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ADAPTING SIX SIGMA FOR ACADEMIA

The quality tool is being used to improve student retention at Rose-Hulman Institute of Technology

By Timothy Chow and Craig Downing

It is hard to miss story after story in the media about the fluctuations in the global economy and the financial difficulties facing the federal and many state governments across the United States. Dealing with limited resources, funding for higher education has been diverted to meet other high-priority needs. Yet society still expects investments in STEM education to satisfy the demand for skilled workers that can feed the high-tech economy.

On one hand, state funding declines for higher education, while on the other hand public sentiment rails against rising tuition that makes up for the reduction of state appropriations. It has become more common to hear about closures of colleges and universities due to enrollment decline and unmet revenue to meet operational obligations. In other cases, budget constraints have eliminated some programs and services.

In a sense, the higher education community faces a similar situation to that of the automotive and electronics industries during the 1980s, a scenario that brought out fierce competition for survival. The turnaround for those sectors came from focusing primarily on improving the quality of their products by reducing defects and wastes during the manufacturing process. Better quality helped them retain more customers.

Those quality initiatives, including the Six Sigma methodology, are still around today. And Six Sigma has a proven track record of success, primarily in manufacturing but also in service organizations.

For the higher education community, the public has focused on issues that include the number of students who complete their degrees and repay their loans. Typically, about half of the students who start a four-year degree program graduate within six years. Identifying ways to increase student retention and improve graduation rates are top priorities for academic institutions. Our team at Rose-Hulman Institute of Technology wondered if quality improvement tools like Six Sigma could help turn things around.

The team took the opportunity to set up a project and identify whether Six Sigma would improve student retention at the institute. This project illustrates how Six Sigma can be implemented in an academic setting and can serve as a launching pad for stimulating creative ways to apply the methodology to address the challenges facing higher education institutions.

They're leaving us

About six years ago, Rose-Hulman Institute of Technology observed a trend of a slight but potentially significant decrease in retention of its first-year students. A project team conducted a study to identify why these students were leaving. Administrators hoped the study would reveal cost-effective ways to combat the increase in first-year student attrition.

Given the differences in missions and student populations among higher education institutions, it was not surprising that the project team would find a variety of solutions being applied in the field to address similar challenges. Identifying best practices among the diverse strategies, therefore, was difficult.

The team considered the challenges of communicating student-retention strategies and results with various constituent groups and the availability of in-house expertise in applying Six Sigma methodology. Consequently, the team adopted Six Sigma's standardized define, measure, analyze, improve and control (DMAIC) process for the project. This approach would allow the project team to use a structured framework to document and organize project and related information, review and examine current processes and student-attrition related factors, and summarize and share process improvement activities and operational results.

The following descriptions highlight the corresponding actions taken in our project during each of the five DMAIC phases. It should be noted that activities in these phases need not occur in a sequential manner.

Define: Identify the problem(s) and define the scope of the project. A project charter is a comprehensive document that helps identify a process that needs improvement, together with the customer requirements for the project. Other relevant information included in the project charter helps communicate with the team and other constituent groups, such as the scope of the project, the availability of resources and the project's desired outcomes.

This team's project charter defined the problem and scope as follows: "Identify causes of student attrition during and immediately after the first college year and cost-effective solutions to mitigate the slowly rising rate of first-year student attrition to be maintained at around 10 percent or less."

Measure: Assess the current level of performance of the reviewed process. During this phase, current process capability is assessed to determine the performance level and potential gap. Relevant information will be gathered to help understand the problem at hand. The measurement system will be checked for accuracy to ensure that consistent measurement steps are being followed.

For our project, both quantitative and qualitative data were gathered to form a baseline for evaluating the current process, such as student-attrition rates for 10 student cohort groups and feedback from both current and former students regarding the challenges they faced while attending our college. The current process capability analysis as shown in Figure 1 (/uploadedFiles/IE_Magazine/2016_09/Content/ISESept16chow_fig1.pdf) indicated that the student-attrition rates were trending upward, although none of them were considered out of statistical control of the upper and lower 95 percent confidence intervals on the student-attrition rates.

Analyze: Study data gathered through the measure phase to determine potential root causes to the stated problem and identify opportunities for improving the current process.. In this phase, statistical tools and quality methods are used to examine available measurement data and identify potential root causes.

In this case, statistical analyses identified student-attrition risk factors by studying the correlations among various indicators, including pre-college academic performance, and student attrition status. In addition, nonacademic factors, such as information gathered through a survey of former students, a survey of faculty and staff who had frequent contact with first-year students, and a focus group of upper-class students who struggled through their first college year were reviewed to determine what factors affected student attrition.

Improve: Apply lessons learned from the analyze phase to implement changes to the current process. During the improve phase, a quality improvement plan and activities were carried out to determine potential impact on first-year student retention.

Based on results from the analyze phase, the team identified three subpopulations of first-year students with increased risk of attrition. The first group was identified according to their mathematics background and preparation. The second group was identified based on students' academic probation status during their first college year. The third group was identified through observers, such as coaches, instructors and residence assistants, who had frequent contact with first-year students to report any observed at-risk behaviors through their interactions with students during team meetings, in the classrooms or in the residence halls.

Targeted interventions were carried out for each of the three at-risk student groups. For example, students with a relatively weaker background in mathematics were assigned to special calculus classes to give them more time to review course materials. Students who were on academic probations would be required to participate in academic action plans that involved specific steps they must take to demonstrate satisfactory progress throughout their first college year.

Potentially at-risk students identified by campus observers were invited to attend student success seminars, which addressed topics such as time management, classroom engagement, utilization of resources, out of classroom preparation, academic performance and attitude. Participants in the seminars were required to come up with two specific, measurable, attainable, realistic and time-bound (SMART) goals. Project team mentors followed up with the students to ensure their actions were carried out. Student retention rates obtained during the improve phase were examined, as shown in Figure 2 (/uploadedFiles/IE_Magazine/2016_09/Content/ISESept16chow_fig2.pdf).

The chart of cumulative percentage defective (p) showed the estimate of the overall student-attrition rate dropped from 8.57 percent to 8.52 percent. Further, the upward trend in the student-attrition rates seemed to be offset with the interventions, shown in the improved process capability (Process Z), which improved from 1.3675 to 1.3712. While the statistical improvements are not great in magnitude, the direction in which they are moving shows promise.

Control: Formalize the improved process, monitor and assure that the desired outcomes are sustained over time. In the control phase, a control plan is defined to monitor process performance under the new and improved process. The new process capability is determined, and desired outcomes of the process are verified. The results of the project are communicated to the constituent groups, and the new and improved process is transferred to the process owner.

With the successful pilot results for determining attrition risk factors, the new processes were established to help identify potentially at-risk students early and offer tailored interventions according to their needs. The enrollment management team assumed leadership for the student-retention initiative and continues to explore ways to improve the process.

Adaptation of Six Sigma methodology

While the Six Sigma framework helped, the different organizational structure and operating environment of industrial settings versus the campus required the team to adapt the methodology to meet the unique needs of a higher education institution.

Customer definition: Perhaps the most significant challenge when adapting Six Sigma in academia is defining "customers." When viewing students as customers, they could fulfill multiple roles: raw materials for receiving instructions to learn new skills and concepts; customers for receiving services from various offices and departments; or as employees for receiving performance reviews for their classes and other learning opportunities.

These roles add complexity when addressing process improvement and related issues. Requirements and expectations vary among diverse customer groups and roles. Clarifying project goals and allocating limited resources to meet the needs of students required prioritizing demands from multiple customers who also are involved in the production process itself. In our case, we considered parents, students, faculty, staff, administration and employers as our customers, and they assumed different roles in the educational process. The faculty, staff and administration of our college have obligations to the parents and employers of our graduates to ensure that students succeed.

Quality definition: Defining and measuring quality outside of the manufacturing sector can be more complex since perceptions are more individualized. For example, two people could judge the quality of the same process or service in very different ways, while customers are more likely to agree about the quality

CITY SCHOOL SYSTEM TACKLES LEAN SIX SIGMA

Teachers, staff and administrators in the Marion City School District in Marion, Ohio, spent the summer tackling lean Six Sigma training to improve the district's operations, *The Marion Star* reported.

The district and several others in Ohio have partnered with the Alber Enterprise Center at The Ohio State University at Marion.

"We are looking forward to learning and applying the concepts of lean Six Sigma in our areas," Gary Barber, superintendent of Marion City Schools, told the newspaper in July. "Everyone is committed to learn the material and take back and apply something that would be of benefit in their area to improve quality."

The district offered webinars, online learning and discussion and mentoring so employees could apply the concepts to specific projects in the school district, which has 3,000 students and 700 staff members. The previous year was spent identifying areas for improvement, including purchase orders/requisitions, facility use, professional development and busing.

attributes of manufactured products.

Such individualized perceptions of academic quality have contributed to the difficulties in identifying and satisfying the diverse expectations of customers. In addition to evaluating the end products or services being rendered, customers with multiple roles are evaluating the quality of the production or service delivery process.

For Rose-Hulman's case, the team focused on first-year student retention as the key customer's critical-to-quality characteristic. Improving student-retention rate would have a significant impact on degree completion, particularly in the STEM fields, enhancing the college's ability to meet society's needs for more skilled workers.

Metrics definition: When difficulties arise in defining customers and the voice of the customer (VOC), defining and collecting the data necessary to study and evaluate the current process and estimate process capability can be daunting, if not impossible. This is particularly true with metrics associated with intangible aspects of the process.

In this case, the Rose-Hulman team attempted to adapt the concept of defect as the number of first-year college students who left and did not return. The project estimated the current process yield, capability and sigma value using available attribute data from student-retention records. This metric is readily available and can be evaluated over time internally, as well as for benchmarking against the national norm or other relevant peer reference groups.

For measure of success, the team estimated the additional annual revenue the college would receive if an improved process retained students after their first college year.

Culture and reward structures: Organizational culture can be a barrier to change, especially change driven by Six Sigma principles. When compared to manufacturing organizations, service organizations and higher education institutions have drastically different governance models and reward structures. This requires combining Six Sigma with other process improvement methods, such as lean, to promote change that may gain broader buy-in and impact throughout the entire organization.

However, effective communication is critical, as the pace of change in academia can be quite different from what happens in manufacturing organizations that have a more hierarchical governance structure. Faculty, staff and administration focus on compartmentalized roles such as teaching, service and operation management, which means that recognition and rewards for improvements are handled quite differently than in industry.

As with other studies conducted on how higher education institutions have adapted Six Sigma, the scope of the Rose-Hulman case has a narrower focus than examples from industry. The team attempted to examine the overall student-retention rates at the college level, which had buy-in from the administration and other campus community groups because it is one of the college's key strategic objectives. The intrinsic reward to project team members is the feeling of doing something good for students by keeping our promises to help them succeed.

Benefits of adopting Six Sigma

Adopting Six Sigma and its five standardized phases has several benefits.

First, process documentation – as a product of adopting Six Sigma – in the form of project charter, process maps, control charts, cause-and-effect diagrams and other project report components helped communicate project activities and results with various constituent groups. The project documentation helped the project team to manage progress and stay focused as the project evolved.

Second, Six Sigma offered a structured framework to organize research activities and establish a baseline for the current process in a format that can be tracked over time and shared with a broader audience for review. In light of the constraints associated with actions that could improve student retention, adopting the Six Sigma methodology enhanced our ability to prioritize and make informed decisions rather than relying on intuition to put out fires.

Third, depending on the nature of the data collected and the needs of the project, the Six Sigma methodology allows for flexibility in applying quantitative and qualitative tools. In addition to using continuous data about students' pre-college academic performance, the team applied the standard Six Sigma metrics DPMO (defects per million opportunities), P chart and the cause-and-effect diagram to analyze other attribute type data.

Overall, Six Sigma helped the project team learn more about process capability and differentiate between common and special causes as the team investigated how student-retention rates fluctuated over time.

In addition, the standardized DMAIC process offers academicians a broader view of workflow in higher education institutions and highlights the interdependence among various campus groups.

In this case, the project team was composed of representatives from different campus units, such as admissions, enrollment management, faculty, institutional research, learning center and student affairs. The project helped all team members gain a better understanding of the college's admission process, as well as ways to identify and provide assistance to at-risk students early on.

Moreover, the high expectation for minimal to zero defects in processes helps promote a culture of continuous improvement that brings out better performance in many, if not all, aspects related to the educational process. Using the results from the analysis phase, the student-retention process was considered in control. This was determined by referencing the process sigma level to the expected range of sigma level of typical service-related processes.

The defects per unit level specified by the college's senior administration also was determined to be within the expected range, which is less than or equal to 10 percent.

Rose-Hulman's defects per unit looked favorable when compared to the national average among the college's peer reference groups. Even so, the project team was motivated and interested in improving student-retention rates by examining existing processes and considering potential causes for the attrition of first-year students.

Furthermore, other process improvement tools, such as lean, complement the adaptation of Six Sigma to capture additional data for use outside of the typical manufacturing environment. For example, the voice of the customer is of significant importance since measuring success will be based on customer requirements and expectations.

Fortunately, higher education institutions are familiar with using survey research and focus groups to obtain feedback from constituent groups. The project team was able to use these quantitative and qualitative tools to identify and examine factors associated with first-year attrition at the college. Aside from these tools, educational theories and models also helped offer insights into common factors that led to attrition when the project team conducted the cause-and-effect analysis on student-retention.

Take it to the next level

Six Sigma methodology offers a structured and standardized framework for approaching process improvement and disseminating project information and results with various constituent groups. With an aim to improve existing processes beyond manufacturing organizations, adopting Six Sigma can bring

about impactful and holistic changes to higher education institutions and service organizations with an expanded scope of workflows.

By adapting Six Sigma to local context and conditions, higher education institutions and service organizations can reap benefits of the data-driven, process-oriented framework to improve their processes. Challenges associated with Six Sigma's manufacturing roots, such as identifying customers and defining requirements and expectations, can be mitigated by using complimentary quality improvement tools like lean. Adding other qualitative tools like opinion surveys and focus groups can help adapt Six Sigma for use in academia and service organizations.

We hope that Rose-Hulman's experience in adopting and adapting Six Sigma for improving student retention may serve as an example of how Six Sigma could be applied to address "customer" retention as well as other challenges facing higher education institutions and service organizations.

Applying these tools can help your organization fulfill the first point of W. Edwards Deming's 14 points for management: "Create constancy of purpose toward improvement of product and service, with the aim to become competitive and to stay in business, and to provide jobs."

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