pairs of data.
7. Stratification: A technique that separates data gathered from a variety of sources so that patterns can be identified. These can also be referred to as flow charts or flow diagrams containing large amount of data.

Implementation of Total Quality Management Models

Total Quality Management involves all functions within an organization, accompanied with the concept that quality is affected by all divisions, departments, and operations in an organization. In recent years, TQM has become the primary approach for organizations to understand and address the dimensions of their systems that affect quality. From small industrial companies to Fortune500 organizations, Total Quality Management has become a fundamental theory and practice, enhancing quality improvement initiatives into more developed and detailed quality models. These TQM concepts have the power to increase the profitability and competitive-edge of an organization, as well as support a healthy and structured company environment. Despite these improvements offered by TQM, the implementation of a TQM model into an organization is not as simple as believing in TQM theories and placing the model into practice. Although the benefits and rewards from implementing a total quality management system are clear and distinct, the methods of implementing a complete TQM model into a company have less definition and detail, and at times, none at all. As the manufacturing community began accepting the notions of Total Quality Management, many management employees began attending conferences, seminars, and courses teaching the characteristics and concepts of a total quality management system (Aravindan & Devadasan, 1996). The industry began to pay close attention to quality management experts due to the potential advantages of implementing a total quality management model into their organizations. This trend began to spread into the global market approximately thirty years after the birth of total quality management in the 1950s, and many corporations began to implement TQM concepts into their processes and management disciplines. However, According to Aravindan and Devadasan (1996), "ten years after the TQM movement gained momentum, manufacturers and quality managers started to re-examine the real benefits accruing from it. In this context, it was realized that exhaustive research work, covering the study of the present status, with a firm commitment to develop practical implementation strategies of TQM, was found to be necessary."

Transforming the concepts of total quality management into physical processes within a system is a difficult task. It involves exhaustive research of total quality management by an organization and well established, knowledgeable management leadership to guide implementation. In addition, these concepts are best understood through an academic discipline or certification curriculum, because so many different mathematical models and management practices are involved in total quality management. The ability to apply the statistical models and management techniques of TQM to a specific industry or organization is enhanced through academic training regarding the material. This training focuses on implementation techniques and strategies that are concrete and effective, especially if they are accurately performed. For this reason, total quality management is a primary topic in many Industrial Engineering programs, and also because of its relation to principles of Industrial Engineering regarding process improvement and quality.

> According to Eskandari et al (2007), "While the types of industries where industrial engineers are working are evolving, changes in the types of roles and responsibilities that Industrial Engineers are performing within these industries are occurring as well. Given these anticipated changes in industries and consequently in the types of assigned roles, Industrial Engineering (IE) programs need to revise their curriculum to educate

and prepare students to meet the future needs of today's rapidly changing industrial workplace."

Total quality management is changing the organizational and operational structure of industrial systems currently in place today. Industrial Engineering programs, in order to stay accurately representative of its student's position in the industry, need to shift the focus of programs towards teaching the principles of total quality management and other relevant improvement strategies practiced in the industry, thoroughly. These programs should address the principles of total quality management, methods of implementation among various industrial systems, and also assess the types of difficulties that organizations face when implementing total quality management theory and practices.

The Shift to Six Sigma

Criticisms of total quality management will assess that a focus on quality improvement does not always guarantee successful processes and procedures that will increase the performance and productivity of an organization. In addition, processes to increase quality cost money, especially if they are activities that react to problems instead of preventing problems, as discussed earlier. With this in mind, it would seem as if total quality management is an insufficient means of achieving better quality. After all, better quality has the intent of increasing sales and profit for an organization, and all of the quality models have a desired end result of improving profitability for an organization, but under a total quality management strategy, an organization may actually harm their processes more-so than improve them, due to the assumed costs, effort, and cooperation that is necessary. Also, the assumption that improving the quality of a process alone will immediately result in better sales is a poor assumption, because there are quality improvements that the customer may never see or be directly affected by. Total quality management addresses the concept of customer based improvements, but many of the models are production based improvements, with very little to do with the overall operational processes in an organization, which are more management driven. According to Aguayo (1990), "to try to justify long-term actions on the basis of their impact on the balance sheet is the modern equivalent of determining how many angels can occupy the head of a pin. Costs and payoffs are important no doubt about it, but there are not enough and in many cases are just useless or deception. The projected return for a given course of action depends on the assumptions and inputs. Any way you look at it, it's a guess. But if a company loses sight of where it is going, which should be improvement in the standard of living of its customers, it will surely suffer along with its customers." Although total quality management concepts and theory confirm that all organizations should focus on providing customer-driven products and services, the main statistical models of total quality management have no means of addressing the considerations of the customer directly. This flaw in total quality management limits the usability of its processes, and calls for the need of a more management oriented quality improvement strategy.

Total Quality Management is a system of management strategies involving broad scale of quality enhancement techniques focusing on an organization's production processes. From this concept, stems another management technique that incorporates quality as not just affected by the organization, but also all entities functioning with the organization, within the organization, and outside of the organization. According to Harry and Schroeder (2000), "Six Sigma is not merely a management concept, but a business process that allows companies to greatly improve their minimal performance criteria by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction." This notion of everyday improvement is beyond the scope of concepts and strategies of the total quality management. Six Sigma was originally a quality concept created to minimize the defects of a production process to a certain variation, called six sigma. This concept developed into an organizational ideology and philosophy that incorporates all management, customer, and business related activities as potential contributions to defects in a system. A defect, in a production line, can be defined as any attribute that goes against the design specifications of a product or service and causes this product or service to not satisfy customer expectations. In Six Sigma management theory, a defect is any wasteful process in an organization or connected to that organization that either negatively affects or has no effect on the quality of an end product or service or doesn't affect it at all. Unlike total quality management, Six Sigma management attempts to address all issues that are not value adding to the organization and all relationships that are not value adding. According to Harry and Schroeder (2000), "the difference between previous total quality approaches and the Six Sigma concept was a matter of focus. Total quality management (TQM) programs focus on improvements in individual operations with unrelated processes. The consequences is that with many quality programs, regardless of how comprehensive they are, it takes many years before all the operations within a given processes are improved. The Six Sigma architects at Motorola focused on making improvements in all operations within a process, producing results far more rapidly and effectively." By definition, Six Sigma can be seen as total quality management in an even larger scope than TQM attempts to address, by redefining the relationship between quality and organizational profits. The Six Sigma management concept, when implemented concisely and thoroughly, is more of a self-sustaining engine that raises the profitable income of a company by reorganizing and restructuring its processes, operations, and way of business by striving for highest profit at lowest costs continuously.

The importance of statistics in Six Sigma is the final connection that needs to be made between Six Sigma and the business world. The name "six sigma" itself is derives from the statistical concept that the defects of a production system, process, or procedure maintain fewer than six sigma defects. Statistics can provide mathematical representations of either a problem or a solution within an organization of company. It is always important to be able to back up any conclusions about a particular process with proof of its effectiveness or its shortcomings. Proper use of statistics allows for this type of evidence. According to Harry and Schroeder (2000), "Once people get beyond the symbols, formulas, and charts they usually find that statistics make problems (and the questions) much clearer and simpler…It's really the simplicity of statistics that allows us to measure, improve, and monitor the processes within our organizations. Statistics are a tool that separates commonsense reasoning from extraordinary reasoning...Statistics allows companies to collect data, translate that data into information, and then interpret the information so that decisions can be made based on fact, rather than intuition, gut feel, or past experience. Statistics create the foundation for quality, which translates to profitability and market share." Statistical analysis techniques allow a company to draw a detailed and concise picture of the problems plaguing their system. These problems can then be addressed head on by engineers and management personnel in an effort to solve the problem and increase revenue for the company. Usually, when the problem is clear and understand by top management, decisions to remedy the problem are just as clear. This leads the organization on the path towards perfection and reduction of defects and waste producing processes in their systems.

Target Audience

The term target audience can be defined in many ways. The most appropriate context to interpret the phrase in this project would be “The consumer group most likely to buy a specific product and identified by region, age, demographics, or economic status. Determining who the appropriate audience to reach trying is an essential part of formulating any new idea. Without defining the proper market, it is nearly impossible to accurately devise a plan to successfully create a new product or idea. This is particularly important when dealing with the creation of a new college course or training program.

For this particular project, the target audiences needed to be initially broken down into two sections: external and internal audiences. The external audiences were determined from our research of the manufacturing industry and education field. It was determined that the audience for this particular project is students, professors, or any other individuals interested in entering the manufacturing industry, particularly those people interested in engineering or operations. More generally, a new college course or training program would be reaching out to individuals that are interested in furthering their knowledge in the particular topic, in this case Six Sigma.

Internal audiences were determined from our research as employees of the educational institution or leaders of the particular training center. This includes professors, department heads, or any other faculty member that may be responsible for teaching this course. It is important to be aware of who would be needed to facilitate this new idea.

Raytheon Six Sigma:

Raytheon is a company that focuses on national defense and homeland security. There are more than 72,000 employees around the world. In 2007, they had 21.3 billion dollars in sales. Raytheon is broken up into six major business units: Integrated Defense Systems, Missile Systems, Intelligence and Information Systems, Network Centric Systems, Raytheon Technical Services Company LLC, and Space and Airborne Systems. These business units offer a wide range of products and services to the government as well as other customers. Raytheon’s corporate vision is “Aspiring to be the most admired defense and aerospace systems supplier through world-class people and technology”.

Six Sigma is a prominent aspect of Raytheon’s corporate culture. “Raytheon Six Sigma™ is the philosophy of Raytheon management, embedded within the fabric of our business organizations as the vehicle for increasing productivity, growing the business, and building a new culture. Raytheon Six Sigma is the continuous process improvement effort designed to reduce costs" (Raytheon Website, 2008).

Raytheon Six Sigma can be best defined by six major steps—visualize, commit, prioritize, characterize, improve, and achieve.

Figure 2: Raytheon Six Sigma Chart

http://www.raytheon.com/ourcompany/r6s/r6s_process/index.html

Raytheon's Six Sigma training has three distinct levels. There are specialist, expert, and master expert training levels. Specialist training is done in addition to ones regular position at Raytheon, while expert and master expert training is done as a full-time job. The breakdown of time each training takes is below.

1. Specialist – 30-60 days
2. Expert – 1 year
3. Master Expert – 2 years +

Specialist training and qualification is a requirement for all employees at Raytheon. For expert training, employees can choose to do it, it is not a requirement. In fact, there are very advanced screening processes to get into the expert track.

Raytheon Six Sigma training focuses on both theory and concepts and the statistical processes. Each Six Sigma certified employee is expected to demonstrate the ability to put the theories learned into practice. There are many different books used during the training, but some of the most important are:

1. The Goal by Goldratt
2. The Profit Zone by Slywotzky, Morrison
3. Getting to Yes by Fisher, Ury, Patton
4. Clockspeed by Fine
5. Innumberacy by Paulos
6. Design for Six Sigma by Creveling, Slutsky and Antix

Figure 3: Raytheon's Business Strategy

http://www.apqc.org/portal/apqc/ksn/Raytheon_customer_article.pdf?paf_gear_id=contentgearhome&paf_dm=full&pageselect=contentitem&docid=120671

Six Sigma was introduced at Raytheon in 1998 by Daniel Burnham. He brought this theory to Raytheon from AlliedSignal. As of 2005, there were over 46,000 Raytheon Six Sigma Specialists, 1,200 Raytheon Six Sigma Experts, and 50 Master Experts. There was also 9,000 senior-to mid-level trained leader. Raytheon estimates that Six Sigma has provided them with 3.8 billion dollars in financial benefit. Six Sigma also provides a common language and culture for the entire company.

Organizational & Educational Training

Training Theory

What exactly are the benefits of training and why do organizations feel they need it? Training, especially in corporate America and the business world, is seen as a method to teach new and old employees how to properly perform job duties and tasks for an organization. Certain job duties require knowledge of large amount of material, and these duties are not easily performed without guidance or training. At times, it may even be impossible to perform certain tasks without proper training. Training becomes important to an organization when the productivity or performance of the employees either needs improvement or maintenance. With regards to productivity and performance, training can be a means of addressing company operations that do not meet previously calculated expectations. In addition, training can also be a means of teaching a new process or set of operations for employees to follow. When the quality of a process decreases, training can be used to address this issue. Training programs can be used to address issues pertaining to productivity, performance, and quality. According to Steinmetz (1976), "man has the ability to pass on to others the knowledge and skill gained in mastering circumstances. In the past, this was done by deliberate example, by signs, and by words. Through these devices the development process called training was administered; and when the message was received by another successfully we say that learning took place and knowledge or skill was transferred." An important observation of this statement is that training should offer both the knowledge as well as the skills of a particular topic. Many training programs disregard the importance of knowledge and mainly teach the skills needed to perform a job duty or duties. While this is an adequate assessment for a job task within a company, this does not allow for proper learning of the knowledge material for a topic. Some skills, because their nature, have many applications outside of a specific job task. It is important that the scope of a particular topic be addressed in a training program so that the trainee can understand the motives of training. This increases the effectiveness of the training program as well. According to Munson (1984), "the quality of educational materials to be used is critically important, both for the consultant-led and client-led training. Although it is very time consuming, training directors are well advised to review these educational materials carefully and thoroughly…" The knowledge aspect of training would come from the educational material related to a particular topic in a training program. This material would not only offer the training program participants knowledge of their job duties outside of the organization, but also allows them to better understand the organization's motive and intent behind following certain procedures. This broadened view of training allows for trainees to get more from the training program and increases their capability to contribute their own knowledge into an organization's processes. This advantage of knowledge contribution focuses more on management and leadership positions where employees have strong influence on the performance of an organization.

Training programs and educational courses are very similar in that they're both focused on combining the practical nature of a task and the theory and concepts behind a task; teaching them simultaneously to maximize the thoroughness of the information offered. According to Tickner (1966), "it is appropriate to begin an examination of the intimate association between education and training at the higher levels of education because, in most of the professions, university study is involved." When a training program loses its connection with high level education, the material also loses its educational value and only maintains its practical nature as applicable to the guidelines set by the organization that the training program is in. It is important that any training program offer material from the educational background of the focused topic because of the enhancement to learning this material can create. Conceptual theory and ideologies of certain topics should not be left out of the training program because of their contribution to the understanding of practical applications in a broad sense. In some cases, it may be necessary to implement sections into the training program that focus on theory instead of practical application because it will enhance the ability for the individual taking the training program to learn and understand the material. According to Craig (1976), "more and more, training directors have become educational as well as training consultants to their organizations, and performance in that role requires a working knowledge of the myriad of educational programs presently offered by colleges and universities, junior colleges, evening schools, and correspondence study." Training programs that also incorporate concepts from their related educational courses attempt to cover the entire scope of a topic beyond its applicable nature in a specific organization. When training programs facilitate this type of learning, the groups of individuals gather knowledge beyond what learning the practical use can offer, and this can potentially enhance the performance of these individuals when applying the skills learned from the training programs. Again, the advantage of aligning a training program's initiatives and goals with the educational information and background increases the learning value of the training program, and broadens knowledge of situations in which the practical content is useful.

Before attempting to analyze the major components of a topic and incorporating them into an academic curriculum, course, or training/certification program, it is important to address the relevant tasks involved in developing and designing a successful training program. There are certain guidelines that the implementers of a certification program or academic course can go through to properly identify the major areas of a particular topic. In addition to identifying the major topics, there are other considerations such as target audience, length of training program or course curriculum, and relevant training theory. The quality of a training program is greatly affected by the effort put forth in the development and design of the program, the ability for continuous improvement of the information offered to the target audience, and the level of educational value of the information offered. Proper design of a training program or academic course involves assessing all of the important issues of a particular topic and creating processes to accurately and thoroughly teach the material, and maximize the quality of content. Some of the major issues to consider when establishing a training program are as follows:

> According to Carr (1992), there are three important concepts to consider when developing a training program, or as he states, "smart training". First, the goal of "smart training" is not simply to train individuals for the tasks of a job, but to establish a program that offers the most learning, in the least amount of time. The focus of learning in training programs draws the similarity between training and education. As education offers individuals with the background to increase their performance in real situations, training should focus on teaching the elements of a task as well as the practical nature of a task. Secondly, training programs are created to improve the performance of a particular task as well as a particular group of people. This is important to note because the material in a training program needs to be applicable to real world career situations as a means to improve the performance of a process and people. Thirdly, the performance of an individual depends on what makes sense to them, what they know and what they know how to do, what they have the means to do, motive and determination, and finally the feedback system installed to gather information on their efforts. A training program should focus on developing all of these components as a means to improve the performance of an individual.

Designing a Six Sigma Training Program/Educational Course

With regards to Six Sigma, the level of detail that a training/certification program or academic course has differentiates the type of program it is. Training programs involving the Six Sigma method need to be designed to incorporate all topics related to total quality management and organizational performance, because Six Sigma is derived from these ideas and practices. In addition, a training program should be designed around the major components of Six Sigma theory and functions, as seen by academic institutions, the industry and corporate America, and the original inventors of the Six Sigma process. Currently, there are Six Sigma programs in colleges, universities, and independent training programs, but among these programs, different material is focused on and different criteria form the completion and objectives of the program. When designing any training program or educational course, it is necessary to target the most relevant subject matter of the topic, and focus the program on this material. According to Odiorne (1966), "…people become so enmeshed in procedures that they lose sight of the reasons for the procedures, and the true goals (results) are displaced by false goals (activity)." It is important that any Six Sigma training program or educational course outline its objectives around the original purposes of Six Sigma. Six Sigma is a result and performance oriented management concept, focusing on all aspects that affect the quality an organization and its processes, and offering theory and methods on how to increase the quality of an organization. Although Six Sigma stems from mathematical theory and defect analysis, the management concepts of Six Sigma are much broader than mathematical calculations, and should be taught as such in a training program. Failure to do so strips away from the true meaning of Six Sigma, which has developed into not only a set of statistical methods, but a management philosophy and practice.

Methodology

Research & Data Collection Summarization

The goal of this project was to create a training program and academic course outline that can be implemented into an academic institution as a course, an organization or corporation as a training/certification program, or an independent company as outline within a particular Six Sigma certification program. Six Sigma programs focus on a comprehensive analysis of quality in business organizations in corporate America, as well as around the world. The development of Six Sigma Management theory from total quality management concepts was discussed in the previous portion of this paper. These two major aspects will be the basis for our team to develop a course outline and training program syllabus that focused on the major topic areas of Six Sigma as a Management theory and organizational practice. In order to obtain this goal, our team established a set of design objectives a training program concerning Six Sigma should follow, and this resulted in the completion of a training program/course syllabus for a Six Sigma Training Program, as well as recommendations for implementation within an academic institution or business.

The following is a summary of the setting of our design project. This project was done over a fourteen week period, broken up into two seven week terms. This project took place at Worcester Polytechnic Institute, located in Worcester, Massachusetts. The first seven week term began January 10, 2008 and lasted until February 29, 2008. This term consisted of initial research and methodology development. The team discussed possible methods for developing a Six Sigma course or training program with professors, high-ranking members of a national corporations (Raytheon and Amphenol RF), and other students at WPI. Research into different Six Sigma concepts, current Six Sigma certification in corporations, and other academic institutions around the country were done during this initial seven week session. Within the first seven week period our team established the following goals.

The second half of the project began March 11, 2008 and lasted until April 30, 2008. During this time, our team initiated the design the other design activities for our project including the interviewing objective, and the Six Sigma Course/Training Program Modeling objectives The team contacted employees that are closely related to the Six Sigma programs at Raytheon, Amphenol RF, and Villanova University, as well as Professor and Advisor to the group Joe Zhu of the Industrial Engineering department at WPI. In addition our team developed and applied a modeling process that would assess the information obtained from the survey and interviews. This modeling process involved the assessment of Six Sigma programs in academic institutions, corporations, and independent small businesses. Through this assessment, our team was able to create an outline Six Sigma topics crucial to obtaining a thorough theoretical, practical, and process knowledge background of Six Sigma. This program can be implemented into Six Sigma certification programs to strengthen the knowledge background of the program, as well as in academic institutions wishing to incorporate an in-depth study of Six Sigma in their Industrial Engineering & Management programs. A summary of the objectives for the entire 14 Week process is as follows:

Objective A: Obtain information of the current Six Sigma knowledge background of the students at Worcester Polytechnic Institute.

Objective B: Conduct interviews with employees who have a certification in Six Sigma processes and management theory and also interview employees with a strong Six Sigma knowledge base.

Objective C: Create a Six Sigma course/training program syllabus that can be implemented into an academic institution as a course, or a certification/training program using the training program/academic course design model established by our team through our research.

Objectives D: Offer recommendations and methods for implementing the Six Sigma program as course in an academic curriculum or training program within a corporation or independent business offering Six Sigma certification.

In order to achieve the objectives previously stated, our team has developed a design model that will assist in the organization, analysis, and interpretation of the data collected from the research and interviews conducted, as well as the surveys given to the students at Worcester Polytechnic Institute. This design model incorporates the training program theory discussed previously. The guidelines of the design model were developed from the research conducted during the first seven weeks of this project, in C-Term of 2008 at WPI. These guidelines include requirements for establishing a comprehensive training program focusing on the major concepts of Six Sigma management practices and theory, course design outlines and specifications for Six Sigma topics, and methods to incorporate the Six Sigma training program into a training program offering Six Sigma certification. The timeline and objectives for the research, data collection, design processes, and results analysis conducted by the team are more clearly shown in (Enter Figure Value Here).

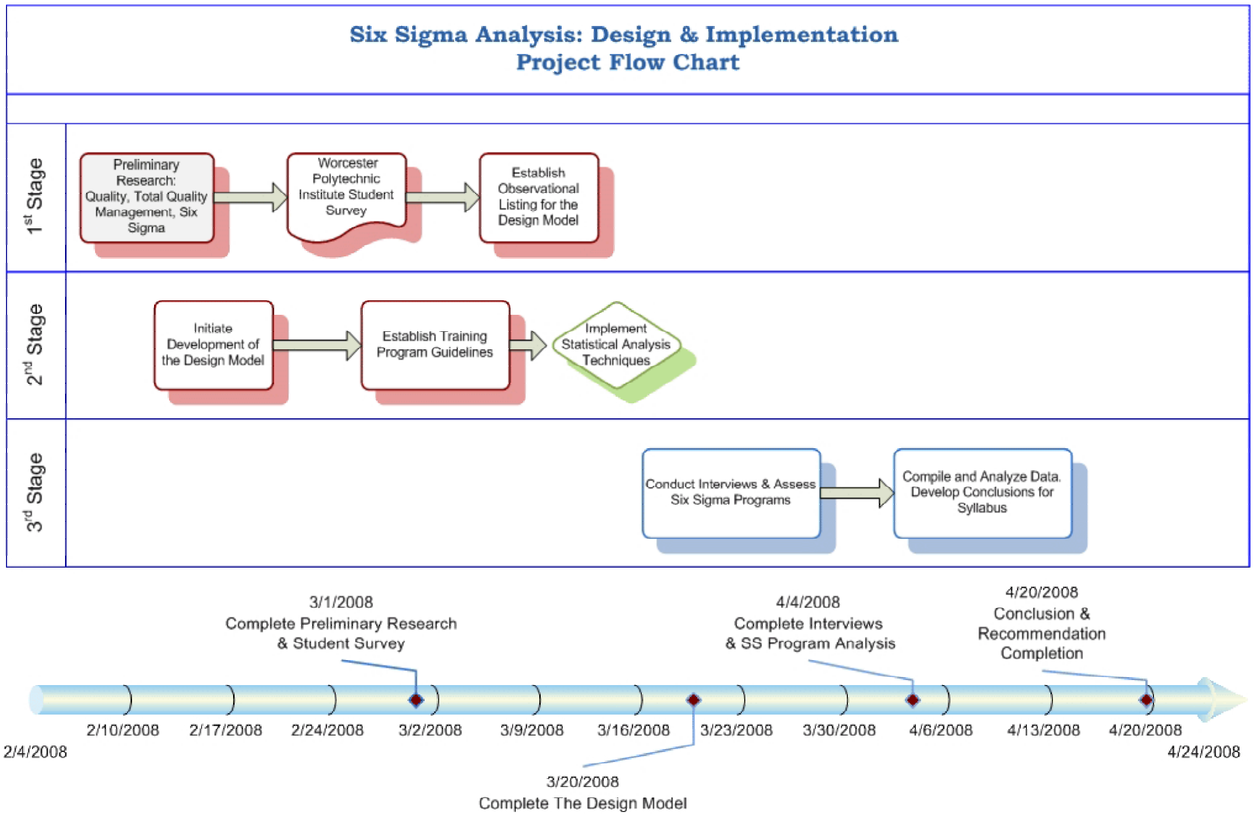

Figure 4 - Six Sigma Analysis: Project Objective Timeline & Flow Chart

Research & Data Collection Plan

Preliminary Research

Preliminary Research occurred during the first seven weeks of the project, in the academic C-Term of 2008 at Worcester Polytechnic Institute. Six Sigma as a process is interrelated with such concepts as Total Quality Management, Quality Control, Quality Assessment, and Statistical Modeling. An analysis of the relationship between Six Sigma and these concepts allowed for our team to create the research space for this project. This project focuses on Six Sigma as not only a set of practices to follow to improve operational and management quality within the systems of an organization, but also as an organizational management concept and theory, applicable to several different types of systems within Corporate America, including major corporate entities and organizations, academic institutions, and training programs of independent businesses. The different systems where Six Sigma can be applicable to improve performance exist in such fields as the medical industry, the manufacturing and production industry, supply chain management systems, and several other industrial systems that involve product, process, and service quality. This research space that our team is focusing involves total quality management and it's relation to Six Sigma management practices. The Design Model used to interpret and collect data from our interviews, surveys, and research is supposed by the preliminary research that addresses the major topics of total quality management and Six Sigma. Our analysis techniques are drawn from our observations made during the preliminary research portion of this project. In addition, this research assists in developing a clear and detailed understanding of the most relevant topics in TQM and Six Sigma Theory.

Student Surveys at Worcester Polytechnic Institute

One of the first evaluation methods completed was the distribution of a Six Sigma Survey. The survey was distributed to the entire undergraduate body at WPI, via email. Students were asked to optionally fill out the survey and return to Matt McCarthy through email. The survey can be found in Appendix A. The purpose of this survey was to gather the current day perspective of Six Sigma from the students at Worcester Polytechnic Institute. Worcester Polytechnic Institute has a student body mainly of engineering students. Six Sigma management is a process that involves not only management personnel, but engineering students across many disciplines, and Worcester Polytechnic Institute meets that engineering criteria. Six Sigma management is a process that most engineers are going to come across at one time or another during their engineering career, because of the multitude of activities that are involved with Six Sigma processes and theory. Due to this, engineering students have the opportunity to adapt to the industry by learning more about Six Sigma and its practices. For the purposes of our project, our team wished to gather a statistical background of how many students are currently knowledgeable of Six Sigma as both a defect analysis technique and a management practice. Our team also asked questions involved student interest in Six Sigma theory and management concepts. The questions identified types of student, their graduating periods, and any Six Sigma experience they feel was relevant to their academic career.

These questions were intended to give the group a means to analyze the students at WPI group who participate in the survey with regards to their knowledge and experience in Six Sigma. In addition, our team wishes to gather a better understanding of the Six Sigma management concepts currently discussed at Worcester Polytechnic Institute, which departments focused on Six Sigma concepts, and the types of classes that Six Sigma is discussed in. Questions that aided in the understanding of the current student knowledge base were as follows:

- Are you familiar with the term "Six Sigma"? If yes, please rate your familiarity with the term
- Have you taken any classes at WPI that have discussed Six Sigma concepts? If yes what is the course(s) and what aspect(s) of Six Sigma were discussed?

These questions, along with the others in the survey, gave the group a good understanding of how familiar WPI students are with Six Sigma, and also what courses currently in place at WPI are effective ways of discussing Six Sigma concepts. Also, this survey allowed our team to match our Six Sigma training program/academic course syllabus model to the needs of students at Worcester Polytechnic Institute.

Six Sigma from the Perspective of Experience

As with many academic institutions that supply students with the knowledge to perform a certain task, often the experience of performing in real world industrial situations is the differentiating factor of performance from one student to another. In order to achieve Objective B, our team conducted interviewed with employees who have the strength of experience with regards to Six Sigma Management theory and practices. The purpose of these interviews was to gather the perspective and experiences of employees currently in top corporations, independent businesses, and academic institutions that have activities related to Six Sigma. This information would assist in establishing the topic criteria for a Six Sigma syllabus. A main criterion for many Six Sigma certification programs is prior project management experience or project execution experience, especially for higher level Six Sigma certification programs at the Black Belt level.

The interview participants include employees from Amphenol RF, Raytheon, Worcester Polytechnic Institute, Villanova University, and Carnegie Mellon. These employees vary in their knowledge of Six Sigma processes, from Green Belt certified employees, to teachers of Six Sigma in other academic institutions. The usefulness of this variation is to gather a broadened sense of the important material to employees that practice in Six Sigma activities on a daily basis. Our team assessed the value of the information we would obtain from the companies and universities by analyzing their academic programs and addressing their corporation's current place and ranking in the business world. Our criteria for the interview selection were individuals that have a certification in Six Sigma, teach Six Sigma, or have participated in a project where Six Sigma related activities occurred. Because of the broad nature of the Six Sigma topic as a defect analysis technique and a management concept, our interviewing pool too was broad in the sense that the employees, professors, and certified Six Sigma interviewee came from many different fields of the industry. These fields included academic institutions, industry corporations, and independent businesses.

Modeling a Six Sigma Program

The modeling of a Six Sigma Program involves achieving Objective C. In order to properly establish a Six Sigma academic course/training program syllabus, the design of such a program should be based on the current industry understanding of important and major topics related to the field. In order to gather a comprehensive and thorough understanding of the relevant Six Sigma Management topics, an analysis of existing programs needs to take place. This step will allow for our team to assess how academic institutions, corporations, and independent businesses feel Six Sigma should be taught, what these entities feel should be taught and why, and under which guidelines should Six Sigma be analyzed, Through this analysis, our team will be able to identify similarities and differences between a variety of Six Sigma programs that currently exist. This is a crucial step to our design process, for it allows our team to create a theme for the Six Sigma training program/academic course that will be accurate to the current understanding of the topic among several different programs. Also, because of the wide range and variety of topics related to the Six Sigma approach and the multitudes of methods it can be implemented into a corporation, this process is necessary and will reduce the broad nature of the Six Sigma topic for our syllabus by identifying similarities between the programs chosen to be observed.

The programs chosen were grouped into the following fields: Academic Programs & Certification Programs and Independent Corporation and Business Training Programs (training programs offered by corporations and independent businesses). The following academic courses & training programs were analyzed by our team for this project.

1. Academic Institution Training & Certification Programs
    a. Carnegie Mellon: Six Sigma Certification Program & Courses
    b. Villanova University: Six Sigma Certification Program & Courses
    c. University of Tennessee: Black Belt Six Sigma Training Program
    d. Arizona State University: Six Sigma Black Belt Certification Program
    e. North Carolina State University: Six Sigma Black Belt Certification Program
2. Independent Corporation and Business Training Programs
    a. Aveta Business Solutions: Six Sigma Online Training Program
        i. Yellow, Green, & Black Belt Certification Options
    b. American Society for Quality: Six Sigma Black Belt Certification Program
    c. Benchmark Six Sigma: Business Excellence Workshops
        i. Includes Six Sigma Yellow Belt Training Program

Recommendations for Implementation & Improvement

After the development of our syllabus, it is necessary to discuss the implementation strategies and improvements that can be added to the program. This section will analyze the thoroughness of our developed training program/course syllabus and the areas it can be applied to. In addition, this section will assess the usefulness of incorporating the academic course outline and syllabus into current certification programs as a facilitation of the knowledge and theoretical foundation needed in Six Sigma training programs. The ability to integrate this course outline and training program syllabus into existent certification programs and academic courses is the main objects and goal of this project. Therefore, our recommendations on how to implement this course into such programs will be included in this section.

The Design Model

Premise & Purpose of the Design Model

An academic course and a training program have many similarities. Both involve a focused topic that is usually derived from a broader area of study, theory, or expertise. In the case of a Six Sigma training program, this is no different, as observed in the literature review. In addition, there exists a wide range of training program theory and guidelines for creating a training program. This information assists in the combination of educational theory and knowledge with the practical tasks and requirements of a business or corporation in order to establish a training program that gives employees the knowledge they would need to perform a specific duty or task. These specific tasks may include the operation of a mechanical device in a manufacturing system, or the operation of a computer in a medical service system at a hospital. The importance of training programs is that they incorporate the practical and real-life nature of a process, and assist employees through teaching and application as a method to increase the performance and abilities of the employees. With regards to Six Sigma, the scope of the participant goes beyond employees of a company and focuses more on management personnel looking to acquire knowledge on how to increase the overall quality, performance, and organizational mentality of a business, incorporating all aspects of the business that affect quality of products, services, and the organization. Because of Six Sigma's excessive theoretical background, our team stresses the importance of creating a training program that encompasses the theory and practices of Six Sigma as offered by the creators of the management idea. Also, the educational value of Six Sigma theory offers as much of a practical understanding of the topic as does the statistical analysis techniques and project management templates that assist in top management decision making.

Our team had developed a model to assess the information obtained from interviews, surveys, and analysis of Six Sigma programs in academic institutions and businesses. This model focuses on achieving the objective of creating a Six Sigma training program/academic course that can be implemented into an academic institution, corporation, or small independent business stated earlier in this section. The usefulness of this training program as an academic course is that there are assignments to assess the information learned by the participants of the training program. These same assignments can be used as performance requirements for passing the training program as a course in an academic institution. These same requirements can be used as a means to measure whether a participant of the training programs has learned the information in order to receive Six Sigma certification. The design model focuses on the quality and performance of the training program being created, and the model is applicable to either the creation of or currently existing Six Sigma programs in America. Training program theory offers a wide range of criteria and methods that, if taken advantage of, can greatly enhance the comprehensiveness, quality, and performance of a training program. Our team had organized our research on TQM, Six Sigma, and training program theory, into a design model for a training program that includes a set of guidelines for increasing the educational value of the training program, training program characteristics and requirements that enhance the quality and performance of the training program, and performance measurement techniques that can be used to evaluate the participants of the training program and the program itself. This design model will assess the aspects of the programs that can be applied to the establishment of an academic course or training program focusing on Six Sigma and its relationship with corporate business in the fields of medical services and manufacturing. This design model also takes into account the information learned from researching Total Quality Management, Six Sigma, and training program practices.

Training Program/Academic Course Design Model

The design model created by our team through research of Six Sigma management theory and practices is separated into several categories. These categories assess the aspects of a training program that our team suggests should be addressed while creating a training program and the methods that the training program creator/coordinator can use to implement these categories and the topics into the training program focusing on Six Sigma. This design model was applied to the training programs and academic course curriculums focusing on Six Sigma processes that our team analyzed. The purpose of this application was the compare the design model created by our team with the current training programs and academic curriculums focusing on Six Sigma and Six Sigma related topics that currently exist. This was combined with the information obtained from the surveys and interviews done by the team. The purpose of this design model was to be used to create a training program/academic course that incorporates all of the beneficial practices currently in training programs and academic courses. This, in combination with the material gathered from our research on TQM, Six Sigma, and training program theory, will serve as a template for training program design with regards to Six Sigma. The end result of this design model is a comprehensive syllabus that can be used to teach Six Sigma management practices and theory, including the statistical defect analysis techniques of Six Sigma, within either a training program or an academic course. The following is an outline of the categories of the design model for the training program/academic course:

1. The Training Mission
2. Structural Design
3. Staffing Design
4. Educational and Industrial Resources
5. Participant Performance Evaluation Measures
6. Training Program Evaluation Measures

The Training Mission

This first category involves defining the purpose and intent of the training program. The deliverable of this category is a detailed mission statement about the training program. Within this mission statement, there should be a definition of the scope of information discussed, an assessment of the participant market targeted by this training program, and a proper assessment of the value of the information in the training program for the participants. Development of the training mission is to offer not only the participants, but also individuals who inquire on the training program, a concise and detailed explanation of what the training program has to offer for them. Included with the mission statement is a summarization of the activities in the training program. These activities are developed from the next four components of the design model, which are the core of what the training program offers to its participants. This summarization is in the form of a short outline of the topics offered in the training program, but for the purposes of making this model applicable to the design of an academic course, this summarization can be more developed and in the form of a course syllabus. The main components of the training mission are separated as follows:

1. Clear definition of the scope, market, value, and purpose of the training program. This includes all goals the training program intends to achieve for its participants. With regard to Six Sigma, this should be, at a minimal level, a detailed outline of the core Six Sigma management concepts, theories, business practices used, and types of initiatives taken.

2. Definition of the type of training program. With regards to Six Sigma, a training program must incorporate more than a mere overview of the topic, especially if the program has the intention of being a certification program. A combination of educational theory and discussion should be complemented by practical case studies related to the Six Sigma approach and practice with statistical analysis techniques used in Six Sigma management. Because both practice and theory share equal importance when discussing Six Sigma, both should be incorporated into a Six Sigma program to maximize the training program value.

3. For the purposes of this design model, the training mission requirements of the training program will be limited to a Six Sigma training program that does not offer Yellow, Green, or Black Belt certification. Although these certifications can be offered through a training program, there are addition requirements to the design model that will need to be addressed. These will be discussed in the results portion of the report.

4. Six Sigma management concepts are branching into a variety of industrial fields. More specifically, the fields of medical services and manufacturing are finding benefits in implementing Six Sigma strategies and processes to further increase the quality of the system. For the purposes of our design model, the relationship between Six Sigma and its capabilities as a management concept in the medical service and manufacturing industries is a major component of the design model, and a focus of the program. This also ties the relationship between Six Sigma and Industrial Engineering.

Structural Design

Structural Design with regards to this design model is the organization of the material discussed in the training program as well as how the information is given in the training sessions. Because this training program focuses on Six Sigma management theory and practices and the audience is industrial engineers, management engineers, and business managers, there need not be multiple versions of the training session for separate groups of individuals. The structural design of a training program should be directly related to what needs to exist in the training program to increase the performance of the participant after they complete it. In the case of Six

Sigma, this is where the focus of theory as well as practice is stressed, due to the nature of the topic as discussed previously. This is also where the separation between a focus on theory or practical applications and statistical techniques is drawn. In order to develop a training program that confidently and accurately supplies it's participants with useful information that will increase not only their knowledge of Six Sigma and its applicable nature, but their performance in businesses and corporations, it is important for the training program coordinators to do a front-end analysis of Total Quality Management and Six Sigma management topics and practices. The Six Sigma approach has several important theories and concepts that go beyond practical application, such as the dramatic change in how a business defines the quality of their products and operations when operating under Six Sigma. This particular point, as with other important Six Sigma knowledge and criteria, should be incorporated into Six Sigma training programs as necessary elements of learning, along with the statistical analysis techniques and methods used to achieve Six Sigma. The structural design element of the design model had been separated into the following categories of information. These categories cover the key areas and principles of Six Sigma management, and were establish through our teams research:

Six Sigma Management Theory

1. The Birth of Six Sigma and Total Quality Management Concepts
    a. This includes discussion of the relevant contributors to initial Six Sigma management theory and it's derivation from the Total Quality Management concepts of William Edwards Deming. Also include the Six Sigma initiatives taken at Motorola by Art Sundry and Mikel Harry.
2. Six Sigma as a Management Concept and Philosophy
    a. Key principles of Six Sigma as a management concept and philosophy should be discussed in a comprehensive program. Among these principles is the importance of metrics and measurements in quality control.
3. Total Quality Management and its relation to Six Sigma
4. Redefinition of Quality and it's relation to Six Sigma

5. Six Sigma vs. The "Kaizen" Approach

Six Sigma Management Practices

1. Six Sigma Statistical Approaches and Techniques

    a. These statistical approaches and techniques focus on analyzing the capabilities of a current process and using calculations to target areas in the system where improvement will be most effective for the system and contribute to the highest reduction of defects.

2. The Cost of Quality: Quality, Cost, and Performance Measurement Techniques

    a. This topic would focus on the contributors of quality as understood from a Six Sigma management point of view. This includes specification limit theory and process control concepts, and variation analysis.

3. Six Sigma as a Organizational Performance Target

4. Six Sigma Implementation Strategies

Staffing Design

The individuals coordinating the training program should have a basic understanding of Six Sigma theory and practices. On the contrary, the personnel teaching the training program need a much more detailed and thorough background of Six Sigma management and its relationship to products and services, as well as business decisions and practices. For this reason, it is necessary that the individual or individuals instructing the training program has experience in Six Sigma practices and implementation strategies in the industry. This experience gives the instructor a practical, real-life connection to the statistical material and methods taught in the training program, as well as the complexities of implementing performance enhancement procedures once problems, defects, and cost increasing complications are found. An individual with Six Sigma certification at the Green, Yellow, or Black Belt level would be a sufficient instructor, although the requirements for the different types of certification programs differ, and some are more comprehensive than others. Professors who have done in-depth research on total quality management and Six Sigma techniques would also be very adequate instructors for the training program, but it is still important that the connection between educational theory and real-life situations is maintained. For the purposes of this training program and its implementation in a company or as an academic course, the staffing design element is limited to the instructor of the training program. This particular element will be observed through the individuals who administer the training programs assessed by our team.

Educational and Industrial Resources

The learning resources used for the training program should not be limited to what the company or academic institution can provide internally. There are several books focusing on Six Sigma management theory and practice, as well as total quality management concepts. These books are useful educational tools for the instructors to create a topic template for their training program. For the purposes of this project, these educational sources can be used to reinforce and complement the template already established by the instructor through this design model. The statistical applications in these academic books are more theoretical than practical, so the examples involving the statistical methods would be, at times, very detached from the practical use of Six Sigma in a specific company. A more useful tactic would be the use of case studies from these books as a means to supplement the theory discussed. These statistical applications would be more useful in an academic course environment as a means to reinforce the statistical knowledge background needed to perform Six Sigma statistical techniques and operations. The industrial resources are more useful in the scope of the training program and these resources include company case studies where individuals implemented Six Sigma approaches and tactics into their organizational structure and operations. These case studies are found not only in academic books related to Six Sigma, but also in books created by researchers and inventors of Six Sigma theories and practices. These types of learning problems are best implemented into a training program by instructors experienced in Six Sigma implementation and statistical methods, which reinforces the need for an instructor that is certified in Six Sigma management. In addition to the former, it is important that the educational and industrial resources of the training program enhance the quality of the training program by adding value to the material learned and discussed. This requires that for a training program, the educational resources and materials focus on the real-life, practical applications of Six Sigma, and methods for implementation. For a company incorporating this training program outline for an internalized training curriculum, this would also involve including the statistical and mathematical operations specific to their company in the training program to teach the top-management participants the details of company operations as a means to later enhance them or other operations within the company.

Participant Performance Evaluation Measures

The accurate measurement of participant performance in the training program/academic course is a high priority with regards to evaluating the quality of the program and its ability to accurately present information about Six Sigma management theory and practices. These evaluation measures focus on the assessment of the knowledge acquired by the training program participants and their ability to understand, interpret, and apply Six Sigma management theory and practices. What this means is that because Six Sigma is a relatively new business management philosophy, and often counters and refutes current ideas and practices in the industry and at organizations, it is important that the theory and practices are learned to a particular level so that the premise and backbone of Six Sigma management is maintained by the participants as they establish business practices and statistical strategies of their own in the organizations and businesses they belong to. Participant performance evaluation measures are a means of observing the level of material acquired and retained by the participants of the training program. These measures include, but are not limited to, testing, requests of reports on major Six Sigma topics and concepts developed by the training program coordinator, and case study analysis of Six Sigma implementation techniques and methods. These evaluation measures can be used as a means to observe the quality of the training program, or these tests can be used as measures for successfully completing the training program and receiving a certification of completion. These requirements are also included in the training program outline for the participants as goals for successful completion of the training program with regards to participant performance and should be established prior to the initiation of the training program. The following categories are the three main focuses of the participant evaluation measures of the design model:

1. Problem solving of case studies involving Six Sigma management theory, practices, principles, and implementation methods.
2. Testing of the core Six Sigma management theories and concepts.

3. Analysis of the major contributions/contributors to the Six Sigma management philosophy, including the reasons for success

Performance evaluation measures that summarize the important and necessary information acquired from training program lectures and training program activities are necessary components of any Six Sigma training program. These performance measures will assist the training program coordinator measuring the participants learning of the theoretical and practical material discussed in the Six Sigma training program. According to Harbour (1997), “performance measures can be used for a number of different purposes. Such purposes can range from determining current performance levels to predicting future ones to carefully controlling an existing process.” With regards to the participants of the training program, it is important that they receive a concise and thorough understanding of Six Sigma, not only as a management idea and theory, but also how Six Sigma has been applied to the industry on a practical level, and how this is applicable to their tasks and job duties as industrial engineers, management engineers, project managers, consultants, and employees in the manufacturing and service industry.

A major component of this design model is to incorporate the performance evaluation standards used in academic courses at college level institutions as a means to evaluate the amount of material retained by the participants of the training program. The similarities between a training program and an academic course can be used to the training coordinators advantage, and the training program can model the design of an academic course with regards to performance measures and participant evaluations. The development of a method to assess the knowledge obtained by the participants as well as the continuous improvement of this method is one of the key objectives in not only creating a training program, but also in increasing the quality of the training program as it progresses.

Training Program Evaluation Measures

The final category of the design model focuses on the quality of the training program itself and the measures taken to evaluate it on a statistical level. The training program evaluation measures focus on measuring the quality of the training program as it progresses. This is much like the measurements taken to analyze the quality of knowledge the participants are acquiring after successful completion of the training program, but this measurement involves the assessment of the training program outline itself. In order for the quality of the training program to be maintained, the training coordinator must implement a training program evaluation measures that assess the effectiveness and efficiency of the training program. This includes addressing such issues as case study relevancy, statistical process relevancy, and updated information on the achievements, and at times failures, of organizations and businesses that implement Six Sigma management principles.

According to Carr (1992), focusing the coordination and creation of a training program on the actual training methods rather than the learning that must occur by the participants focuses on the wrong activities. Much, if not all of the real, practical knowledge that a training program or academic course provides occurs somewhere other than in the formal training program. The primary job of training is to facilitate the overall learning that occurs after training is completed and the knowledge acquired is put into practice in real world situations. Because Six Sigma is very activity oriented, the best way to become accustomed to operating under Six Sigma is to practice implementing Six Sigma methods into a real organization. This process assists in establishing the types of information, resources, and analysis techniques needs for specific industries, such as the medical service industry, or manufacturing industry. These industries have particular characteristics that have to be addressed when attempting to implement Six Sigma processes and achieve Six Sigma. Because of this specificity, our design model focuses more on the information of the training program and the level of details of this information as well as the methods to deliver this information. The training program evaluation measures focus on measuring the quality of these processes and their effectiveness of achieving the goals stating in the training program's statement of purpose.

Results

Survey Conclusions

Through our research, one of our accomplishments as a team was to develop an understanding of Six Sigma not only as a statistical defect analysis technique, but more importantly as a management theory and set of business practices. To develop a clearer understanding of the knowledge of Six Sigma in an academic institution focusing on engineering, our team compiled a survey given to the student body at Worcester Polytechnic Institute. This survey was created to observe the current Six Sigma knowledge-base of the students at

Worcester Polytechnic Institute. This survey was used to establish the basis of a Six Sigma training program or academic course targeting engineering and management students. Our results for the surveys are as follows:

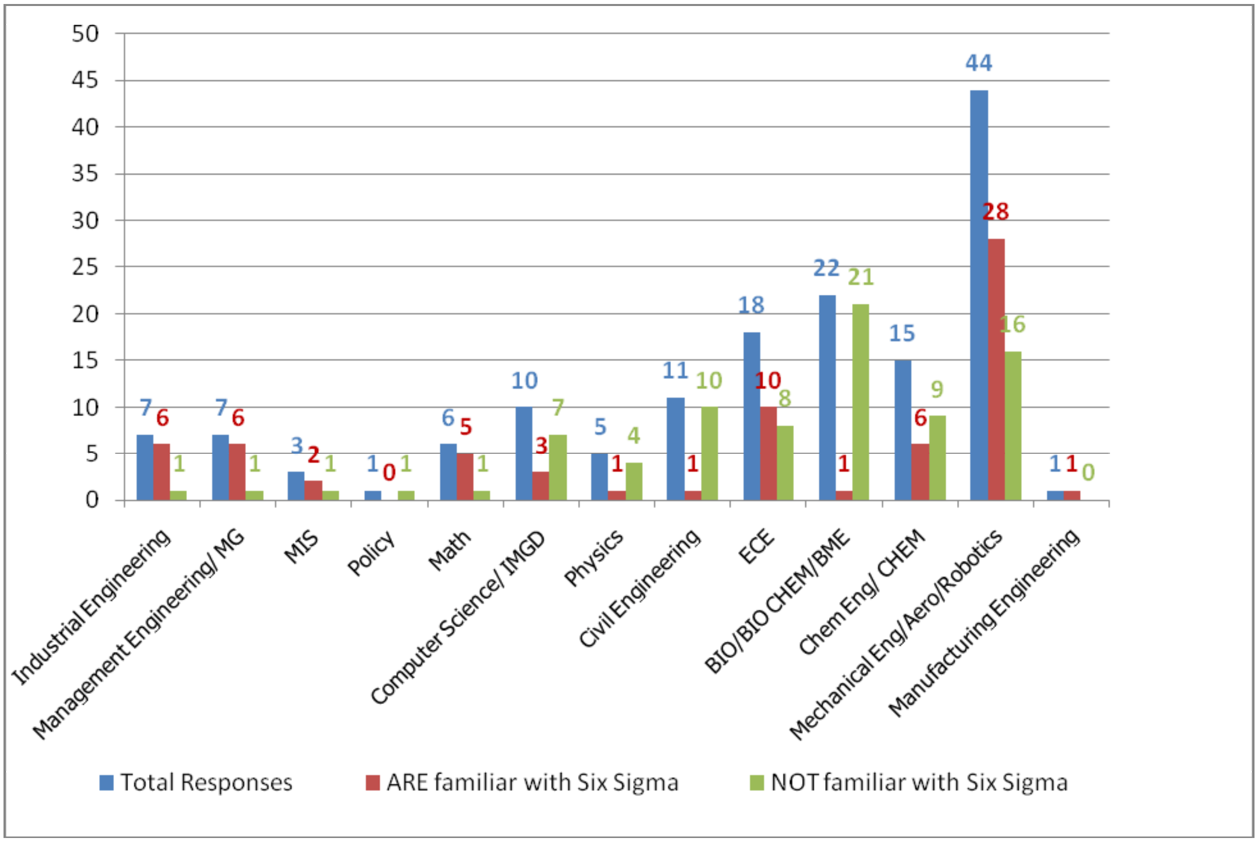

Figure 5 - Bar Graph indicating student majors familiar with Six Sigma

The group received a total of 150 responses from students in a wide range of majors. The breakdown by major is as follows:

1. Mechanical Engineer/Aerospace Engineering/Robotics Engineering: 44 responses—28 were familiar with Six Sigma
2. Biology/Biochemical/Biomedical Engineering: 22 responses—1 was familiar with Six Sigma
3. Electrical and Computer Engineering: 18 responses—10 were familiar with Six Sigma
4. Chemistry/Chemical Engineering: 15 responses—6 were familiar with Six Sigma
5. Civil Engineering: 11 responses—1 was familiar with Six Sigma
6. Computer Science: 10 responses—3 were familiar with Six Sigma

7. Industrial Engineering: 7 responses—6 were familiar with Six Sigma
8. Management Engineering: 7 responses—6 were familiar with Six Sigma
9. Mathematical Sciences: 6 responses—5 were familiar with Six Sigma
10. Physics: 5 responses—1 was familiar with Six Sigma
11. Management Information Systems: 3 responses—2 were familiar with Six Sigma
12. Manufacturing Engineering: 1 response—1 was familiar with Six Sigma
13. Policy: 1 response—0 were familiar with Six Sigma

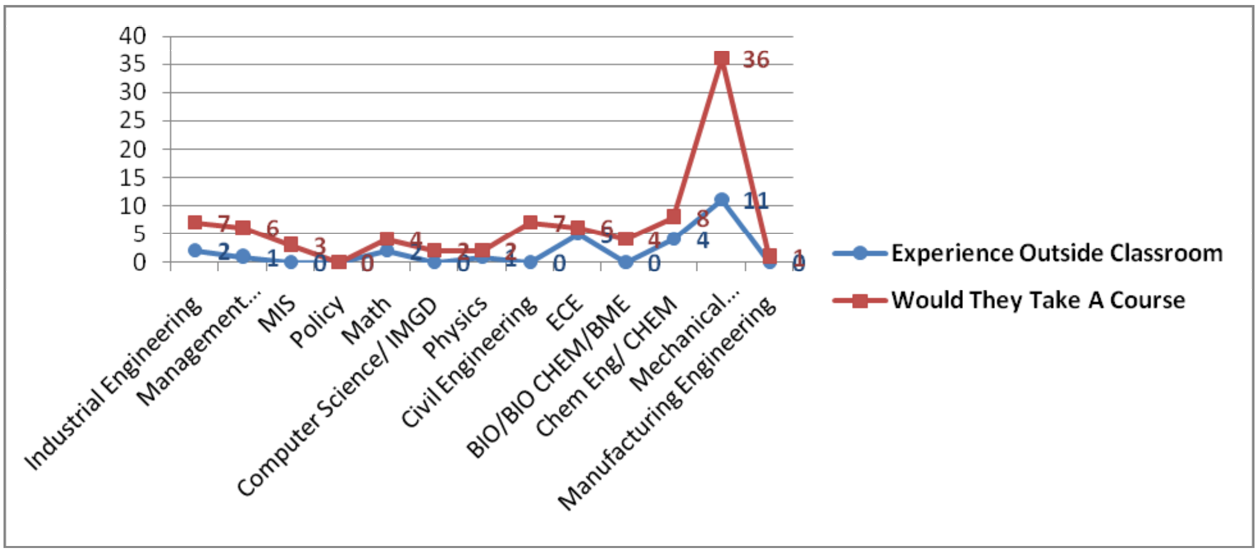

Figure 6 - Six Sigma experience outside of the classroom.

Students were asked whether they had experience with Six Sigma outside of the classroom. The breakdown of responses by major was:

1. Mechanical Engineer/Aerospace Engineering/Robotics Engineering: 11 have experience with Six Sigma Outside of the Classroom
2. Biology/Biochemical/Biomedical Engineering: 0 have experience with Six Sigma Outside of the Classroom
3. Electrical and Computer Engineering: 0 have experience with Six Sigma Outside of the Classroom
4. Chemistry/Chemical Engineering: 4 have experience with Six Sigma Outside of the Classroom
5. Civil Engineering: 0 have experience with Six Sigma Outside of the Classroom

6. Computer Science: 0 have experience with Six Sigma Outside of the Classroom
7. Industrial Engineering: 2 have experience with Six Sigma Outside of the Classroom
8. Management Engineering: 1 have experience with Six Sigma Outside of the Classroom
9. Mathematical Sciences: 2 have experience with Six Sigma Outside of the Classroom
10. Physics: 0 have experience with Six Sigma Outside of the Classroom
11. Management Information Systems: 0 have experience with Six Sigma Outside of the Classroom

Students were also asked whether they had would take Six Sigma class if one were offered at WPI. The breakdown of responses by major was:

1. Mechanical Engineer/Aerospace Engineering/Robotics Engineering: 36 would take a Six Sigma course if one was offered at WPI
2. Biology/Biochemical/Biomedical Engineering: 6 would take a Six Sigma course if one was offered at WPI
3. Electrical and Computer Engineering: 7 would take a Six Sigma course if one was offered at WPI
4. Chemistry/Chemical Engineering: 4 would take a Six Sigma course if one was offered at WPI
5. Civil Engineering: 2 would take a Six Sigma course if one was offered at WPI
6. Computer Science: 4 would take a Six Sigma course if one was offered at WPI
7. Industrial Engineering: 7 would take a Six Sigma course if one was offered at WPI
8. Management Engineering: 6 would take a Six Sigma course if one was offered at WPI
9. Mathematical Sciences: 4 would take a Six Sigma course if one was offered at WPI
10. Physics: 2 would take a Six Sigma course if one was offered at WPI
11. Management Information Systems: 3 would take a Six Sigma course if one was offered at WPI

Six Sigma Training Program/Academic Course Analysis

Each training program and academic course was analyzed and evaluated in the following format. This format was created by our team and focused on the design & design quality aspects of the training programs and academic courses. More specifically, aspects of our design model were taken into consideration and correlations between our design model and the training curriculums used in businesses and academic institutions of today were made. The major components of each training program and academic courses were observed and outlined similarly. Such components included the mission statement of the training program or academic course, overall structure and quality of the program, organization of Six Sigma topics within the program, and a listing of unique observations for each program. Our team gathered information and made observations on several training programs and academic curriculums focusing on Six Sigma management practices and theory. In addition, the purpose of these observations was to locate the similarities and differences of many Six Sigma programs in America. Our established design model for Six Sigma training programs/academic courses and the observations made from the training programs and academic courses of the current day were combined and incorporated into the design of the training program outline and academic course syllabus template. Our observations and conclusions of the Six Sigma programs were outlined in the following format and categories:

1. Training Programs/Course(s)
2. Program Offered By
3. Program Type(s)
4. Program Length
5. Program Entrance Criteria
6. Program Assessment
    a. Program Mission Statement & Summarization
    b. Structural Design & Quality
    c. Unique Design Observations

Six Sigma Programs of Academic Institutions

Training Program(s)/Course(s):

(1) Designing Products and Processes Using Six Sigma

(2) Improving Process Performance Using Six Sigma

Program Offered By: Carnegie Mellon University: Software Engineering Institute

Program Type(s): Training Program/Academic Course

Program Length: 5-Day Program Schedule

Program Entrance Criteria: No entrance criteria, but the target audience includes project managers and consultants, as well as black, green, and yellow belt certification holders.

Program Assessment:

1. Program Mission Statement & Summarization
    a. These two training programs focus on the statistical tools of Six Sigma management practices and how these tools can be applied to the current processes in the industry. The process performance course focuses on the key analysis techniques and statistical methods, such as the 7 Basic Statistical Tools, used in Six Sigma management. This course is also a prerequisite for the process and product design course offered by the university. According to the Software Engineering Institute at Carnegie Mellon University (2008), "participants learn a framework in the form of tools, methods, and practices for analyzing data to make more informed business decisions about project and process performance, quality, schedule, and cost." The course description for both courses offers a clear and distinct mission statement with regards to the material covered related to Six Sigma. With regards to Six Sigma, the focus
2. Structural Design & Quality
    a. In order to perform well in these courses, the institution recommends material that should be covered before registering for either training program. These courses are less involved with the theoretical nature of Six Sigma, and are more focused on the analysis techniques used to make business decisions in the industry, as well as improve processes. As such, the design of these courses involves case studies and analysis problems using data that replicates real industrial situations. In addition the Six Sigma product and process design method is taught in the higher level design course. Topics include the DMADV (Define-Measure-Analyze-Define-Verify) Method for Six Sigma management.
3. Unique Design Observations
    a. These programs offer the use of real life case data and project case studies to assist learning the use of the statistical and analytical tools of Six Sigma.
    b. The software packages needed for the courses are provided by the institution.
    c. The DMADV (Define-Measure-Analyze-Define-Verify) Method taught in the higher level Six Sigma course closely resembles the DMAIC method of total

quality management taught by one of the pioneers of total quality and Six Sigma management, William Deming.

d. These Six Sigma training programs focus on using Six Sigma techniques for the development of software, system, and hardware product and process solutions. This emphasizes the applicative nature of Six Sigma management practices outside the realm of manufacturing systems.

Training Program(s)/Course(s):

(1) Six Sigma Green, Lean Six Sigma, & Lean Six Sigma Black Belt certification courses.

(2) Six Sigma Master Certifications in HealthCare, Information Technology, & Financial Services

Program Offered By: Villanova University

Program Type(s): Certification Programs/Academic Courses

Program Length: Follows Villanova's Academic Calendar.

Program Entrance Criteria: No entrance criteria.

Program Assessment:

1. Program Mission Statement & Summarization
   a. The academic courses and certification programs at Villanova University offer a thorough and comprehensive curriculum of Six Sigma management practices and an analysis of the many industrial areas that Six Sigma processes and tools can be implemented and used to improve company quality. The university also offers individual courses that cover the theoretical and statistical aspects of Six Sigma, but are not as in-depth as the Master Certification program. Master Certification is granted upon the completion of a 4-Hour test after completing the necessary courses. The goals of Villanova University's Six Sigma programs involve teaching individuals how to improve processes, customer satisfaction, and invent processes that lower the defect levels of systems and eliminate wasteful processes in systems.
2. Structural Design & Quality
   a. The structural design of the Six Sigma certification programs and courses emphasize theory as much as the statistical techniques and data analysis methods

of Six Sigma management. These courses involve historical and philosophical observations of Six Sigma as not only a management concept, but as a way of thought. This is intertwined with the data analysis techniques taught in these courses. Each certification program offers is separated into eight major categories of Six Sigma management practices and theory, which are called modules. These categories separate the statistical models of Six Sigma, the history and philosophy of Six Sigma, and methods to design and implement Six Sigma tools and processes into eight modules that are covered during each type of certification program. The difference between Green Belt and Black Belt certification in this particular program is the depth of study and material covered in these modules. However, the same material is covered in both programs.

3. Unique Design Observations
    a. This program offers Six Sigma Master Certification in the fields of HealthCare, Information Technology, and Financial Services. The master certificate programs focus the material covered around one of these three industries.
    b. Classes are taught by pioneers of Six Sigma implementation strategies such as George Eckes.
    c. Programs and courses offer industry specific statistical case studies and data.
    d. Separation of Six Sigma topics into modules. This organizes the flow of the certification program much like an academic course.

<u>Training Program(s)/Course(s):</u>

(1) Process Improvement Fundamentals
(2) Principles of Analytics: Fact Based Management
(3) Data Acquisition Strategies: Six Sigma and Beyond I & II
(4) Design of Experiments I & II
(5) Transactional Six Sigma I & II

<u>Program Offered By:</u> University of Tennessee

<u>Program Type(s):</u> Training Programs/Academic Courses/Green Belt & Black Belt Certification

<u>Program Length:</u> 1-Week to 2-Week Programs

<u>Program Entrance Criteria:</u> Requirements for Certification include project experience, employment at a managerial level in an organization, and successful exam completion.

Program Assessment:

1. Program Mission Statement & Summarization
    a. The University of Tennessee combined their process development courses with their Six Sigma academic courses to create a comprehensive program for individuals looking to become experts of Six Sigma management practices. Their programs focus not only on the statistical tools According to the University of Tennessee (2008), the process improvement/ Six Sigma program has the following three competitive advantages in the industry:
        i. Unrivaled Expertise
            a. "For over 25 years, the University of Tennessee has pioneered the field of process improvement / six sigma. Our faculty literally "wrote the book" on improving industrial processes, helping hundreds of organizations worldwide maximize productivity and profits."
        ii. Heavy-Duty Instruction
            a. "UT's heavy-duty programs teach more than statistical methods; they equip you with the ability to improve systems, deliver value, and maximize your bottom line. Faculty members are easily accessible for project coursework and ongoing implementation assistance."
        iii. Immediate and Tangible Return On Investments (ROI)
            a. "The hallmark of UT's programs is hands-on learning using specific, applied project work that you can apply to your organization's processes. You will see an immediate, tangible return on your investment in this training, and your sponsoring organization will begin to recoup an ROI even before your instruction has concluded."
2. Structural Design & Quality
    a. The Six Sigma management practices at the University of Tennessee are separated into several categories that focus on different aspects of Six Sigma management in the industry. These programs separate the theory and history of

Six Sigma methods from the statistical tools and management strategies that Six Sigma knowledge holders use. Excellence through Analysis is the program that incorporates all five courses, and students meeting the requirements can complete this program and attempt to acquire Black Belt certification.

3. Unique Design Observations
    a. The University of Tennessee has historical experience with establishing Six Sigma implementation strategies for use in a variety of industrial systems.
    b. The five-courses of Six Sigma management separate the focus theory and statistical methods, which allows for in-depth study of each category of Six Sigma management.
    c. This curriculum offers academic courses involving Six Sigma management as well as certification in Green-Belt & Black-Belt for employees.

Training Program(s)/Course(s):

(1) Advanced Quality Control
(2) Designing Engineering Experiments
(3) Regression Analysis
(4) Six Sigma Methodology
(5) Six Sigma Methodology Capstone Experience

Program Offered By: Arizona State University: Ira A. Fulton School of Engineering

Program Type(s): Black Belt Certification/Academic Courses

Program Length: ½ Year Semester Courses, 20 – 30 classes per course.

Program Entrance Criteria: Business professionals currently working in the industry.

Program Assessment:

1. Program Mission Statement & Summarization
    a. Arizona State University offers a professional and academically recognized Six Sigma Black Belt certification program for engineers looking to enhance the quality of processes and products using statistical analysis at their current area of employment and beyond, and also for students seeking to focus their engineering degree on Six Sigma management practices and strengthen their data analysis techniques. This program offers both a graduate degree certification and a Black Belt certification upon completion of the academic courses. According to the

Arizona State University Website (2008), "Industrial Engineering faculty and industry leaders, who have successfully deployed Six Sigma transformations in industrial and business organizations, bring both methods, leadership and deployment strategies into the curriculum. Additionally, experience among classmates will include students and engineering and technical professionals."

2. Structural Design & Quality
    a. The Six Sigma program at Arizona State University is separated into five courses, one of which is a capstone project. These courses incorporate the statistical analysis techniques taught in Industrial Engineering disciplines regarding quality and defect analysis. The Six Sigma courses are only available after successful completion of two out of the three courses in Advanced Quality Control, Designing engineering experiments, or regression analysis.
3. Unique Design Observations
    a. Courses are offered both online and in the traditional classroom environment, making the program easily accessible for both students of the university and professionals considering Black Belt Certification.
    b. Six Sigma management theory and practices are learned only after the participant of the program learns the statistical analysis techniques and quality theory regarding process improvement and quality control.
    c. This program offers both a graduate certification and a black belt certification upon completion of the program
    d. This program offers a capstone experience with an industrial company in which the program participants must display their understanding of Six Sigma and their ability to use Six Sigma management practices to improve on a process or product.

Training Program(s)/Course(s):

(1) Twelve courses (modules) related to Six Sigma management practices and procedures applicable in several industries.

Program Offered By: North Carolina State University

Program Type(s): Master Black Belt Certification

Program Length: 3 ½ Course Days per Module

Program Entrance Criteria: Black Belt Certification Holders Only

Program Assessment:

1. Program Mission Statement & Summarization
    a. The Six Sigma program offered by North Carolina State University resides above the level of Black Belt Certification, offering Master Black Belt Certification to Black Belt holders. This program targets business professionals and executives with intent on mastering their Six Sigma management tools and strategies to deliver optimum results for their respective companies.
2. Structural Design & Quality
    a. The design of this program focuses on the mastery of Six Sigma management practices, tools, and implementation. For that reason, this program offers twelve different modules, all focusing on a particular statistical tool, performance tactic, or process improvement technique. Each module focuses on three tasks, training, application, and teaching. These three core topics are covered in each of the twelve modules focusing on Six Sigma. Eligibility of the Master Black Belt certification comes only after the completion of five of these modules. Master Black Belt certification is granted after a display of Six Sigma project leadership within the employees current organization is displayed.
3. Unique Design Observations
    a. This program offers the highest accredited level of Six Sigma certification, which is the Master Black Belt Level. This is unique because of the comprehensive nature such courses must have.
    b. This program offers a variety of Six Sigma components, statistical methods, and business strategies to master.

Six Sigma Programs of Independent Businesses and Organizations

Training Program(s)/Course(s):

(1) Six Sigma Certification Programs

Program Offered By: Aveta Business Solutions

Program Type(s): Yellow Belt, Green Belt, Black Belt, and Master Black Belt Certifications

Program Length: Maximum of One Year

Program Entrance Criteria: No entrance criteria

Program Assessment:

1. Program Mission Statement & Summarization
   a. Aveta offers all four levels of Six Sigma certification for all individuals interested in learning Six Sigma management practices. All programs focus on teaching the basic statistical methods and techniques used to reduce defects in systematic processes and by doing so, reduce costs for organizations. These certification programs focus on the fundamental data analysis techniques of Six Sigma management and how to incorporate them into an organization. The focus of Aveta's Six Sigma program is implementation into business systems and processes.
2. Structural Design & Quality
   a. Aveta offers all levels of certification, and separates the depth of study and material covered depending on the certification one wishes to Obtain. Yellow Belt Certification requires that the student pass 5 exams with a grade of 70% or higher, whereas Master Black Belt certification requires the completion of 16 exams with a score of 90% or higher on each, and two Black Belt projects. The structure of this program is purely on a business level, and the certifications programs emphasize the ability to integrate Six Sigma methods into the organizations of the students that apply to the programs.
3. Unique Design Observations
   a. All Six Sigma certification levels are offered by Aveta, and there is no entrance criteria for any of the programs

Training Program(s)/Course(s):

(1) Six Sigma Certification Exams

Program Offered By: American Society for Quality (ASQ)

Program Type(s): Green Belt, Black Belt, and Master Black Belt Certification

Program Length: Exam: 4-Hour Exam, taken in 1-Day

Program Entrance Criteria: Minimum of three years working experience in a Six Sigma related occupation, organization, or project.

Program Assessment:

1. Program Mission Statement & Summarization
    a. The American Society for Quality offers certification to individuals who pass its certification exam focusing on Six Sigma. The difficulty and depth of the exam depends on the type of certification an individual wants to acquire. The exam incorporates Six Sigma management topics, statistical tools, and methods of implementation into the exam. In addition, the exam also incorporates the philosophies of Six Sigma and areas where many of the techniques and methods were derived from.
2. Structural Design & Quality
    a. In order to obtain Green Belt certification, successful completion of the exam and experience in using Six Sigma methods are the limitations of the requirements. The exams are 100 multiple choice exams that span over the time of four hours. The material in the exams reflects the current technologies, advancements, and strategies in the business world. Due to this fact, re-certification must occur every three years in order to maintain the certification level you have acquired.
3. Unique Design Observations
    a. Open book exam in which calculators are prohibited, as well as any other reference tools the exam taker feels is necessary.
    b. The exam is separated into the elements of the DMAIC model, incorporating all Six Sigma management topics that relate to each step of the model.

Training Program(s)/Course(s):

(1) Six Sigma Certification & Training

(2) Six Sigma Consulting Program

(3) Six Sigma Excellence Workshops

Program Offered By: Benchmark Six Sigma

Program Type(s): Training Workshops, Green Belt & Black Belt Certification

Program Length: 1 Day – 5 Day Certification Training. 6-8 Month Consulting.

Program Entrance Criteria: **Minimum of three years working experience in a Six Sigma related occupation, organization, or project.**

Program Assessment:

4. Program Mission Statement & Summarization

a. Benchmark Six Sigma is an organization with master black belts who teach the Six Sigma management concepts as well as offer their knowledge to corporations and companies in the form of consultation work.

5. Structural Design & Quality
    a. The trainers of the Six Sigma program have experience on over 100 projects and several certifications such as Black Belt, and Master Black Belt. The five day course is structured to teach the fundamental theories and practices of Six Sigma. The Green Belt and Black Belt certifications do not require the completion of a project, but an additional certificate is awarding for project completion.
6. Unique Design Observations
    a. Certification does not require the completion of a project. A separate project completion certification may be acquired at the participant's discretion.
    b. Benchmark Six Sigma offers Six Sigma consulting services for organizations looking to use the advantages of Six Sigma in their processes.

Six Sigma Training Program/Academic Course Syllabus

The training program/academic course syllabus was established by our team by incorporating the information from interviews, research, and Six Sigma program assessments. The syllabus was compiled as follows:

Professor: Name of Training Program/Academic Course Teacher

Contact Information: Contains the teachers e-mail address, phone number, and location of academic office. The teacher may also designate times for the trainees to seek assistance with the material and ask questions.

Class Time & Place: Outlining meeting times and locations for all classes within the curriculum.

Required Text Books: These textbooks cover the topic of Six Sigma management at both the theoretical and statistical level. In addition, they serve as a means to assist the training coordinators with the creation of statistical exercises, case studies, and practicing design techniques. Suck textbooks include:

1. Antis, David: Creveling, M Clyde; Slutsky, Jeff (2003). *Design for Six Sigma in Technology and Product Development (Prentice Hall Six Sigma for Innovation and Growth Series).* New Jersey: Prentice Hall, PTR.

   a. This book focused on Six Sigma from a theoretical and statistical standpoint, introducing design of experimentation methods and the statistical as well as management tools used in Sig Sigma management practices.
2. Box, George E.P.; Hunter J. Stuart; Hunter, William G (2005). Statistics for Experiments: Design, Innovations, Discovery. New Jersey: John Wiley & Sons. Inc.
   a. Strong statistics book offering several different statistical tools and strategies for design experiments. This book not only includes the seven statistical tools of Six Sigma and quality management, but dozens of additional tools that are applicable to industrial systems, products, and processes.

Additional Reading: Six Sigma management practices are constantly evolving within the industry, so suggestions for additional reading will be useful for trainees expecting to achieve high level certifications and become project leaders. Such textbooks include:

1. Harry, M., & Schroeder, R. (2000). *Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations*. New York: Currency and Double Day of Random House Inc.

Course Objectives: The objectives of a Six Sigma training program/academic course vary depdning on the level of certification the program intended to offer. Higher certification requires more experienced training coordinators and training instructors because of the amount of material the instructor must be familiar with. It has been observed through our research that certification levels vary depending on the amount of information covered per topic. The objectives of a new training program,/academic course teaching Six Sigma material should follow the same format of covering the entire scope of Six Sigma as a set of theoretical and statistcal management concepst, and also as a philosophy, and variations of the program can be developed to offer certification after the initial program design parameters are made. Most importantly, the course objective for this program is to teach the methods, strategies, and theories of Six Sigma, and offer a course project where these concepts can be applied. The course would teach the following:

1. Reduction of defect rates in industrial systems and processes
2. Strategies to increase the quality of products and processes in industrial systems using Six Sigma management practices

3. Increae Profits and Return on Investments by rising the quality initiative in organizations and businesses
4. Application and implemention of Six Sigma management practices and statistical tools.
5. Use realistic case studies and design projects based on real-life indsutrial systems, products, and processes.

Scheduling: The syllabus includes the schedule of the program and all relevant activities that will occur in the program. This includes a breakdown of course material throughout the entire course, exams, project deadlines, and any additional training program/academic course milestones. Scheduling is much more important for academic courses, as student usually take more than one classes and this would serve as an organizational tool for their efforts in the class.

Course Outline: Since Six Sigma certification courses depend on the level of depth of material covered per topic, our teams suggests that any Six Sigma program should follow the same comphrehensive and thorough format of discussing both theoretical and statistical concepts. This conclusion was drawn from our analysis of Six Sigma programs, interview, and creattion of the design model. Although program vary between the names of certain topics, a correlation can be drawn between the topics that every program considers. As such, our team assessed this coorelation and developed a Six Sigma course outline as follows:

1. Introduction to Six Sigma philosophy & its origins
    a. History of Six Sigma
    b. Major contributors to Six Sigma
2. Six Sigma Modeling methods
    a. DMAIC process
    b. Design of Experiments
    c. Data Collection methods
3. Statistical analsys techniques:
    a. Review of necessary basic statistics concepts
    b. Control Chart construction and analysis
    c. Seven statistical tools
4. Industrial Processes and System Theory
    a. Analysis of process limitations and design parameters
    b. Data Analysis

    c. Distribution theory (higher level statistical analysis)
5. Project Oriented Case Studies
    a. Use real-life industrial data and situations
    b. Projects should focus using Six Sigma analysis techniques in a team environment

Recommendations & Conclusions

The following recommendations are summarizations of the information obtained through our research, surveys, interviews, and analysis of Six Sigma program.

Design Model Conclusions

The design model that our team established is applicable to the creation of all types of Six Sigma training programs and academic courses in either the development stages or in the post development stages, where the program coordinator is looking for means to increase the quality of information taught or the enhance the organization of the information. Our design model incorporates training program theory and guidelines along with core Six Sigma management theory and practices. Its usefulness is that the design model can serve as a template for the creation of a Six Sigma training program by an independent organization, and also as a template for the establishment of an academic course in a college institution. In addition, because Six Sigma is as much a philosophy as it is a set of statistical analysis techniques, the design of a Six Sigma program needs to focus on this observation. Through application of the design method, that key factor is continuously taken into consideration, increasing the quality of the overall program and information delivered.

Future Project Recommendations

One major limitation of our design model is that it does not include an analysis of the methods and duties necessary to become a certified Six Sigma program. The design model can be expanded to incorporate certification programs; but for this to occur, research on the steps to become a validated certification program is necessary. For example, some of the academic institutions analyzed by our team offer not only Six Sigma training programs, but Six Sigma certification programs. Depending on the level of certification, there are certain criteria that must be met before entering the program. In the case of black belt certification, such criteria is work experience with Six Sigma projects, and the typical student would not have this type of experience, so their training is limited to certain certification levels until they obtain experience in the field. Also the staffing of such a program is very different than that of a standard Six Sigma training program, because the level of information and intensity of the course is substantially higher at the Black Belt and Master Black Belt certification levels. The requirements for teaching such a class are more experience oriented in terms of the amount of Six Sigma projects. An analysis of what constitutes adequate experience would need to occur before that type of information can be incorporated in the design model.

Learning Experience

Our team's interest in Six Sigma management practices and theory stems from our experiences with the topic in the academic courses at Worcester Polytechnic Institute. The institution briefly covers the topic of Six Sigma is several courses, and its most in-depth analysis occurs in the Total Quality Management course offered by the Industrial Engineering department. In this particular course, the topic of Six Sigma is discussed as both a theory and as a defect analysis measure for a particular systematic process. This relationship between Six Sigma and Total Quality Management was the basis of our research scope and our design modeling of the Six Sigma training program/academic course syllabus. Through our research, interviews, and analysis of training programs and academic courses involving Six Sigma throughout the nation, our team realized the close relationship with not only Six Sigma and Total Quality Management, but also the relationship between Six Sigma and process improvement strategies for corporations across America. Initially, Six Sigma is seen as a performance measure for a particular process, but in the industry, Six Sigma means much more than mathematical calculations. In the industrial world, Six Sigma is a business mentally for perfecting a system and all of its components. In addition, this perfection is continuously strived for, in an attempt to ensure excellence as a priority within an organization or corporation as a whole. This incorporates much more than process improvement on a production level. This involves creating cost-effective processes throughout an organization and maintaining their quality indefinitely. More importantly, Six Sigma is a means of increasing a corporations overall net worth and profit margins by effectively, honestly, and thoroughly measuring all of the activities in the corporation. This includes not all process improvements for the product or services, but also organizational improvements among employees in all departments.

References

Aguayo, R., & Deming, W. E. (1990). *Dr. Deming: The American Who Taught the Japanese About Quality.* New York: Simon & Schuster Inc.

Aravindan, P., & Devadasan, S. (1996). A focused system model for strategic quality management. *International Journal of Quality and Reliability Management , 13* (8), 79-96.

Arizona State University . (2007). *Six Sigma Black Belt Certification Program*. Retrieved March 22, 2008, from Industrial Engineering: Ira A. Fulton School of Engineering: http://ie.fulton.asu.edu/continuing-education/six-sigma-black-belt-certification-program

Carnagie Mellon SEI. (2008). *Carnagie Mellon University*. Retrieved March 22, 2008, from Improving Process Performance Using Six Sigma: http://www.sei.cmu.edu/products/courses/p49b.html

Carr, C. (1992). *Smart Training.* New York, New York, USA: McGraw-Hill Inc.

Charbonneau, H. C., & Webster, G. L. (1978). *Industrial Quality Control.* Englewood Cliffs, New Jersey, United States: Prentice-Hall, Inc.

El-Haik, B. S. (2005). *Axiomatic Quality.* Hoboken, New Jersey, United Stated: John Wiley & Sons Inc.

Eskandari, H., Sala-Diakanda, S., Furterer, S., Rabelo, L., Crumpton, L., & Williams, K. (2007). Enhancing the Undergraduate Engineering Curriculum. *Education + Training , 49* (1), 45-55.

Harbour, J. L. (1997). *The Basics of Performance Measurement.* Portland, Oregon: Productivity Press.

Harry, M., & Schroeder, R. (2000). *Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations.* New York: Currency and Double Day of Random House Inc.

Kirkpatrick, E. G. (1970). *Quality Control for Managers and Engineers.* New York, London, Sydney, Toronto, United States: John Wiley & Sons, Inc.

Lo, V., & Sculli, D. (1996). An Application of TQM Concepts in Education. *Training for Quality , 4* (3), 16-22.

Martin, L. (1993). Total Quality Management in the Public Sector. *National Productivity Review , 10*, 195-213.

Odiorne, G. S. (1966). Management by Objects. In R. Craig, *Training and Development Handbook* (pp. 13-1). New York: McGraw-Hill Inc.

Sakthivel, P. B. (2007). Top Management Commitment and Overall Engineering Edcucation Excellence. *The TQM Magazine , 9* (3), 259-273.

Steinmetz, C. S. (1966). The History of Training. In R. Craig, *Training and Development Handbook* (pp. 1-3). New York: McGraw-Hill Inc.

Tague, N. R. (2005). *The Quality Toolbox, Second Edition.* Milwaukee: ASQ Quality Press.

Tickner, F. (1966). *Training in Modern Society.* Albany, New York, USA: Williams Press Inc.

University of Tennessee. (2006). *Heavyweight in Process Improvement*. Retrieved March 22, 2008, from University of Tennessee: Process Improvement: http://thecenter.utk.edu/process/

Appendix A: Six Sigma Survey

Six Sigma Survey

1. What is your major? ____

2. What is your year of graduation? ______________________________________

3. Are you familiar with the term "Six Sigma"? (Yes or no) ________________________

    b. If yes, Please rate your familiarity with Six Sigma.

    1 2 3 4 5

    LOW HIGH

4. Have you taken any classes at WPI that have discussed Six Sigma concepts? (Yes or no)

____

    b. If yes, Please indicate the name of the course and what aspects of Six Sigma were discussed.

    Course Title:____

    Aspects learned: ____

5. Have you had any experience with Six Sigma outside of the classroom (i.e. Internship/IQP/MQP)? Please indicate the extent of this experience.

6. If there were a course designed exclusively for Six Sigma, would you be interested in taking it? (Yes or no)

Appendix B: Six Sigma Analysis Interview

Interviewee: Alison Howlett

Company/Organization: Raytheon

Questions for Six Sigma Certification Holders

1. How many Six Sigma training programs/learning opportunities have you had?
   A1. There are a few ways to interpret this…..I've only had Raytheon six sigma training, versus training at other companies, or industry "generic" six sigma training. Raytheon has different levels of six sigma certification/qualification: specialist, green belt, expert, black belt, and master expert. I am specialist and expert trained and certified.
2. What was the focus of your Six Sigma training programs?
   A1. Specialist training focuses on the six steps of the six sigma process – visualize, commitment, prioritize, characterize, improve, achieve. It also focuses on the Raytheon six Sigma principles – which can change based on the business focus.
3. Was your experience in learning about Six Sigma been focused more on the theory and concepts, or on the statistical processes used?
   A1. Yes – it's focused on both. The training has been theory based, but depending on each expert's area and expertise, statistics may be necessary. No matter the situation, each certified expert is expected to put theory into practice in order achieve results. Some projects use more statistics tools than others.
4. Are you familiar with the "Kaizen" method?
   A1. Yes, we use Kaizen where it makes sense. It's typically a good tool to get people through Visualize, Commit, Prioritize, and some of the Characterize. Where teams need to be careful in using Kaizen is that when you leave the blitz, there is typically more work to be done, so follow-through and good program management by the expert is necessary to achieve end results.
5. In your experience, what type of employees can best take advantage of Six Sigma?
   A1. Every employee must take advantage of six sigma in order to keep the business competitive. Raytheon Six Sigma is broken into levels so any individual (no matter the job grade or experience) can utilize six sigma. The type of individual that should LEAD six sigma efforts must be outgoing, have a strong business sense, good

organization and program management skills, work well with others – including difficult personalities, and an excellent communicator – at a project level and with the 3-minute elevator speech in order to sell a project to management.

6. What type of experience do you feel is necessary before attempting to achieve Six Sigma certification?
   A1. Assuming expert certification, 2-5 years of experience is necessary to have a good understanding of what drives the business and how it grows. Specialist qualification is expected by all employees.
7. Do you feel that knowledge of Six Sigma on a theoretical level is necessary before attempting to achieve certification at any particular level?
   A1. Some theory is necessary, but practice makes perfect. Business is about achieving results, not philosophizing. One has to only look at successful entrepreneurs – Bill Gates, Donald Trump – most likely never formally trained in six sigma, but if you looked at the types of processes they use, they would align with six sigma theory. So you could interpret this as you need to know it, but formal training isn't required – a lot of it is intuitive to a good business mind.
8. What was your major in college and how closely tied is your major to the concepts of Six Sigma management theory and practices
   A1. My major was Chemical Engineering and had little tie-in to Six sigma management theory and practices.
9. Do you feel that certain Six Sigma is more effective on an engineering level or a business level?
   A1. Six sigma is effective on all levels of business, but you have to pick and choose the right tools to use when and where. Design for Six Sigma is definitely need for engineering and design phases of programs. Design for manufacturability and lean principles is needed for production environments. There are separate sets of tools that work for program management six sigma activities, like critical chain and theory of constraints, which are necessary to keep a program on schedule and on budget – and should be used on all phases of a program life cycle.
18. Do you feel that integrating Six Sigma management concepts and practices into an organization is particularly difficult? Why or Why not?

A1. Consultants answer – it depends. It depends on how flexible your environment is; it depends on how strong of a leader you have, and how bought into the six sigma tools, principles and process he/she is; it depends on the need for the process with schedule, budget, and design constraints. For ex., the program I work on is bought into programmatic six sigma management – meaning, the use of management tools, like critical chain. We have a strong leader who enforces these tools and that makes it work (that isn't always easy either). However, they are less bought into design for six sigma tools because the design is so difficult – the focus is not on optimizing for six sigma, but on simply being able to meet the requirements (defense versus commercial).

19. How would define the term quality, with regards to your duties.

A1. "Ideal" Quality means doing it right the first time with no rework, meeting the requirements, on time, on budget.

20. Do you feel that Six Sigma is an attainable performance target for an organization?

A1. An organization or company should not be focused on setting six sigma performance targets. Last time I checked, I don't believe this is a metric Wall Street monitors to set stock values. Six Sigma is a process that should be used in order to meet company performance targets like bookings, profit, cash, etc. Metrics drive behavior, so one must be careful which metrics are chosen to monitor.

21. What types of performance measures were taken during your training programs? Was there any testing or reports drafted by the training participants?

A1. Cost Avoidance, Risk & Opportunities Impacted, Profit, Cash, Bookings

22. What types of organizations do you feel Six Sigma management theory is most applicable in?

A1. he theory is applicable in all organizations – it's the tools used that need to change based on organization and also on phase in a program life cycle

23. What educational tools were used during the training programs you were a part of? Were there any specific books used in the teaching of the program?

A1. This would be a separate sheet of about 30 books we used. To name a few….The Goal, Goldratt; The Profit Zone, Slywotzky, Morrison; Getting to Yes, Fisher, Ury, Patton; Clockspeed, Fine; Innumberacy, Paulos; Design for Six Sigma, Creveling, Slutsky and Antix

24. Do you feel that the training programs you participated in were of high quality?

    A1. Yes, excellent quality. The other thing about Raytheon training programs, especially the six sigma training, it is constantly changing and growing to meet the demands of the business.

Questions regarding Six Sigma Training at Raytheon

25. How many Six Sigma training programs are in place?

    A1. Raytheon has different levels of six sigma certification/qualification: specialist, green belt, expert, black belt, and master expert. I am specialist and expert trained and certified.

26. How many have you gone through?'

    A1. I am certified and received training for specialists and experts. I have received most of the green belt training, but I am not a certified greenbelt.

27. How long does each of these take?

    A1. Specialist – 30-60 days; Green Belt – 60-90 days; Black Belt – 6 months – 1 year; Expert – 1 year; Master Expert – 2 years +

28. Was this done in addition to you everyday workload, or was it an independent assignment?

    A1. Specialist training was an additional workload. Expert training was a full-time job.

29. Was this a requirement, or was it something you chose to do?

    A1. Specialist training and qualification is a requirement. For expert training, I choose to do this – not a requirement. In fact, there are very advanced screening processes to get into the expert track.

30. What specific concepts that you learned have you applied most in your work?

31. Were there concepts learned that you feel are less important (used less) than others?

    A1. These previous two questions are very long to answer. There is a slew of stuff learned in the training and I'd say I've used all of it and still do use it. Again, some of the tool usage I use more often than others, but I use all the theory and principles applied in training. If you care to have a conversation about this, give me a call at the office.

32. What types of projects did you do during your training?

    A1. My expert certification was based on a specific parameter we were constantly failing that was impacting on-time delivery of our units to the Navy. I worked with the Navy on collecting data and discussing a possible spec relief in order to allow units to flow faster. It required a lot of statistical analysis and even required the customer to come to Raytheon to give a demonstration of the system with the degraded specification requirements. The customer approved the spec relief. Typically I'd say don't aim for spec relief, aim for a better design, but redesign was too expensive at this point in the game.

33. What types of people (positions/departments) normally participate in this training?
    A1. I had people across all Raytheon business units and across all functions participate in my training. I'd say the majority are from Operations. But we even had someone from IT and another from HR. The next largest category was engineering. \
34. Would you recommend this training to somebody else within Raytheon?
    A1. I would definitely recommend the training to an individual that had the drive and skill set to become an expert. It's not easy and takes much diligence and endurance.
35. Would you recommend someone outside of Raytheon to participate in Six Sigma training?
    A1. We have had customers and suppliers as part of our training.
36. Do you feel it is important for college students to receive six sigma training before entering the workforce?
    A1. I'd be more interested in someone who has work experience or project experience than I would someone who has taken a six sigma class. Business is a about execution, and anything the universities can do to demonstrate execution is valuable to a company. A six sigma course at a University would need to be constructed so that it required an involved project – I'd like to see a type of project that starts at the beginning of the semester and as you learn theory and tools, you're able to immediately apply them – rather than learn the theory for the first month and do the project the second month.