AC 2008-1028: TEACHING SIX SIGMA CONCEPTS IN AN ENGINEERING COLLEGE

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Abstract

Six Sigma is a process improvement methodology currently being employed across various types of business and industry. DMAIC (Define, Measure, Analyze, Improve, Control) has been developed more recently with the goal to apply the Six Sigma principles for the improvement of existing products and processes. The Six Sigma approaches provide a disciplined way of solving problems, eliminating defects and improving business results. In order to increase students' creative ability, college should provide them with the Six Sigma. Learning about such a well-structured approach and developing related skills would enable today's students to become tomorrow's more effective employees.

In this program, fifty-three students in the class are divided into 13 groups. As project, each group finds college facilities and services to be improved and tries to solve these problems with DMAIC. The curriculum in this class furnishes instant feedback to the students by solving the problems directly associated with them. The students' creative thinking and power of expressing are also improved by learning various creative skills and teamwork. As the results of this class, 52 out of 53 students have acquired the honor of receiving *Green belt*.

Introduction

As the industries are growing up on large scale and high density, the demand for more creative engineers is increasing. Engineers need to have abilities to handle out multi tasks simultaneously. Therefore the engineer who not only is an expert in the industry field but also has creativity and cooperating skill is required and it is a new role of colleges to educate and discipline these novel skills. In this paper, the curriculum including the education for the theory of Six Sigma is developed as shown in Figure 1. The curriculum proposed in this paper consists of two contents; 1) Lectures for *Six Sigma* which include the definition, procedure and applications; 2) Group project which is performed by students, applying the theory of Six Sigma to real problems.

Six Sigma is one of creativity improvement methods, which is a data-driven, fact based, decision making management tool. It is used to improve the profitability of a business enterprise by reducing the waste and defects while improving the quality of products, processes and services, thus increasing the customer satisfaction. Six Sigma is widely used in industry to improve the efficiency of product design, development, manufacturing and marketing. The Greek letter Six Sigma(б) in the context of mathematical statistics represents standard deviation. However, in industry, б is used as a measure of performance variation. Industry's performance is measured by the sigma level of their business performance. Traditionally industry operates on three sigma (3б), translated into 670,000 defects per million opportunities. Six Sigma (6б) means 3.45 defects per million opportunities, which is near error-free business performance.[1] DMAIC refers to a data-driven quality strategy for improving processes, and it is an abbreviation for Define, Measure, Analyze, Improve, and Control.

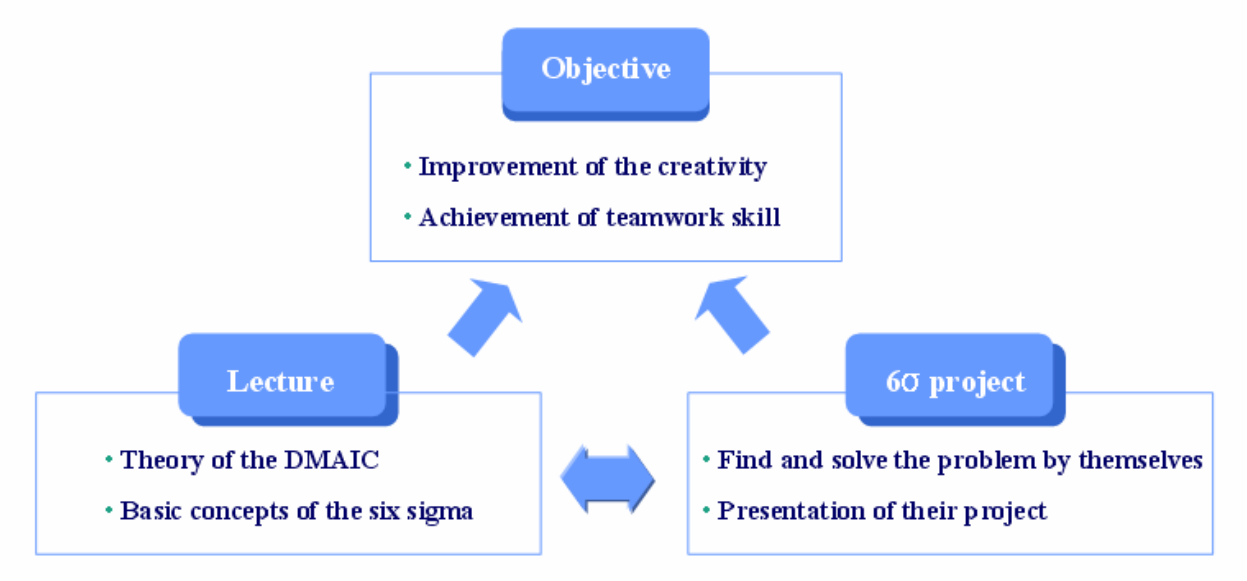

Figure 1. Overview of the curriculum proposed in this paper

2. Curriculum

2.1 Objective

The recent trend for Six Sigma's application in manufacturing processes underscores the value of teaching students about this approach. Students need to know how to operate and improve the processes they own and to improve business results. In addition, a majority of students will be engineers in the manufacturing sector, where there has been an increasing emphasis on Six Sigma programs. Therefore, the major objectives of this curriculum are as follows:

1. Improvement of the creativity of students. As teaching a basic knowledge about Six Sigma methodology, student can find a solution more creatively and objectively.
2. Achievement of teamwork skill. This curriculum makes students organize several teams and perform some projects.

The scope of the curriculum is to provide the knowledge of Green Belt level and enable students to gain the title of Green Belt.

2.2 Features

To incorporate Six Sigma concepts in an engineer education curriculum, there are three kinds of alternatives approved by Stevemson.[2] They are to:

1. integrate throughout the core curriculum.
2. teach in a dedicated course.
3. teach as a component of a course such as operations management or strategy and policy.

The curriculum proposed in this paper has several benefits, such as:

1. tight control in terms of topical coverage.
2. needing only one or a few instructors trained Six Sigma.
3. Six Sigma topics covered in a logical sequence.

4. instructors being more enthusiastic about teaching this material than instructors teaching core courses.

2.3 Contents

Two areas of teaching are necessary for students to perform Six Sigma analyses. One is basic knowledge of a Six Sigma method and the other is the ability to apply the knowledge in a purposeful manner. Therefore, the curriculum proposed in this paper includes two major contents ; a lecture for teaching Six Sigma concept and a group project for application of Six Sigma

2.3.1 Education Subject

The curriculum proposed in this paper provides an integrative approach. It pulls together many of the concepts and tools they have encountered into an organized framework that will enable them to apply their knowledge and analytical skills to perform Six Sigma analyses. The lecture shown in this paper includes the following five subjects which are in accordance with the step of Six Sigma. The title of subject 1 is *Define* which involves defining the scope of the problem, containing customer impact and potential benefits. Subject 2 deals with the understanding of the customer requirements and translating the key ones into some measurable characteristics. Subject 3 involves studying the preliminary data to document the current performance and identifying root causes. Also in subject 4, the concept improvement is introduced which deals with significantly reducing the defect levels and the ways to do it. Finally, subject 5 trains students to acquire the concept of *Control* which is putting a system in place to sustain the improvements that are achieved.

Lecture #	Subject	Details	Week	Homework
Lecture 1	Define	Team Charters	1	Submit the cover letter
		SIPOC (Suppliers, Inputs, Process, Output and Customers)	1	
		Process Mapping Techniques	2	
		Customer Focus	3	
		Voice of the Customer	4	
Lecture 2	Measure	Input, Process and Output Measurement	5	
		Measurement Plan	5	
		Sampling	5	
		Statistics	6	
		Calculating Six Sigma	6	
		Control Charts	7	
		Simple Data Presentation	7	
Lecture 3	Analyze	Data Stratification	8	Submit the draft group paper
		Pareto Analysis	8	
		Determining Potential Root Causes	8	
		Brainstorming Techniques	9	
		Historical Data	9	
		Problem Solving Techniques	9	
Lecture 4	Improve	Change Management	10	Submit the final group paper
		Solution Selection Techniques	11	
		Criteria Selection and Solution Ranking	11	
		Pilot Planning	12	
		Pilot Implementation Schemes	12	
Lecture 5	Control	Implementing the Solutions	13	Submit the portfolio
		Plan –Do-Check-Act	13	
		Elements of the Plan	14	
		Ramping up the Pilot Plan	15	
		Auditing for Compliance and performance	16	
		Change Management Issues	16	

Table 1. The subject and schedule of the lecture

2.3.2 Group project

In this curriculum, 53 students are divided into 13 groups and each group finds the college facilities and services to improve. After this process, they try to solve these problems with DMAIC. Students carry out thirteen Six Sigma projects. Table 2 shows the summary of Six Sigma projects that comes from this curriculum.

Students begin the project with the proper metrics. They collect the data and set up definitions such as the supplier, input, process, output, customers, FDM (Functional Deployment Mapping). They have learned that sub process, step path, decision making and the man who are responsible for process, using the FDM concept. Students then measure the Critical-To Quality (CTQ) characteristics in defect of real problem such as a college facilities and services. Finally they develop methodologies to identify and implement the solutions to improve their processes. To solve problems efficiently, they perform not only Six Sigma but also other problem solving methods such as Brainstorming, Brain Writing, Checklist, and Morphological Analysis.

Team #	Title	Objective
Team 1	Improvement in reliability of a vending machine	CTQ 2.32σ
Team 2	Improvement of recommendation process	CTQ 2.00σ
Team 3	Improvement in control process of a banner	CTQ 6.00σ
Team 4	Improvement of the lending service in a library	CTQ 1.00σ
Team 5	Reassignment of a concession stand	CTQ 1.00σ
Team 6	Improvement of a common process	CTQ 0.50σ
Team 7	Improvement of the lending service in an engineering college	CTQ 1.00σ
Team 8	Improvement of the arrangement system in library	CTQ 1.65σ
Team 9	Reassignment of a copy room	CTQ 2.00σ
Team 10	Improvement in process of the notice service	CTQ 2.58σ
Team 11	Reassignment of a lost property office	CTQ 0.20σ
Team 12	Improvement in process of assign rockers	CTQ 2.40σ
Team 13	Reassignment of a library	CTQ 1.82σ

Table 2. Summary of Six Sigma projects

2.4 Grading

For evaluation of student performance in this class objectively, a combination of presentation, homework, exam and group project is utilized. Roughly, the total grade of this class consists of group project(60%) and exam(40%). Especially the grade for group project includes the evaluation of presentation skills. Final students who mark over 80 score are certificated with Green Belt.

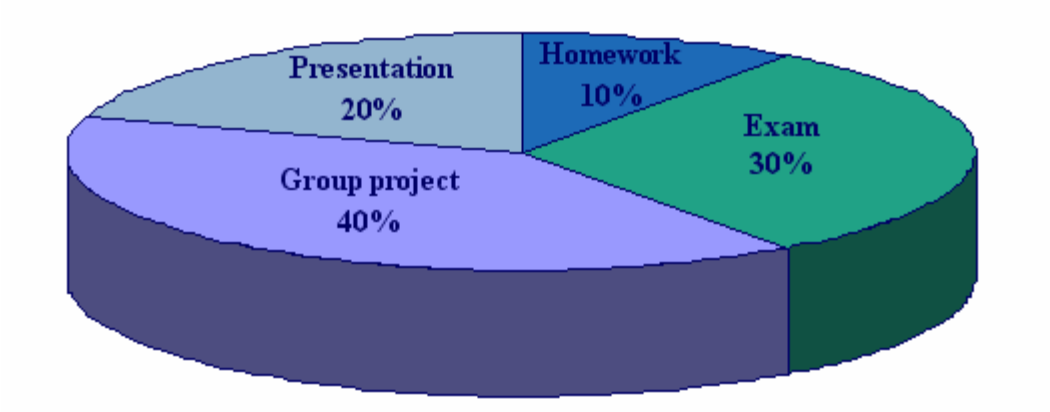

Figure 2. Diagram of grading

2.5 Examples of the Group Project

As the result of this class, 52 out of 53 students have acquired Green Belt. Each Six Sigma project is successful and creative. The mean value of the CTQ is -0.60σ to 1.89σ as shown in Table 3. Table 3 shows the title of 13 projects and the changes of CTQs. 6 teams (Team 2,4,5,6,7 and 9) improve their CTQ greatly than what they have targeted.

Team #	Title	Result
Team 1	Improvement in reliability of a vending machine	CTQ 1.99σ → 2.26σ
Team 2	Improvement of recommendation process	CTQ 0.35σ → 2.16σ
Team 3	Improvement in control process of a banner	CTQ -0.24σ → 1.32σ
Team 4	Improvement of the lending service in a library	CTQ 0.40σ → 1.05σ
Team 5	Reassignment of a concession stand	CTQ -1.00σ → 3.48σ
Team 6	Improvement of a common process	CTQ -1.81σ → 1.05σ
Team 7	Improvement of the lending service in an engineering college	CTQ -5.32σ → 1.74σ
Team 8	Improvement of the arrangement system in library	CTQ -0.53σ → 1.17σ
Team 9	Reassignment of a copy room	CTQ 0.08σ → 2.22σ
Team 10	Improvement in process of the notice service	CTQ 0.25σ → 2.58σ
Team 11	Reassignment of a lost property office	CTQ -0.92σ → 0.15σ
Team 12	Improvement in process of assign rockers	CTQ -0.45σ → 2.40σ
Team 13	Reassignment of a library	CTQ -0.57σ → 0.91σ

Table 3. Results of the group projects

Control System of the Project			
Make a Copy	Make a copy in 5 minutes		Cycle Time
Process Map	Check List		
Flow	Measure	Record	Frequency
Order			
Wait	Waiting Time	100%	Every Time
Fill in the Form	Rate of the Record	100%	Every Time
Dispatch	The time required		

Figure 3. A result of the group project (Team 9)

For example, team 9's project—'Reassignment of the copy room'— is one out of the projects that reaches the goal. Students measured how long it takes to make a copy. The objective is to reduce that time. The solution is replacing the copy room. As the result of this project, they save the process time up to about 45%.

Control System of the Project			
Arrangement System	95% Arrangements in 16 Hours		Cycle Time
Process Map	Check List		
Flow	Measure	Time	Frequency
Collection	Waiting Time	3.9 Hrs	Once a week
Classification	Classification Time	3 Hrs	
Cart	Waiting Time	3 Hrs	Once a week
Arrangement	Rearrangement Time	10 Hrs	Once a month

Figure 4. A result of the group project (Team 8)

On the other hand, team 8's project —'Improvement of the arrangement system in library'— is one of the groups that failed to achieve their targets. The objective of this project is setting up a well-organized arrangement system in a library. They defined CTQ as the rearrangement time and the solution is the reorganization of a work responsibility schedule. Although it is effective enough a solution to improve CTQ, the result is unsuccessful because of the absence of library manager supporting.

3. Conclusions

In this paper we introduced the curriculum and covered the Six Sigma principles in the Engineering College. Having the students exposed to this integrative philosophy will not only make them be able to bring together the things that they learned in other courses, but also prepare themselves for the real challenges, where many organizations —both manufacturing and service— are increasingly employing Six Sigma thinking in decision making. The education through this curriculum also has the best chance of giving students the integration and application skills they need. As a result of this class, 52 out of 53 students have acquired Green Belt and carried out 13 Six Sigma projects successfully.

Although a lot of curriculums about the improvement of creativity have been introduced in college education, it is difficult to verify the effectiveness of those educational programs. With learning knowledge and skills associated with creativity such as DMAIC and applying them into the real problem, this curriculum can rapidly ascertain the performance of educational programs.

Acknowledgment

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