Application of Service Experiential Learning Opportunities with Deployment of Six Sigma Problem Solving Teams

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Abstract:
The Industrial Engineering and Management Systems Department at the University of Central Florida has incorporated service experiential learning opportunities into the curriculum within a Total Quality Improvement course. This graduate level course teaches the Six Sigma body of knowledge, including quality management principles and problem solving tools. It provides just-in-time experiential learning opportunities to reinforce the in-class instruction. This paper will provide examples of Six Sigma tools applied in the project case studies including Voice of the Customer, Design of Experiments, and Benchmarking.

Introduction:
The Industrial Engineering and Management Systems (IEMS) department in the College of Engineering and Computer Science at the University of Central Florida has incorporated community-based service experiential learning into their curriculum. The Total Quality Improvement course, ESI 5227, is a graduate level course that focuses on the development of tools for the management and improvement of quality in different organizations. [1] Essential concepts, practices, and methods of modern quality improvement tools are discussed, along with the Six Sigma DMAIC (Define, Measure, Analyze, Improve, and Control) problem solving approach, and critical success factors to team building and teamwork. Six Sigma team projects are performed that apply the class lecture material to "real world" organizations. There is a requirement that each organization be a community-based organization, or have some component of providing a benefit to a community organization. A description of the Total Quality Improvement graduate course objectives, components, and structure of the course will be discussed in this paper, as well as three examples of how Six Sigma tools were applied in just-in-

time experiential learning opportunities.

Total Quality Improvement Course Description:

The Total Quality Improvement, ESI 5227, graduate level course provides a broad exposure to topics in quality improvement. [1] It provides learning of the Six Sigma DMAIC problem solving approach and allows the students to perform just-in-time experiential learning opportunities encompassed in a Six Sigma project. The course runs for the 16-week semester. The course is intended to focus on the development of tools for the management and improvement of quality in community-based organizations. Essential concepts, practices, and methods of modern quality improvement tools are discussed, along with the Six Sigma DMAIC problem solving approach, and critical success factors to team building and teamwork. The Six Sigma team projects are performed by the students applying the DMAIC problem solving approach and appropriate quality tools to help a community-based organization understand and improve their processes and use of technology. The tools are applied within the phases of the DMAIC problem solving methodology, as they are learned in the lecture portion of the course. Tables 1 and 2 provide the mapping of the Six Sigma tools and principles taught in the course. [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13], [14], [15], [16], [17]

Table 1: Course Map of Six Sigma Principles by DMAIC Phase

DMAIC PHASE				
DEFINE	**MEASURE**	**ANALYZE**	**IMPROVE**	**CONTROL**
Principles				
• Value of Six Sigma Process • Variation • Voice of Customer • Customers, Stakeholders • Empowerment • Quality definition • Quality history • Team building • Teamwork and participation • Types of teams • Stages of development • Risk • Critical to Quality	• Value stream • Training • Systems thinking • Process focus • Statistical thinking • Variation • Conflict resolution • Process performance metrics • Benchmarking • Financial benefits • Cost of quality • Types of data • Measurement scales	• Process capability • Lean principles of value, value chain, flow and perfection • Statistical thinking • Variability • Process focus • Empowerment • Team work and participation • Measuring • Training	• Change management • Continuous one-piece flow • Pull • Standardization • Statistical thinking • Measurement • Education	• Perfection • Continuous improvement and Kaizen • Standardization • Statistical thinking • Education • Learning • Knowledge transfer • SPC

Table 2: Course Map of Six Sigma Tools by DMAIC Phase

DMAIC PHASE				
Tools				
DEFINE	**MEASURE**	**ANALYZE**	**IMPROVE**	**CONTROL**
• Brainstorming • Nominal Group Technique • Process charter • Work plan • Responsibilities matrix • SIPOC • QFD • SWOT	• Multi-voting • Process flow charts • Benchmarking • Check sheets • Surveys • Interviewing • Focus Groups • Waste Identification and elimination • Standardization of operations • Good housekeeping • 5S's • Pareto analysis • Cause & Effect • Check sheets • SPC • Histograms • Performance metrics • Capability analysis • Affinity diagrams • Benchmarking	• Cause & Effect • Cost/benefit analysis • Waste identification • Standardization of operations • Good housekeeping • Kanban and visual control • SPC • Improvement plans • One-piece flow • Pull	• Cost/benefit analysis • Improvement plans • Standardized procedures • Training, pull, one-piece flow	• SPC • One-piece flow • Kanban and visual control • Continuous improvement and Kaizen

The course consists of a lecture component that uses PowerPoint presentations to teach the students the principles and tools of Six Sigma and the DMAIC problem-solving approach. Case study examples of "real world" application of Six Sigma tools are presented to the students to enhance their understanding of the tools. The students select teams of five to seven students that apply the DMAIC and Six Sigma tools in a community organization throughout the semester. The students perform the Define, Measure, and Analyze phases of the DMAIC problem solving approach and suggest process improvement and control recommendations that allow the project sponsors to Implement the recommendations and Control mechanisms. The course instructor, the principle author of this paper, serves as the Master Black Belt that provides mentoring to all of the teams. Professionals from the local American Society for Quality Orlando Section 1509 perform Six Sigma Black Belt coaching and knowledge transfer for each of the student teams. A certified Six Sigma Green Belt leads or mentors each team. The weekly class is composed of two hours of lecture and one hour of in-class team-based problem solving and team-building activities. Each student spends about 8 to 10 hours per week outside of class on the Six Sigma project activities, for a total resource and mentor effort of approximately 5200 hours across the 16-week semester. The students complete a team assessment to extract lessons learned as well as a 360 degree assessment across the teams to understand the level of effort and commitment of each student on the Six Sigma project. The students share knowledge across the teams by uploading their presentations and reports to a shared website. The project champions also complete an assessment of the value provided by each team to the champion's organization.

Just-in-Time Experiential Learning Opportunities:

The Total Quality Improvement course was taught in the fashion described above for the first time in the Fall 2004 semester at UCF. Thirty-one students participated in the course and the Six Sigma projects. Five Six Sigma teams of from five to seven students per team helped organizations improve their processes and how they used technology. Four of the five teams were organizations within the university and the fifth team was a financial services organization who agreed to share the lessons learned from the project to enhance future students' learning. Three examples of the application of Six Sigma tools will be discussed. The tools are Voice of the Customer, Design of Experiments and Benchmarking.

Voice of the Customer: [18]

The Voice of the Customer (VOC) includes techniques to understand the needs and requirements of the customers of the processes under study for improvement. There are many ways to collect the voice of the customer, including customer surveys, focus groups, email and websites, test marketing, customer interviews, 800 phone numbers and suggestion boxes. In one of the Six Sigma projects, the Industrial Engineering and Management Systems (IEMS) department at the University of Central Florida requested that one of the Six Sigma project teams identify improvement opportunities for the graduation administration processes. The team developed and delivered a customer survey to gather the graduate students' needs and satisfaction with the graduate administration processes. The survey was distributed via email to each graduate student, and in person to a subset of the graduate classes. The response rate was about 17%. The sample size varied by question, because not all of the graduate students that responded to the survey had experience or used each process. Table 3 summarizes the graduate students' satisfaction with the identified processes. The percent of satisfied ratings (very satisfied, satisfied, indifferent) and percent of unsatisfied ratings (very unsatisfied, and unsatisfied) are identified. The graduate students are the most satisfied with the petition process, and least satisfied with the intent to graduate process. The customer survey data was used to focus the improvement efforts on the student management process which had a fairly high un-satisfied frequency and high frequency of use by the student. The survey data and interviews with the process owners were also used to identify critical to quality characteristics and metrics to assess the improvement of the process.

Table 3 Summary of Graduate Students' Satisfaction with Graduate Administration Processes

Survey Question	n	Satisfied Rate Very Satisfied/ Satisfied/Indifferent	Un-satisfied Rate Very Unsatisfied/ Unsatisfied
1. Rate your overall satisfaction with the student management process.	42	50%	50%
2. How satisfied are you with the Program of Study Process?	41	59%	41%
6. Rate your satisfaction with the guidance your advisor has given you.	40	53%	48%
10. Rate your satisfaction with the transfer credit process.	17	47%	53%
11. How satisfied are you with the method of notification of approval/disapproval?	16	69%	31%
12. How satisfied are you with the amount of time it took to process the transfers?	17	65%	35%
17. How satisfied are you with the petition process?	10	60%	40%
19. How satisfied are you with the method of notification of approval/disapproval of the petition?	9	78%	22%
20. How satisfied are you with the amount of time it took to process the petition?	9	56%	44%
25. How satisfied are you with the Intent to Graduate process?	18	44%	56%

Table 4 presents the critical to quality characteristics (CTQs) and metrics.

Table 4 Critical to Quality Characteristics and Related Metrics

CTQs	**Metrics**
Advisor Knowledge	Student satisfaction level (gained by semester critique form)
POS Form Accuracy	# Changes (less changes the better)
Course Schedule Accuracy	# of courses that change when semester next semester starts (less changes the better)
Promptness	Time between meeting with advisor and POS approval by department chair

The Critical to Quality Characteristics are components of the process that are important to the students (customers). The metrics can be used to measure the process with respect to the CTQs. The advisor knowledge, the program of study (POS) form accuracy, the course schedule accuracy and promptness of the process steps were identified as the CTQs for the graduate administration processes. The VOC tools were very effective in understanding the needs and satisfaction of the customers and the critical areas to focus first on and improve.

Design of Experiments: [19]

Another Six Sigma project team focused on reducing the repeat customer calls for a financial services organization. The percentage of repeat calls and the cost associated with processing these calls was deemed as a high cost of doing business, and management desired to reduce this cost. Design of Experiments was an effective tool that was used to identify some of the critical variables that contribute to the repeat calls. The potential variables were identified by the process owners and the organization's Black Belt that were hypothesized to contribute to repeat customer calls. The variables initially identified were:

Loan status – delinquent or in good standing
Board date – date servicing transferred to the financial services organization
Previous services that the customer has used
Agent number
Location of call center (2 call centers in India, one in Orlando, Florida)
Length of training of agent
Agent language skills
Length of time the loan has been originated
Escrow- whether the customer escrows taxes and insurance or not
Tenure – length of employment of customer service agent

The financial services organization's call center system was not equipped to automatically collect all of the data needed to study each of the ten variables, so five independent variables were chosen to study including: loan status, board date, length of time loan originated, tenure of call center agent, and escrow. Location of the call center (United States and India) was used as experimental blocks. The Design of Experiment is a randomized block design that compares five treatments (loan status, board date, length of time originated, tenure, and escrow) in two blocks (location). Each of these five independent variables is blocked according to location by randomization of loan number. Replication of the data set ensures validity of the analysis. The analysis shows the impact of each independent variable on the dependent variable, number of calls by customer (loan number), over a 30-day period of time.

The Design of Experiment (DOE) takes into consideration the screening step. This step involves a screening test that is concerned with identifying the most important variables (x's) that influence the response (y's). The importance of the DOE created in this section is to show statistical evidence of the influence on repeat calls that each factor and their combinations provide. Two India locations were collapsed into one as a result of insufficient data across the three month study period, thus the design depicts different combinations for a 2^{6-1}= 32 runs full factorial design with two blocks, one for Orlando and one for India. The Design of Experiments assumes a simple random sample. Each treatment combination was chosen randomly from the group of combinations available that satisfied each treatment. The response variable (dependent variable) was the number of calls by loan number within a thirty day period.

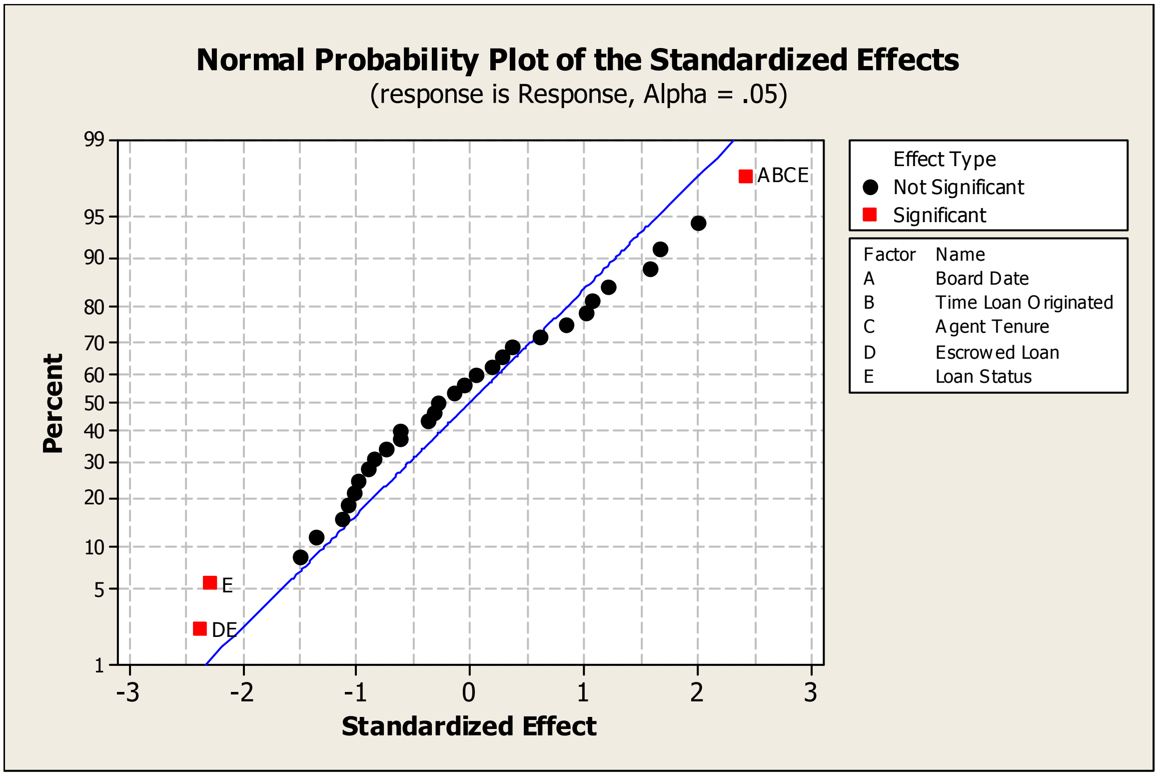
The factors (levels) for the experiment consisted of the following:

A) Board Date if greater than 180 days = 1 (high), if less than 180 days = -1 (low)
B) Time loan originated if greater than 1 year = 1 (high), if less than 1 year = -1 (low)
C) Agent Tenure if more than 180 days = 1 (high), if less than 180 days = -1 (low)
D) Escrowed Loan if yes = 1 (high), if no = -1 (low)
E) Loan Status if more than 30 = 1 (high), if no = -1 (low)

The design consisted of 32 treatment combinations since 2^{6-1}= 32. The design process consisted of determining which loan numbers satisfied a treatment combination with each loan number used as an index. The calls for April, May and June of 2004 were combined and the data were pulled together in the same pool so that they could be randomly chosen for the experiment. If more than one loan number existed then only one was chosen for each treatment combination. Even though the three months were combined, not all the treatment combinations were available for the experiment. If no loan existed for the treatment combination, zero was assigned as the number of calls for that particular treatment combination. The reason for assigning a zero value follows the idea that if no call was made at all, than no issue (reason to call) ever existed from that possible treatment combination. The design consisted of 2 blocks such that 32 combinations were found for India (1 block) and Orlando (1 block).

Figure 1 show the Normal Probability graph. The significant effects lay further away from the line than the other effects making them outliers. The location of the call center was found to be significant with a standardized normal z-value of 2.04 at a significance level of α=0.05. An Analysis of Variance (ANOVA) was conducted. The loan status was the only main effect that was shown to significantly impact the repeat calls at a significance level of .05. There was a significant interaction effect of Escrowed Loan and Loan Status. There was also a significant interaction effect of Board Date, Time Loan Originated, Agent Tenure and Loan Status. The blocks for location (Orlando and India) are also found to be significant (p=0.03) verifying the conclusions made from the Normal Probability plot and Analysis of Variance.

Figure 1 Reducing Repeat Calls Design of Experiment Normal Probability Plot



Benchmarking: [20]

Benchmarking is a powerful tool that organizations can use to identify best practices and understand how their organization compares to these best practices. The College of Engineering and Computer Science (CECS) at the University of Central Florida implemented a pre-application process for students interested in applying for a graduate program in the college. The degree of competition for space in the college's graduate program is increasing. The pre-application process enables the departmental graduate coordinators the ability to review the pre-applicants' qualifications to identify candidates that would be a good match for the respective programs. It also allows the departmental graduate coordinators to waive the application fees of the prospective applicants. The Six Sigma project helped to define improvements to the pre-application process, as well as identify areas for improvement to enhance the technology that is used within the pre-application process. The team effectively used benchmarking techniques to identify and compare best practices use of technology for the pre-application processes. The team benchmarked the College of Optics and Photonics (CREOL) to understand the technology and processes that they used to enable their prospective graduate students to pre-apply to their graduate programs. They identified aspects of the technology that provided more efficient handling of the pre-applications, including having a menu driven, user-friendly interface; having immediate response and feedback of data throughout the system from one process owner to the next; allowing easy access to entered data with knowledge and confidence that the data was available when needed; efficient and streamlined reporting features; secure login ID and password, integration with the graduate admissions system. Process best practices were also identified, such as: ability to track students through the process, ability to distribute the workload for efficient processing, ability to reduce and eliminate delays due to inefficient processes. The benchmark data was collected through in-person interviews with the process owners and technology experts in CREOL. The ultimate application of benchmarking is the project champion embracing the idea of using the technology that already was being effectively used in CREOL, instead of enhancing the existing programs and codes that were difficult to maintain and did not meet the users' needs.

Summary and Conclusions:

The Total Quality Improvement course taught in the Industrial Engineering and Management Systems department at the University of Central Florida provides a valuable opportunity for the graduate students to learn and apply the Six Sigma tools and DMAIC problem solving approach. This paper described three Six Sigma tools, Voice of the Customer, Design of Experiments, and Benchmarking that the students applied to help organizations improve their processes. This course helps engineers learn and apply state of the art principles and techniques and gain critical thinking and problem solving tools.

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