The application of Six Sigma methodologies to university processes: The use of student teams

Mildred Golden Pryor
Texas A&M University-Commerce

Christine Alexander
Texas A&M University-Commerce

Sonia Taneja
Texas A&M University-Commerce

Sowmya Tirumalasetty
Texas A&M University-Commerce

Deepthi Chadalavada
Texas A&M University-Commerce

ABSTRACT

The first student Six Sigma team (activated under a QEP Process Sub-team) evaluated the course and curriculum approval process. The goal was to streamline the process and thereby shorten process cycle time and reduce confusion about how the process works. Members of this team developed flowcharts on how the process is supposed to work (by procedure) and how it works in reality. The reality flowchart was developed by interviewing process stakeholders. The two flowcharts were compared & integrated. Then the process was streamlined by making many serial approval steps simultaneous. The team members briefed process stakeholders, received their input, and validated the proposed process revision. The revised process resulted in a reduction of cycle time by 78.9%. The procedure has been written to reflect the new process. To fully implement the revised process, technological changes are being made as well.

Key Words: Six Sigma, University Processes, Student Teams, Key Performance Indicators, Stakeholders

INTRODUCTION

Drake, Sutterfield, and Ngassam (2008) emphasize that "Six Sigma is a discipline that has revolutionized many corporations. It has literally transformed them from a state of loss to one of profitability. It can be used to improve any process . . . whether one used for tangible products or services" (p. 29). While universities are not typically viewed as "profit and loss" institutions, their leaders have to be concerned with improving quality, reducing costs, and meeting customer and other stakeholder requirements.

Bandyopadhyay and Lichtman (2007) state that ". . . universities and . . . colleges in the United States have been continuously striving for higher quality under the continuous pressure of public scrutiny, budget crunches and cuts in private, state and federal funding" (p. 802). They suggest that Six Sigma can be used to improve quality and productivity in institutions of higher learning. The authors agree and suggest that Six Sigma can also be used (1) to support accreditation efforts and (2) to involve students in the co-management and improvement of university processes. The involvement of students also supports accreditation efforts.

The Southern Association of Colleges and Schools (SACS) is an accrediting agency for universities, colleges, and schools. One of the requirements of SACS is a Quality Enhancement Plan (QEP). A sub-team of QEP at Texas A&M University-Commerce is the Process Team under the auspices of which are student Six Sigma teams. The first student Six Sigma team evaluated the course and curriculum approval process. Members of the team included four graduate students in the Department of Industrial and Engineering Technology (Technology Management and Management Information Systems tracks). Three of the student team members are Six Sigma Green Belts. An MBA student who is a Six Sigma Black Belt at a local factory supported the team. The Six Sigma champion was the Associate Vice President for Academic Affairs. Faculty members in Management, Industrial and Engineering Technology, and Management Information Systems were available as advisors as needed. This article provides an in-depth discussion of the University's first Six Sigma improvement project. It also includes information about Six Sigma in universities and other educational institutions as well as a literature review of the historical and theoretical foundations of Six Sigma.

HISTORY AND THEORETICAL FOUNDATION OF SIX SIGMA

Six Sigma may be categorized as an organization-wide improvement initiative, a quality initiative that is focused on financial results, a statistically-based process improvement method, and a statistical measure of process/product capability and variability. Incorporating elements from the work of many quality pioneers, Six Sigma aims for virtually error free performance. As an initiative, Six Sigma originated at Motorola in the 1980s in response to a CEO-driven challenge to reduce product-failure levels tenfold in five years. Meeting this challenge required swift and accurate responses from Motorola employees (Harry, 2000).

Mikel Harry and Bill Smith were engineers who worked together at Motorola, the company at which Six Sigma was first used both as an organization-wide improvement initiative and a statistical tool. According to Harry (http://www.isixsigma.com) and Harry and Schroeder (2000), Bill Smith was the originator of the Six Sigma concept in 1984. In addition to the requirements for top management support and structured implementation, Six Sigma includes the rigorous application of statistical tools to increase profits, reduce costs, and improve quality and speed. It uses a structured systems approach to problem solving and strongly links initial improvement goal targets to bottom-line results (http://www.isixsigma.com; Harry & Schroeder, 2000).

As a statistical measurement, Six Sigma had its foundation in the work of Carl Frederick Gauss whose pioneer work included Gaussian statistics based on the normal curve, a continuous probability distribution which has a symmetric distribution about its mean. It is from this foundation that Shewhart (1931, 1939, 1980), a statistician who worked at Western Electric, Bell Laboratories, introduced the use of the normal curve as the basis of statistical process control to measure and explain process variability. The American Society for Quality (2010) lists Shewhart as the Father of Statistical Quality Control. Folaron (2003) indicated that Western Electric "was a breeding ground for many quality leaders including Joseph M. Juran, W. Edwards Deming, and Walter A. Shewhart" (p. 39). Juran (1997) suggests it is because "In the 1920s and 1930s, there was Western Electric, its Hawthorne Works, and a committee puzzling over how to use statistics to solve quality problems" (p. 73). Juran (1997) offers specific details about the quality improvement efforts and notes that "Shewhart invented the control chart on May 16, 1924" and that it was a "p chart – a chart of percent defective (product)" (p. 79). It was Dr. W. Edwards Deming (1986, 1993) who publicized the usefulness of statistical process (quality) control and specifically the use of control charts to describe variability in processes. However, Deming rightfully credited Shewhart with the development of theories of statistical process control and their use in manufacturing organizations, particularly at Western Electric.

As a statistical tool, Six Sigma (6 σ) is used to measure the variability in processes. Traditionally companies accepted three or four sigma performance levels as the norm, despite the fact that these processes created between 6,200 and 67,000 problems per million opportunities. The intent of Six Sigma is to improve customer satisfaction by reducing defects. The ultimate performance target of Six Sigma is virtually defect-free processes and products since Six Sigma means an average of 3.4 defective parts per million or 99.99966% good quality. See Chart 1. Although the goal is zero defects, Six Sigma also drives organizations toward achieving higher levels of customer satisfaction as well as reducing cycle time and operational costs.

While Six Sigma originally focused on product defects, the emphasis is currently on service and process defects as well. In order to streamline processes, Six Sigma includes the use of flowcharts, trend charts, cause and effect diagrams, Pareto charts, synchronous as opposed to serial process steps, and many other statistical and non-statistical tools.

SIX SIGMA IN HIGHER EDUCATION

Little (2003) emphasizes that "First Six Sigma focuses on reducing process variation. Then it addresses improving the capability of that process" (p. 106). According to Little (2003), there are three key elements to achieving (Six Sigma) quality: customers, processes and employees. Customers define quality and expect – among other things – performance, reliability, competitive prices, on-time delivery, service, and clear and correct transaction processes" (p. 105). Jenicke, Kumar, and Holmes (2008) emphasize that customer definition is one of the challenges in the implementation of Six Sigma in an academic environment. They list other challenges as the difficulty in measuring quality and analyzing data, the limitations of academic reward systems, and the influence of uncontrollable factors on student success, faculty success, even organizational success (Jenicke, et al, 2008).

Jenicke, et al (2008) suggest that a framework is needed to successfully implement Six Sigma in an academic environment. They propose such a framework in terms of implementation level, Six Sigma methodology, and key performance indicators. They also provide examples of strategic objectives and performance indicators by levels of implementation for the DMAIC (Define, Measure, Analyze, Improve, and Control) process. The authors agree that a framework is needed and offer Chart 2 as an indication of some of the elements that are needed in such a framework, particularly stakeholders, processes, and key performance indicators.

In spite of the challenges and difficulties of implementing Six Sigma in an academic setting, the literature indicates that there are Six Sigma project successes in selected universities. Various authors have written articles about Six Sigma in education from the perspectives of the role of academia in Six Sigma education, including e-learning (Burns, 2005; Little, 2003; Mitra, 2004); Six Sigma in experiential learning (Box, 2006); a Six Sigma framework for academic institutions (Jenicke, et al, 2008); using Six Sigma to design university housing (Johnson, 2006); improving self service at university libraries (Kumi & Morrow, 2006); and the integration of Six Sigma concepts in management, statistics, and other classes (Weinstein, Castellano, Petrick & Vokurka, 2008; and Zahn , 2003). Zahn (2003) feels that professors need to help students and colleagues develop process thinking skills.

SIX SIGMA CASE BACKGROUND

Year 1. A junior faculty member at the University was charged with creating a new graduate program, a Master of Science Degree in Management Information Systems (MS/MIS). After much research and several meetings of the MIS faculty, courses were identified, course descriptions were created, and other paperwork and forms related to the creation of a new program were completed. However, the paperwork went nowhere.

Year 2. There was still a push underway for an MS/MIS degree. Course titles and descriptions were reviewed, faculty excitement was high, and paperwork was modified to reflect changes.

Year 3. The idea of an MS/MIS program, though no longer on the front burner, was still attracting attention. Someone mentioned in passing that the new course and new program process had changed several years earlier from being a paper based process to being a partially online process. The junior faculty member made several inquiries before finding out how to gain access to the online system. The data was entered. The submit button was clicked. Weeks later . . . still nothing happened. The department chair had not been notified that there was anything in the new system requiring his approval. The notification had to be made manually by the faculty member submitting changes or the department chair had to be extremely proactive in logging into and monitoring the online system. Notification was made to the department chair. Approval was received from the Associate Dean. Weeks later . . . still nothing happened – nothing that is, but a growing level of frustration among the MIS faculty. It seemed as if the process for making changes to course descriptions or adding new courses to the course catalog was a closely guarded secret. It was obvious that this was a long drawn out business process that was broken. Out of frustration and the desire to create a much needed degree program was born the perfect candidate for a Six Sigma project!

STUDENT TEAM SIX SIGMA PROJECT

The project followed the five steps of Six Sigma – Define, Measure, Analyze, Improve, and Control (DMAIC). See Figure 5. In Step one, the students worked with customers and stakeholders to define the problem, to determine what the customers and stakeholders needed, and what the project goals should be. As a result of the definition phase, the students determined that Six Sigma tools and methodologies should be applied to the course and curriculum approval processes where the following problems were identified:

(1) Confusion existed among faculty members and others in terms of what the processes were, what forms need to be completed, and who the contact people were.

(2) Discrepancies (or perceived discrepancies) existed between processes described in procedures and the actual processes that were used by those submitting course and curriculum changes. Actual processes were referred to as reality processes.

(3) There was potential to streamline the course and curriculum processes by eliminating non-value-added steps and/or utilizing parallel (i.e., simultaneous) process steps instead of serial ones.

PROJECT DESCRIPTION

As a part of stages one and two (Define and Measure), the students listed the following as goals of the Six Sigma project and fully expected their achievement: (1) a significant reduction in process cycle time; (2) reduction in confusion and frustration of people submitting course and curriculum changes; and (3) the elimination of discrepancies between the reality processes and the procedural processes. To continue measurement and data analysis (Steps two and three), students began to collect relevant process data from procedures and process stakeholders (i.e., the internal customers and suppliers in the process (Pryor, Toombs, Cooke, & Humphreys, 2010). Their intent was to analyze cause-and-effect relationships in order to understand why process problems existed and to use their data analysis to improve the process (Step 4). Finally, the students proposed a new process (Step 4). In (Step 5) a procedure was written documenting the new process, and the procedure was validated and published. It was in the control phase (Step 5) that the students made their final presentation to the executive leadership team, the university executive council, and the associate vice president who was the Six Sigma champion and explained to them the necessity for teaching process stakeholders the new process and for tracking results over time. Students completed the following activities in Steps 2 – 5 of the Six Sigma project (See Figure 5):

- Reviewed the procedures for course and curriculum approval;
- Documented those procedures through the use of flowcharts;
- Interviewed process stakeholders to determine reality processes;
- Documented the reality processes through the use of flowcharts;
- Compared the reality processes with the procedural processes;

- Analyzed process steps to determine ways to streamline the processes;
- Created a proposed course and curriculum approval process;
- Created a flowchart documenting the proposed process;
- Reviewed and refined the proposed process;
- Briefed process stakeholders including the Six Sigma champion (i.e., the Associate Vice President for Academic Affairs), the President and his vice presidents, the University Executive Council, and the deans and curriculum representatives of the College of Arts and Sciences, College of Business and Technology, and College of Education;
- Used feedback from stakeholder briefings to improve proposed new process;
- Reviewed and validated the proposed procedure for the streamlined course and curriculum approval process; and
- Published the new procedure.

The procedural flowchart and reality flowchart for the original course and curriculum approval process and the revised flowchart for the streamlined course and curriculum approval process are in Figures 1, 2, 3, and 4. The proposed process and flowchart were approved by process stakeholders. The streamlined process reduced cycle time by 78.9%. The procedure was revised and validated to reflect the new process. Technology was identified to support the new process.

CONCLUSIONS AND RECOMMENDATIONS

Time for collecting data is an issue in an academic environment because the course and curriculum approval process usually occurs only once a year. Inputs to the process were categorized as controllable or uncontrollable as well as whether they were capable of being influenced. The length of time required to complete Six Sigma projects is a problem at universities since you have to deal with the startup and phase down times associated with semesters (Kukreja, Ricks, Myer 2009). Other problems associated with the implementation of Six Sigma at universities are: (1). It is difficult to create a compelling reason to implement Six Sigma as an organization-wide, structured, top down approach. As a result, it is difficult in universities for a Six Sigma initiative to be owned at the executive leadership team level and thereby given the required priority. (2). Resources to support educational initiatives are often scarce and do not necessarily include support for improvement initiatives. (3). Six Sigma requires specific knowledge in terms of theories and tools and the application of those theories and tools. It is difficult in terms of money and time to involve faculty members, staff and administrators in Six Sigma training and projects in order for some of them become green belts, black belts, and master black belts. (4). Key performance indicators must be utilized. University personnel are accustomed to measurements required by accrediting agencies, legislatures, boards of education, boards of trustees, etc. These measurements are not necessarily the metrics that are needed to significantly improve processes. (5). Once resolutions for problems are identified, it is difficult and time consuming to get them implemented because they often require additional computer support (e.g., online applications and approvals, including eSignatures). So, the problem involves more than process changes and the potential negative reactions against them. It also involves the time and money that are required to implement even simple changes. (6). Procedures often must be updated to document process changes; and stakeholders must learn what the new process entails. At this stage, improvements can be stalled or even never implemented. (7). Recognition and rewards for improvement are limited, thus negatively impacting the extent to which stakeholders are eager to be involved in improvement initiatives.

To be successful in universities and colleges, Six Sigma and other improvement initiatives should be aligned with elements that are an integral part of their respective systems (e.g., accreditation efforts and/or institutional effectiveness departments which are responsible for data analyses and report submissions). Also, university leaders should be involved in state and national quality initiatives, including applications for various quality/excellence awards. Finally, students should be involved in Six Sigma and other excellence initiatives. After all, students are the ultimate stakeholders. They are customers, in-process material as they learn, co-managers of the teaching/learning process, and final products as they graduate and seek employment.

REFERENCES

American Society for Quality (ASQ). Retrieved October 26, 2011 from http://asq.org/about-asq/who-we-are/bio_shewhart.html.

Ask Dr. Mikel Harry – FAQs about Six Sigma (2011). Retrieved October 26, 2011 from http://www.isixsigma.com/.

Bandyopadhyay, J.K. and Lichtman, R. (2007, December). Six Sigma approach to quality and productivity improvement in an institution for higher education in the United States, *International Journal of Management,* 24(4): 802-824.

Box, T.M. (2006). Six Sigma quality: Experiential learning, *S.A.M. Advanced Management Journal,* 71(1): 20-23.

Burns, T. (2005). E-learning: The future of quality training, *Quality Progress,* 38(2): 50-56.

Deming, W.E. (1986). *Out of the Crisis*, 2nd ed., Cambridge, Massachusetts: MIT Center for Advanced Engineering Study, Cambridge, Massachusetts.

Deming, W.E. (1993). *The New Economics,* Cambridge, Massachusetts: MIT Center for Advanced Engineering Study.

Drake, D., Sutterfield, J.S., and Ngassam, C. (2008). The revolution of Six Sigma: An analysis of its theory and application, *Academy of Information and Management Sciences Journal,* 11(1):29-44.

Folaron, J. (2003). The evolution of Six Sigma, *Six Sigma Forum Magazine,* 2(4): 38-44.

Harry, M. J., (2000). Six Sigma Leads Enterprises to Coordinate Efforts. *Quality Progress,* 33(3): 70-72.

Harry, M. and Schroeder, R. (2000). *Six Sigma—The Breakthrough Management Strategy Revolutionizing the World's Top Corporations,* Doubleday.

Jenicke, L.O., Kumar, A., and Holmes, M.C. (2008). A framework for applying six sigma improvement methodology in an academic environment, *The TQM Journal,* 20(5), 453-462. Retrieved October 1, 2011 from www.emeraldinsight.com/1754-2731.htm.

Johnson, J A. (2006). Designing new housing at the University of Miami: A "six sigma" dmadv/dfss case study. Quality engineering, 18(3): 299.

Juran, J.M. (1997). Early SQC: A historical supplement, *Quality Progress,* 30(9): 73-81.

Jenicke, L.O., Kumar, A., and Holmes, M.C. (2008). A framework for applying six sigma improvement methodology in an academic environment, *The TQM Journal,* 20(5): 453-462. Retrieved October 1, 2011 from www.emeraldinsight.com/1754-2731.htm.

Kukreja, A., Ricks, J.M., and Meyer, J.A. (2009, February). Using Six Sigma for performance improvement in business curriculum: A case study, *Performance Improvement,* 48(2): 9-25.

Kumi, S. and Morrow, J. (2006). Improving self service the six sigma way at Newcastle University Library, *Electronic Library and Information Systems* 40 (2), 123-36. Retrieved October 1, 2011 from www.emeraldinsight.com/0033-0337.htm.

Little, B. (2003). Six Sigma Techniques Improve the Quality of E-Learning, *Industrial and Commercial Training,* 35(3): 104-108.

Mitra, A. (2004). Six Sigma educations: A critical role for academia, *The TQM Magazine,* 16(4): 293-302.

Pryor, M.G., Hendrix, M., Alexander, C. and Collins, B. (2010). World Class University tm - The Implementation of Strategic Quality Management (SQM*), International Journal of Education Research*, 5(2): 1-19.

Pryor, M.G., Toombs, L.A., Cooke, J., and Humphreys, J.H. (2011). Strategic quality management: the role of process ownership, management, and improvement, *International Journal of Business Excellence,* 4(4): 420-439.

Shewhart, W. A. (1939). *Statistical Methods from the Viewpoint of Quality Contro*l, Washington: Graduate School, Department of Agriculture.

Shewhart, W.A. (1931, 1980). *Economic Control of Quality Manufactured Product*, Van Nostrand, (reprinted , American Society for Quality Control, 1980).

Weinstein, L.B., Castellano, J., Petrick, J. & Vokurka, R. J. (2008). Integrating Six Sigma Concepts in an MBA Quality Management Class, *Journal of Education for Business,* March/April, 2008: 233-238.

Zahn, D. (2003). What influence is the Six Sigma movement having in universities? What influence should it be having? *Six Sigma Forum Magazine,* 3(1): 33-34. Retrieved October 21, 2011 from ABI/INFORM Global.

APPENDIX

Chart 1: Defects per Million Opportunities at Various Sigma Levels

Sigma Level	**Defects per Million Opportunities**
One Sigma	690,000
Two Sigma	308,000
Three Sigma	66,800
Four Sigma	6,210
Five Sigma	230
Six Sigma	3.4

Chart 2: Selected Key Stakeholders, Processes, and Key Performance Indicators (KPI's)

Institutional Levels	Key Stakeholders	Selected Processes	Key Performance Indicators (KPI's)
University/Institution level And College/School Level	Alumni	Alumni donation process	Alumni satisfaction # of alumni making donations Total of alumni contributions
	Employer Students	Student placement process	# of employers recruiting on Career Day Level of employer satisfaction with students they hire # of job offers pending graduation
		Student recruitment and retention processes	# of students recruited % of students retained Student satisfaction
	Faculty	Faculty hiring process	# of qualified applications per job Length of (cycle time) of hiring process
		Faculty tenure & promotion process	% approved for tenure on initial application % denied tenure
	Administrators Board of Trustees Board of Education Legislature (Public institutions)	Financial/Budgetary process	% of employees who understand financial/budgetary process % reduction in budget required by stakeholders
Departmental Level	Alumni Employer Students	Course development process Curriculum development process	Cycle time to develop courses and get them approved Cycle time to develop curricula and get them approved Employer satisfaction with student readiness
	Faculty	Research & publication process	Productivity (# of scholarly articles per faculty member)
	Administrators	Financial/Budgetary justification process	% increase/decrease in budget

Source: Adapted from Jenicke, L.O., Kumar, A., and Holmes, M.C. (2008). A framework for applying six sigma improvement methodology in an academic environment, *The TQM Journal,* 20(5): 459.

Figure 1: Procedural Flowchart (Process Cycle Time = 19 Weeks)

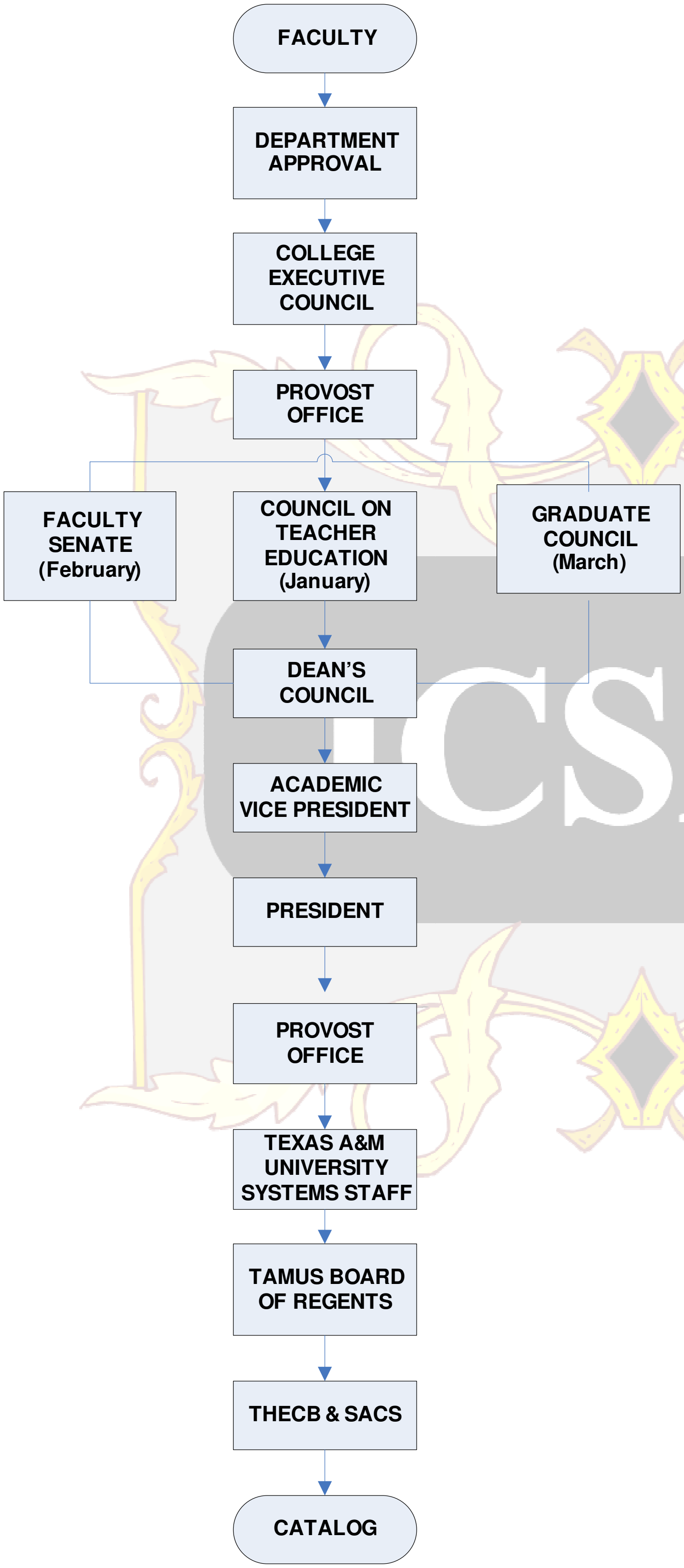

Figure 2: Reality Flowchart – Variable Cycle Time – 19 Weeks or More

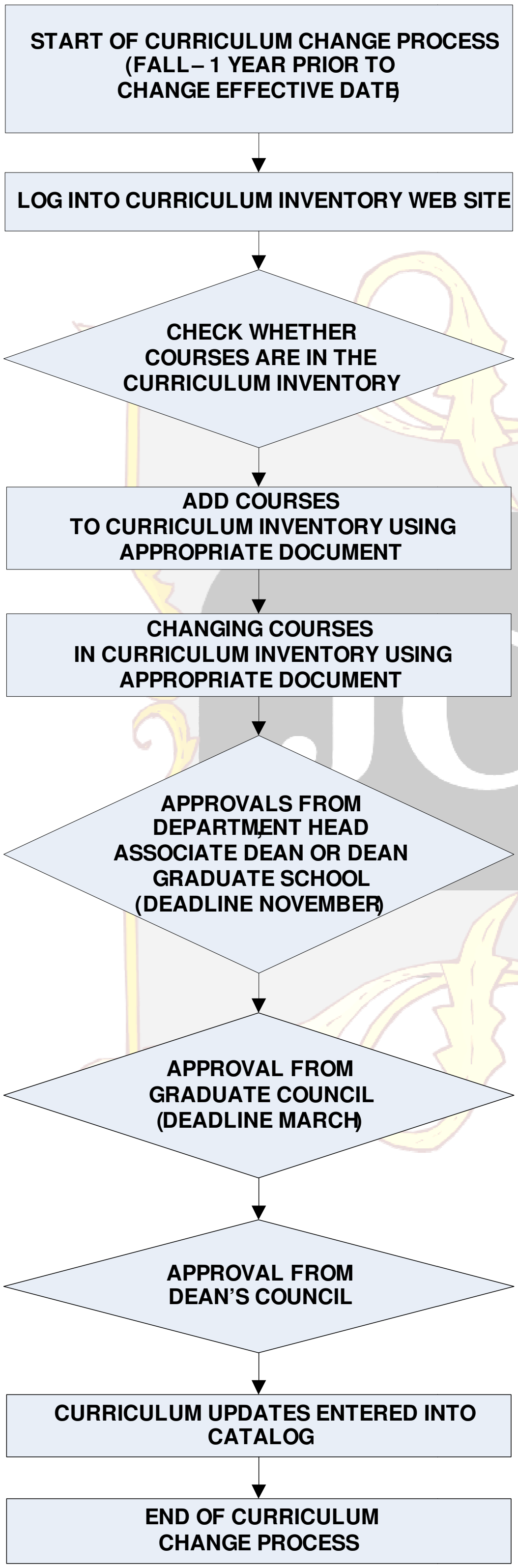

Figure 3: Recommended Flow Chart

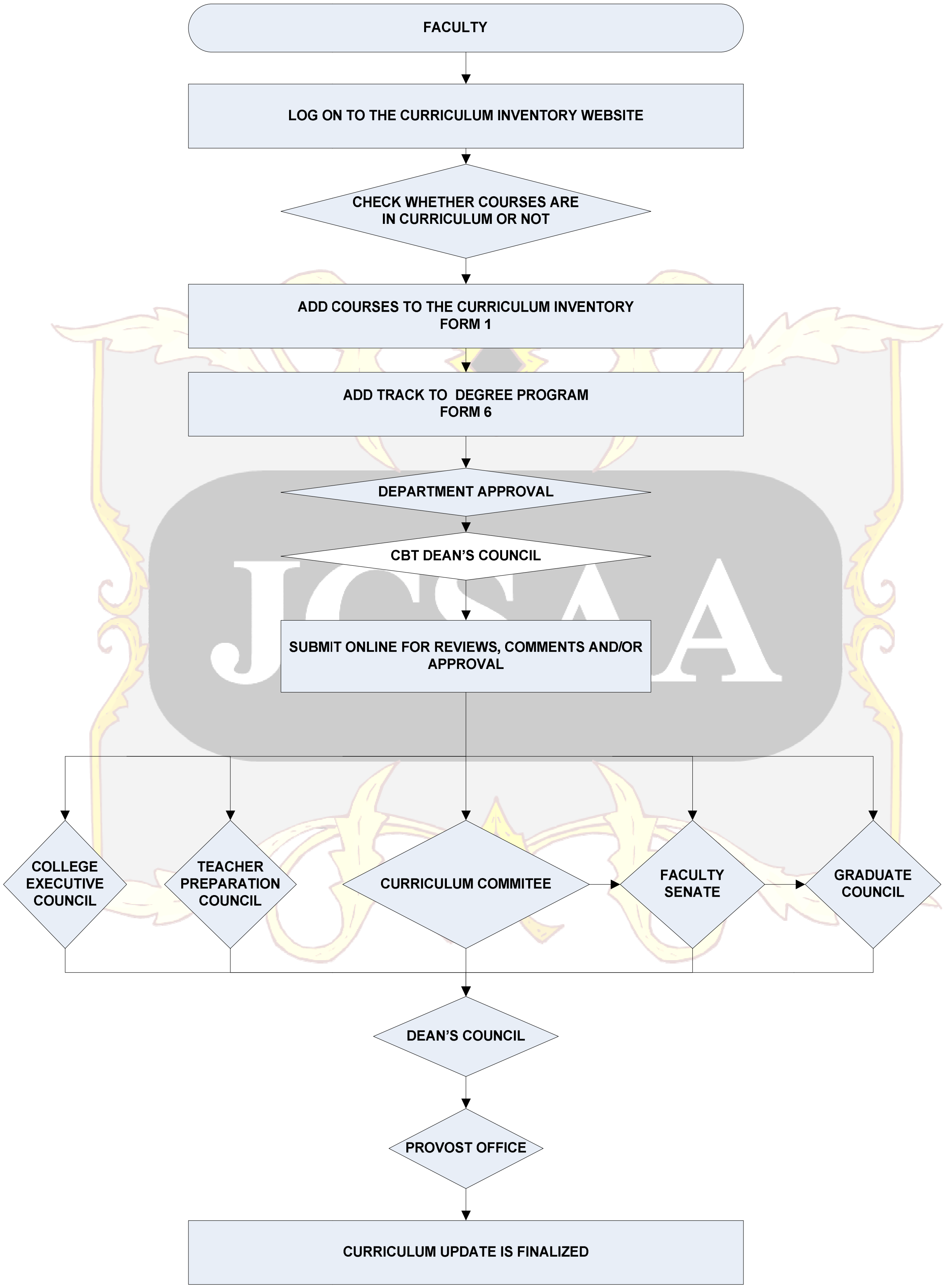

Figure 4: Six Sigma DMAIC Steps for Course and Curriculum Process Improvement