Quality Approaches in Higher Education

Improving business processes in higher education through DMAIC.

Case Study: Application of DMAIC to Academic Assessment in Higher Education

Andrew S. Bargerstock and Sylvia R. Richards

Abstract

At a small university in the Midwestern part of the United States where Lean Six Sigma is a lively imperative, a newly trained kaizen team applied the Deming five-stage Define-Measure-Analyze-Improve-Control (DMAIC) methodology to streamline and improve efficiencies for an academic assessment process. In this case of the close-the-loop (CTL) report, the targeted process was a procedure for assessing effective delivery of course outcomes and for planning instructional improvements for all courses taught in the College of Business at Maharishi University of Management in Fairfield, IA. Through a structured lean improvement event (e.g., kaizen), a cross-functional team utilized its recent training in Lean Six Sigma to streamline the efficiency of the CTL process and boost faculty compliance. The enhanced CTL process reduced cycle time by two-thirds, removed frustrating non-value-added activity steps, discovered additional customer value, and boosted compliance rates significantly.

Keywords

Continuous Improvement, Lean/Six Sigma/DMAIC, Quality Assurance, Process Management, Best Practices

Introduction

In the decades since W. Edwards Deming (1986) began consulting with Japanese industries in the 1950s on how to improve quality controls for production systems, the world has witnessed an evolution of organizational developmental philosophies that have moved sequentially from quality control to total quality management to lean management (lean). Although the roots of lean spring from Japanese manufacturing, Womack, Jones, and Roos (1990) revealed a more generic set of elements, rules, and tools that can be applied to any organization including manufacturing, merchandising, service-oriented, non-profit, governmental, and educational organizations.

In the late 1980s, Xerox Corporation adopted Deming's Define, Measure, Analyze, Improve, Control (DMAIC) methodology to resolve inefficiencies in its business processes. Gradually, Xerox also used DMAIC as a tool to improve information flow into, through, and out of its educational clients (Kurt, 2004). George (2003) also demonstrated how continuous process improvement (CPI) methods have been adapted to service organizations.

Literature Review

In higher education, lean methods have been introduced in various forms. CPI initiatives have been incorporated within the classroom as experiential learning opportunities (Hand, Dolansky, Hanahan, Sundaram, & Tinsley, 2014). Systems thinking has been embraced as a conceptual framework within educational organizations in order to go beyond functional silos to sustain consistent improvement over time (Furst-Bowe, 2011). A business case was made for using Lean Six Sigma to support a systems-thinking and project-based approach for improvement in higher education (Simons, 2013). Emiliani (2015) has focused on implementing lean with instructional methods in a variety of ways.

The DMAIC method has been increasingly utilized to solve problems in higher education administration (Ramanan & Ramanakumar, 2014). It has been applied in administrative practices to improve process consistency and to reduce cycle time in salary calculations in higher education institutions (Utecht & Jenicke, 2009). At Central Michigan University, DMAIC was adopted by information systems faculty for the purposes of academic program design and curriculum development (Holmes, Jenicke, & Kumar, 2005). Sarda, Bonde, and Kallurkar (2006) demonstrated the role of DMAIC in a technical institution for continuously improving student results.

However, there is a lack of papers describing how DMAIC is used to streamline academic assessment processes. This article presents a case study applying the classic five-step DMAIC Lean Six Sigma procedure for improving business processes. At Maharishi University of Management, the timely and complete delivery of each course's close-the-loop (CTL) report is needed by academic program directors who monitor student course satisfaction and faculty plans for improving their curriculum and classroom experience.

Background

Since 1999 when the Higher Learning Commission (HLC) established the Academic Quality Improvement Program (AQIP), many institutions in higher education have been discovering ways to improve their quality improvement cultures (Higher Learning Commission, 2015). Maharishi University of Management is an accredited university located in Fairfield, IA, offering degrees with B.A., M.A., and Ph.D. programs in various academic disciplines. Overall, in spring 2015, enrollment for resident and online degree programs exceeded 1,400 students.

In 2012, executive leadership established a core group for applying tools of lean management to enhance communication with students, alumni, and faculty, while producing improvements to selected business processes. As enthusiasm and interest grew from these pilot projects, in 2013 the university decided to engage an outside consulting group to provide training in lean facilitation for a combined group of approximately 40 faculty and administrative leaders. After the training, the university's lean steering committee approved a series of kaizen events to validate the training as pilot projects. Although there were some good results, it became apparent that the teams needed some additional techniques in data collection, baselining, and problem analysis.

Consequently, in October 2014, two business faculty members, both certified lean facilitators, agreed to provide the next generation of training to a new set of faculty and administrators in conjunction with the executive leaders of the lean steering

committee team and leaders. Both facilitators possessed solid credentials. Thomas Palladino had earned a Six Sigma Black Belt and was an experienced human resources executive and trainer with more than 30 years of experience in corporate human resources management. The other certified lean facilitator and chair of the accounting department in the college of business, Andrew Bargerstock, had consulted in numerous lean projects on administrative processes within businesses, federal and state agency organizations, and universities.

The training was delivered in five, half-day sessions that covered a discrete sequence of topics: lean history and structure, project selection, team selection, process mapping, baselining and data collection, root-cause analysis, future-state mapping, implementing and standardizing changes, and monitoring and assessment.

In the college of business, an MBA program administrator, Sylvia Richards, took the role of lead facilitator for the CTL report project and began building the framework for a kaizen event during the week of training. In the weeks that followed, she led a team toward improvement solutions.

This case study follows the five sequential DMAIC stages that were presented in the university's lean management training program. For this kaizen event, the five stages unfolded in this manner:

- **Define**—Selecting and planning the project.

- **Measure**—Gathering data on the current level of effectiveness of the process.

- **Analyze**—Mapping/understanding the process and discovering forms of waste.

- **Improve**—Utilizing collaborative problem solving to remove non-value-added elements.

- **Control**—Standardizing, monitoring, and managing process effectiveness.

Stage 1, Define: Selecting and Planning the Project.

The selection and planning of the project involved identifying the CTL project, determining the existence of a business case, and developing the project charter.

Identifying the CTL Project. When the MBA program administrator announced she was participating in the CPI training in October 2014 and that she was looking for a project to complete during the training, one of the then business department co-chairs, Scott Herriott, jumped at the idea of a kaizen event on a critical departmental business process that he felt needed attention. As an accreditation team member for the North Central Association of Colleges and Schools (NCA), the department chair had many years of experience with onsite visits and evaluations of colleges and universities seeking new or renewed

accreditation. As a result of this expertise, the department chair had guided the university successfully through its own accreditation renewal in 2012, both with NCA and with the International Assembly of Collegiate Business Education (IACBE). From his passion for academic assessment and improvement methods that prove an institution delivers on what it purports to teach, he had developed a seven-question form called the CTL report as part of a series of assessment tools to demonstrate the department's commitment to academic excellence and continuous improvement.

Determining the Business Case. The business case, or the cost/benefit of this project, was determined by analyzing its potential impact compared to cost. Because the purpose of the CTL report is course improvement, which ultimately is for the benefit and satisfaction of future students, this process can be seen as directly impacting the mission and goals of the university. To determine if there was a business case for this project, it was rated on the following selection criteria: high customer impact, high expected benefit, low cost to improve, high availability of data, and high ease of implementation using a five-point scale, with five rated as highest. The CTL project scored high in potential impact. The marginal cost of doing the project was virtually zero, because it had already been determined that all participants would devote some time to a kaizen event. Thus, the business case was supported.

Developing the Project Charter. The project charter for the CTL project served as a focused articulation of the purpose and scope of the project, e.g., expected outcomes, names of the kaizen team members, expected length of the project, and specification of deliverables. As stated in the project charter, the scope of the CTL project and the expected outcome was "to improve compliance rate of faculty submissions of the CTL reports. At the end of each course, the professor evaluates student learning outcomes and makes recommendations for changes to improve the course in the next offering. CTL reports are reviewed by the department chair and are made available to accreditation teams." As the developer of the CTL report for that purpose, the department chair was named the process owner. Normally, a kaizen team should include people who work directly in the process to take advantage of their experience and also some people from

Implementation Tip 1:

In selecting an initial project to demonstrate the usefulness of DMAIC, it is best to engage customers of business processes to identify "low-hanging fruit," e.g., processes that are likely to yield significant improvements through systematic analysis and problem solving. If the project seems too complex, it is probably not the best opportunity.

outside the process, who provide an independent non-attached perspective. The project facilitator was alert to getting outside perspectives and enlisted a cross-functional team from the lean training event. Impromptu conversations were held with available kaizen team members in lieu of more formal kaizen meetings because of scheduling challenges with faculty and time constraints of the five-day lean training course.

Stage 2, Measure: Gathering data on the current level of effectiveness of the process.

The measurement phase took two directions. First, it was important to ascertain the productivity and effectiveness level of the current state of the process. Although faculty cooperated in preparing CTL reports leading up to the accreditation visit in 2012, the compliance rate had slipped dramatically in 2014 to approximately 10% of the expected reports, despite regular reminders to faculty. Hearing complaints about the CTL process as "cumbersome, complicated, and tedious," the department chair wanted to get some fresh eyes to evaluate how the process could be simplified and improved. Secondly, the kaizen team wanted to get a clear definition of value from both primary and secondary customers.

Determining the Voice of the Customer. In lean management, customer satisfaction is the goal, and customer specifications drive the improvement process. Consequently, the voice of the customer and baselining customer satisfaction are key to lean processes. In the CTL project, the primary customers are the department co-chairs and the secondary customers are the faculty. The baseline for customer satisfaction was determined by the 10% compliance rate and additionally by an informal poll of a few secondary customers.

The voice of the primary customers, who request and receive the CTL report, was clearly articulated by the department chair. As an accreditation team member, he greatly desired a measureable assessment instrument that could prove an institution delivers on what each course purports to teach, and that would help demonstrate an institution's commitment to academic excellence and continuous improvement. To satisfy the primary customer, the solution would need to provide accountability of faculty to improve their courses continuously, some way to monitor quality, and a means of institutional metrics with regard to course improvement.

Secondary customers were identified as the faculty members who receive the benefit of thoughtful inquiry to improve their courses. In this case, the faculty members were both secondary customers and also the performers of the process. Therefore, to satisfy the secondary customers, the CTL report process would have to provide clear value and also be easy to perform.

It was clear that the primary and secondary customers viewed the process and its value very differently. Some faculty had devised their own means of noting changes they wanted to make to their courses or felt they already had a good "feel" for what changes they wanted to make in the next course offering from conversations with students and their own experience in the classroom. However, these informal and more subjective approaches to course improvement did not satisfy the requirements of the primary customer.

To achieve success, the CTL project had to meet the following customer specifications:

• facilitate the continuous improvement of every course taught,

• simplify the CTL report process,

• provide oversight by the department chair, and

• supply measurable evidence of faculty attention and commitment to course improvement.

These customer specifications defined the value for the primary and secondary customers.

The next question addressed by the CTL project team was, "For the CTL report process, what is the value stream, the activities, and the steps involved in delivering value to the customer?"

Stage 3, Analyze: Mapping/understanding the process and discovering forms of waste.

To begin the improvement process, the team mapped the current state of the CTL process to understand the value stream. The kaizen team looked first at the CTL report template as a starting point for discussion of the resources and activities needed to create the CTL report. Figure 1 shows the current-state map describing the activity steps followed prior to the kaizen intervention.

This map forms the foundation for understanding how value emerges from the various activities. Notice the multiple information sources that are needed to answer the seven questions on the CTL report. The current-state map enabled the team to question how each activity adds value.

With respect to facilitating the continuous improvement of courses, the following resources and activities all add value:

• course description;

• course objectives;

• data from the grade sheet indicating student learning outcomes on tests, reports, and presentations;

• student evaluation data from the end of course (EOC) survey; and

• delivery of the completed report to the department chair provided oversight and allowed the chair to assess compliance and to report to accrediting bodies.

The current-state map also indicated how much time is involved in performing the activities and in waiting for other processes to deliver inputs. Based on faculty feedback, it took five minutes to review the report template and another 45 minutes to complete the report. Much of the 45 minutes were spent

Purpose of the close-the-loop (CTL) report: To improve each course by evaluating student learning outcomes and making recommendations for changes in the next offering of that course.
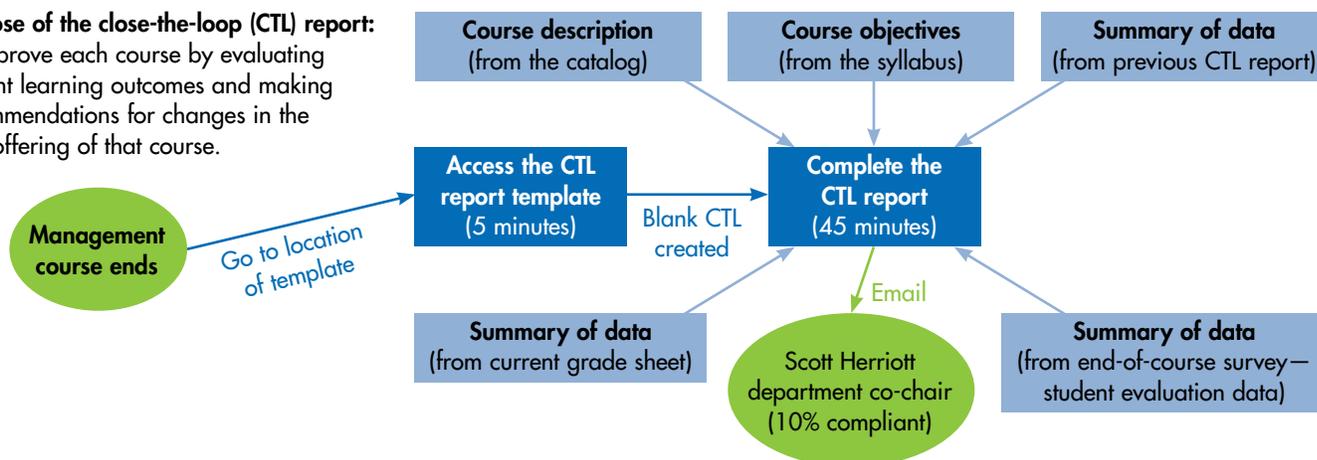
Figure 1: Current-State Map

	Yes	No			
1. Are you a major or minor in the department?					
	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
2. Gained knowledge					
3. Well-organized					
4. Challenged					
5. Good balance					
6. Clear answers					
7. Timely feedback					
8. SCI valuable					
	Always	Frequently	Half	Rarely	Never
9. Percent time student prepared					
	Too fast	Little fast	Appropriate	Little slow	Too slow
10. Pace					
11. What was your most significant experience in this course?					
12. What aspects of the course would you definitely keep? Why?					
13. What aspects would you change?					

Figure 2: Student Course Evaluation

in retrieving the required information from various sources. For example, the old process required the professor to summarize the student course evaluation feedback that is reported by a third-party company which manages the course evaluation process. Figure 2 shows the questions asked on the student course evaluation. The course evaluation reports are delivered 10-12 days after the end of the course to allow faculty time to submit grades before reviewing student feedback. Addressing this 12-day waiting period was outside the scope of the CTL report project as it was defined for the five-day, part-time training program and was identified as an issue for a second round of improvement.

The goal of the kaizen team was to make the value stream for the CTL report process flow smoothly without interruption by eliminating or reducing non-value-added steps described in the current-state map.

Implementation Tip 3:

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Many lean projects fail because the voice of the customer has not been heard. Don't fall into the trap of assuming what the customer wants. Engage in a dialog to determine exactly how customers evaluate value coming from products and services.

Stage 4, Improve: Utilizing collaborative problem solving to remove non-value-added elements.

CPI tools were used to identify forms of waste and inefficiencies, identify root causes of the low compliance, and map the future state.

Identifying Forms of Waste and Inefficiencies. Developing the current-state map began a process to identify eight possible types of waste: defects, overproduction (things not demanded), accumulation of inventories, over-processing, excessive motion of people, unnecessary handling of goods, waiting time for an upstream process to deliver, and limiting behaviors. By studying the current-state map, the kaizen team found several forms of waste:

- multiple forms of duplication,
- time consuming copying and pasting from one document to another,
- summarizing data from three different sources,
- waiting for the student evaluation end-of-course survey data, and
- a low compliance rate, which defeated the purpose of the report.

On the surface, the low compliance rate appeared to be primarily a behavioral issue—the majority of faculty members were not complying with the request for CTL report submission. One kaizen team member commented that the faculty "should just do it." Why were faculty not preparing what seemed like a simple seven-question report? The project facilitator kept the team members focused on the CPI process without judging those who perform the process and emphasized using the tools of the CPI process to identify the root causes for lack of performance.

Utilizing the Cause-and-Effect Diagram to Identify Root Causes. Figure 3 shows how the team utilized the classic CPI tool, the cause-and-effect diagram, to analyze the results of focus group sessions with faculty members who offered their perspectives about the low compliance rate. Faculty responses were grouped into four categories: people, procedures, information systems, and policies. In the cause-and-effect diagram, the visual display is set up with the identified problem (the "effect") on the right side, e.g., low compliance rate, and the contributing causes on the left side.

The problem is then examined in light of relevant contributing factors. By asking "Why?" up to five times in a sequential trail, the line of inquiry moves closer to root causes. By asking why the faculty members were not submitting the reports, several problems and inefficiencies emerged:

- perception that the process was too cumbersome and time consuming,
- repeated copy/paste operations,
- unnecessary duplication,
- report elements not easily accessible,
- no systematic storage system for completed reports,
- waiting time between the end-of-course survey and delivery of the student evaluations, and
- lack of follow up on low compliance.

During the kaizen conversations, suggestions for improving the process, as well as the factors that led to low compliance, began to emerge. The project facilitator acknowledged and noted all suggestions as they arose, and, without committing prematurely to any particular suggested solution, guided the team to complete the steps of the CPI process.

Having identified non-value-added as well as value-added activities and resources, the team was ready to collaborate on improving the process.
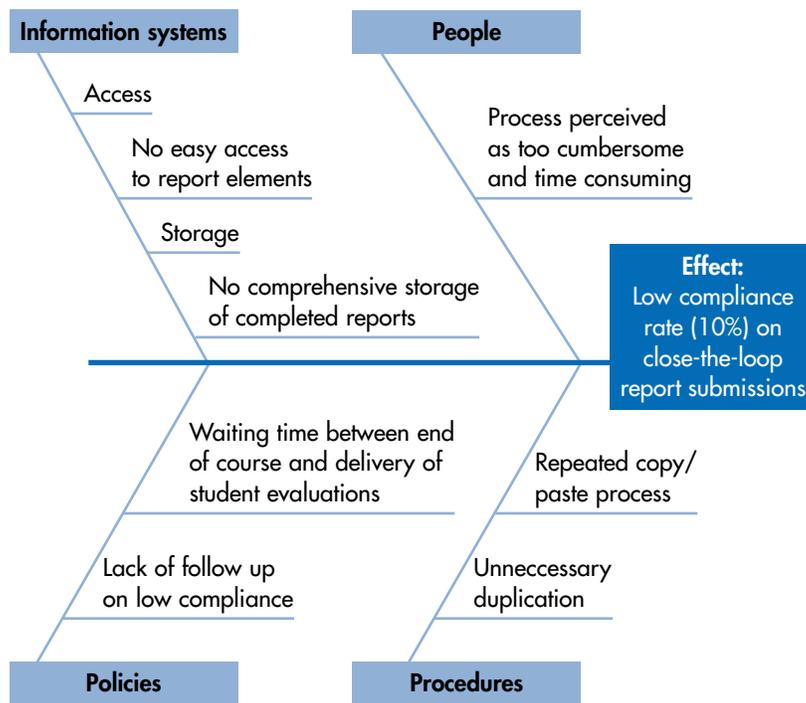

Figure 3: Cause-and-Effect Diagram

Collaborating on Low-Cost Solutions and Mapping the Future State. The information gained from the previous steps of the CPI process was reviewed by the kaizen team and a series of improvements were developed to streamline this process. From the value stream, shown in Figure 1, several of the resources (course description, course objectives, learning outcomes, and student evaluations) were deemed valuable for the faculty when making decisions about how to improve their courses. The repetitious activities of copying and pasting text and summarizing data from the same resources were clearly inefficiencies, however. A few changes in how the source documents and the elements of the CTL report were handled offered a solution, shown in the future-state map in Figure 4.

Among the key changes were:
- Creating an accessible location to assemble CTL reports. The project facilitator and the department administrator worked together to create a folder system on the existing Sakai course management platform for all CTL reports. Professors now have a folder for each course where the source documents (syllabus, grade sheet, and students' evaluations summary) can be dropped along with the CTL report. The same folder system is easily accessible by the department chair and by the department administrator to facilitate compliance monitoring.

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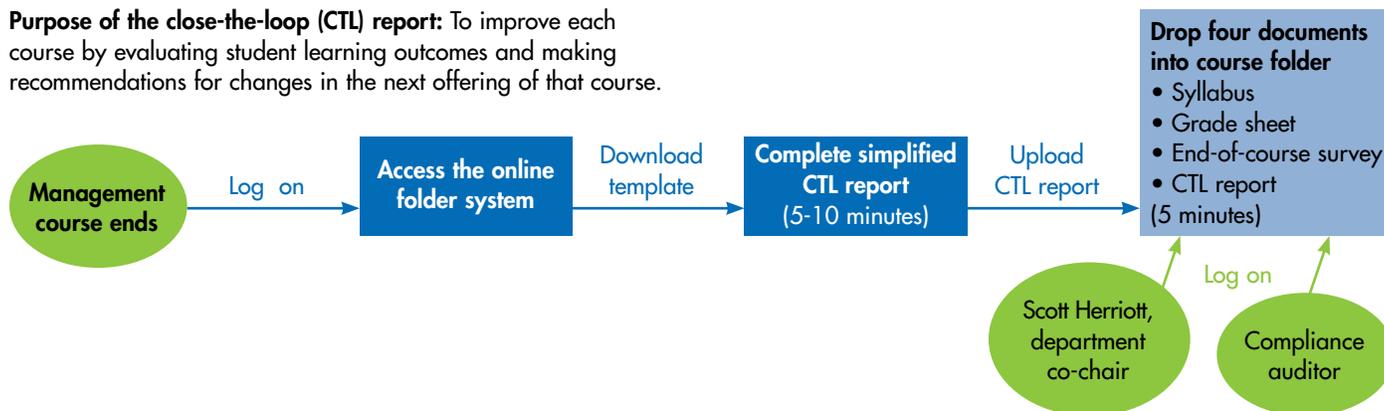

Figure 4: Future-State Map

- Eliminating the need for repetitive copying and pasting of course descriptions in the former report format by getting faculty to agree to insert the course descriptions into the syllabi. With the new process, the syllabus contains both the course description and the course objectives. Both are delivered in one operation by dropping the syllabus copy into the CTL course folder.

- Eliminating the need to summarize data from various course documents.

- Reducing the seven-question form to two questions as shown in Figure 5.

Stage 4, Improve: Utilizing collaborative problem solving to remove non-value-added elements.

After the changes were approved by the process owner, the team moved ahead to standardize the process so that there was a coherent method for implementing the new procedures and to provide a means for monitoring compliance. The following steps were taken to standardize the new process:

- Detailed instructions on how to use the new CTL report process were distributed to faculty.

- Instructions for faculty, the two-question CTL report template, the university's current catalog, and the tracking spreadsheet were uploaded to the CTL folder system in Sakai for easy access by all faculty members.

- The benefits of the new CTL process, shown in Table 1, were discussed during a department meeting and the process was demonstrated to the faculty.

After the process was standardized, the team developed a procedure for the department administrator to monitor the completion of CTL reports, send email reminders to faculty, and report to the department chair after each semester.

Implementation Tip 4:

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Every lean improvement project requires a somewhat different approach for analyzing what is happening and developing possible solutions. Over time, lean facilitators learn how to add new techniques to their toolbox and how to design a solution relevant to the project at hand.

Implementation Tip 5:

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All the good work for improving a process can be quickly lost if the new process is not stabilized and institutionalized. Regular monitoring is required, e.g., the gains from improving the CTL report will require vigilant monitoring and communication with faculty to enhance the initial gains in faculty compliance.

Summary and Conclusions

In the past, some leaders in higher education have been reluctant to apply kaizen methods to administrative processes due to misconceptions that lean is primarily a tool for manufacturing enterprises. This case study demonstrates clearly that Six Sigma methods, such as DMAIC, can dramatically improve business processes in higher education settings. Any organizational process with inputs, outputs, and feedback loops can be targeted for continuous process improvement efforts.

The kaizen event for the CTL process produced a variety of results including a simplified, web-based process that allowed faculty members to simply drop three existing documents (grade sheet, syllabus, and student evaluation reports) into a folder and then to complete a two-question report. The old process required approximately 45 minutes to complete and excessive document searches, movement, and summarization of

Before	**After**
Close-the-Loop Report	**Close-the-Loop Report**
After teaching a course, the professor should prepare a short memo to the program director or department chair with the following points:	Professor: Your Name MGT xxxx Course Name YYYYMM Date: mm/dd/yy
1. Paste into the catalog description of the course and the course objectives from your syllabus.	
2. What were the data on student learning outcomes in the previous offering of this course? Summarize (from a previous report, ideally) the results of tests, papers, projects, conversations with students, and end-of-course surveys. What strengths did the students show in light of the course objectives? What weaknesses?	1. What changes did you implement in this offering?
3. What changes did you intend or recommend after the previous offering?	2. What changes do you intend to make or recommend for the next offering?
4. What changes did you actually implement in this offering?	
5. What were the data on student learning outcomes in this offering? Summarize the results of tests, papers, projects, and end-of-course surveys.	Upload the following documents to the CTL Archive in Sakai:
6. What changes do you intend to make or recommend for the next offering?	☐ Course syllabus *(including course description and course objectives)* ☐ Grade sheet ☐ End-of-course survey ☐ Close-the-loop report
7. What resources would be required to implement your recommendations?	

Figure 5: The CTL Report Form—Before and After

Table 1: Benefits of the Revised Process

Simplified form	Seven questions reduced to only two questions and a document checklist
No more copy and paste for each CTL report	The syllabus already contains the course objectives. It is now very important, however, that all business faculty add the course description from the catalog to the syllabus (a one-time operation). From that point on, no more copying and pasting! The syllabus, complete with course description, will simply be dropped into a folder in Sakai after each course.
Updating course description in the catalog	Including the course description in the syllabus allows faculty members to stay on top of any changes and facilitates timely updating of the catalog.
Private archive for your documents	Within the CTL Archive folder, each professor has a separate, private folder to store all the documents related to the CTL report syllabus, grade sheet, EOC student evaluation, and the CTL report itself for each course taught. Only you and the site administrator will be able to see your CTL reports.
Easy two-step procedure	First prepare your documents (syllabus, grade sheet, EOC evaluation, and the CTL report) and then upload these four documents into the CTL Archive worksite in Sakai.
Value added	Including the course description in the syllabus allows the professor to easily see when the course description needs to be updated in the catalog. Students appreciate accurate, up-to-date course descriptions in the catalog.

information. The new process takes about 10-15 minutes with much easier flow.

As an unexpected side benefit, the department was alerted to the need for changes in course descriptions as courses evolve. Consequently, the new CTL process created an opportunity to simplify a related business process that had not been systematically managed in the past, e.g., the procedure for updating the university's catalog of course descriptions. The CTL project also identified a related process—delivery time of the student evaluation data—as an area to address in a later round of improvement.

Within a few months of implementing the incremental improvements, the business department's CTL project produced an improvement in compliance from the base condition of 10% with the old process, to 47% with the new process. Clearly, continuous monitoring of compliance will be needed to drive compliance rates higher.

Among the key lessons learned from this project were:

- **Proper training in lean methods can produce some significant impacts quickly.** On Monday of the five-day training, the CTL facilitator was uncertain of her ability to perform. By Friday (after five, half-day training sessions), she was confident about what to do.

- **Baselining is critical. The base condition was 10% non-compliance.** The post-DMAIC condition was 47%. Further monitoring is needed to institutionalize the changes. Knowing the base condition allowed the team to claim a significant measurable improvement in compliance.

- **Lean tools are very flexible.** There are many tools available to a kaizen team. Based on the nature of the process and the data available, the lean facilitator can choose the tools that fit the need of the project to discover root causes of poor quality and alternatives for change.

- **Streamlining can produce unanticipated added value.** With the new CTL process, faculty members now see their catalog course descriptions embedded in the course syllabus. As faculty update the syllabus for a new course, they quickly observe if the catalog course description also needs updating for changes that have moved into the course content. Thus, the university's course catalog descriptions are more accurate.

- **Lean Six Sigma training enriches job satisfaction.** Administrative staff members often recognize where issues and inefficiencies exist, but may not be able to effect positive change. Lean training as part of staff development provides the language and tools that empower staff

members to identify, propose, and facilitate continuous improvement projects throughout the university.

In this particular application of the DMAIC method, the goal was to streamline the efficiency of a process for monitoring effective delivery of academic courses. As the new dean of the college of business administration, Scott Herriott, the process owner who requested the kaizen intervention, expressed his appreciation of the streamlined CTL process that enables program directors to monitor the quality of academic delivery more effectively. We encourage the application of Lean Six Sigma tools throughout higher education academic and administrative processes to enhance value to customers and fulfill the potential of the HLC's AQIP mandate.

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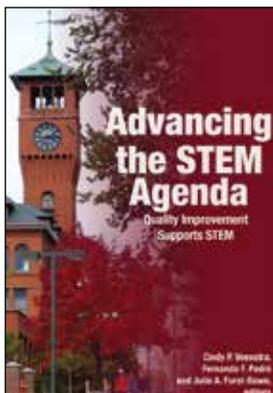Womack, J., Jones, D. & Roos, D. (1990). *The Machine That Changed the World.* New York, NY: Simon and Schuster.

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