Improvement of Course Scheduling Using Lean Six Sigma

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Abstract

In this paper, a Lean Six Sigma project aimed at improving the course scheduling process in a large engineering department at Texas A&M University is presented. The current scheduling process faces numerous challenges, including inadequate enrollment capacity, a lack of documentation, and inefficiencies that frustrate students and faculty members alike. By applying the DMAIC (Define, Measure, Analyze, Improve, Control) methodology, this project identifies critical areas for improvement and proposes a new streamlined scheduling process. Key outcomes include reducing classroom overcapacity and ensuring equitable access to courses. This case study demonstrates how Lean Six Sigma tools can address systemic issues in academic operations, benefiting students, faculty, and administrators.

Introduction

Lean Six Sigma is a widely used methodology for process improvement, originally developed for the manufacturing industry[1]. Over time, it has been adopted as both a management tool[2] and a technical problem-solving approach[3]. While its roots lie in manufacturing, Lean Six Sigma has proven effective across various sectors. For example, Koning *et al.*[4] applied it to financial services, Perry and Barker[5] implemented it in the service industry, and Van Den Heuvel *et al.*[6] utilized it in healthcare. Leon and Crimi[7] further demonstrated its potential in fostering university-industry collaboration. Today, Lean Six Sigma can be applied to any process to achieve measurable improvements. An extensive review of Six Sigma methodologies is available in[8].

Given its widespread use in industry, educators have explored how to integrate Lean Six Sigma into academic curricula. Rao and Rao[9] investigated this integration, while Ho *et al.*[10] discussed challenges faced during adoption in higher education. Furterer[11] presented strategies and tools for teaching Lean Six Sigma to engineering technology students, and Zhan and Porter[12] introduced project-based learning to enhance student understanding of Lean Six Sigma principles.

In addition to teaching Lean Six Sigma, the methodology can be applied to improve processes within higher education institutions. Coowar *et al.*[13] successfully used Lean Six Sigma to streamline the pre-application process at the University of Central Florida's College of Engineering and Computer Science. Similarly, Desai and Thomassian[14] applied Lean Six Sigma principles to curriculum design. An interesting approach involves engaging students in Lean Six Sigma projects that directly impact their academic experiences. This provides practical learning opportunities while addressing real-world challenges.

Since 2012, the Electronic Systems Engineering Technology Program has offered a Lean Six Sigma course, where students earning a grade of B or higher receive a Yellow Belt Certificate. The course features case studies to illustrate how the DMAIC (Define, Measure, Analyze, Improve, Control) process can enhance products or processes. One of the authors, as the instructor, continuously seeks meaningful projects related to higher education process improvements. Upon assuming responsibility for departmental class scheduling as Associate Department Head, the author identified inefficiencies in the scheduling and registration process, which became the focus of a Lean Six Sigma project beginning in fall 2024.

While reviewing related work, it was noted a Lean Six Sigma project conducted at the University of California, San Diego (UCSD)[15]. At UCSD, scheduling 2,500 classes across 103 classrooms required 3-5 months, 2,400 phone calls, and 13,000 emails involving 58 academic departments each quarter. Through Lean Six Sigma, UCSD achieved a 75% reduction in wait time, a 56% reduction in process time, a 33% reduction in communication overhead, and cost savings of

$226,500. Inspired by UCSD's success, the authors sought to apply Lean Six Sigma principles on a smaller scale within our department, recognizing our limited resources. A small-scale Lean Six Sigma project was started in fall 2024, targeting the low hanging fruits within one department of the College of Engineering. This continuous improvement effort is expected to span several semesters, with plans to share successful results with other departments and colleges.

The goals of this project are twofold: to improve the scheduling process and to use it as a case study in the Lean Six Sigma course. Scheduling is a process that directly affects students' academic experiences, and many students expressed frustration about being unable to enroll in desired courses. By involving students as end-users, the project not only provided practical learning opportunities but also motivated them to contribute to meaningful improvements. Students engaged in discussions, proposed ideas, and gained a deeper understanding of the scheduling and registration process. Some noted that understanding the process reduced their frustration and made them more willing to collaborate on solutions.

The project completed its first round of the DMAIC process, and improvement ideas were implemented for the spring 2025 semester. Significant progress has been made, but additional problems have been identified during the improvement phase. The process is expected to undergo several more iterations to achieve optimal results.

DMAIC Process

The DMAIC (Define, Measure, Analyze, Improve, Control)[16] process was followed during the project execution.

Define

In the Define phase, the justification for the project was evaluated, selected process performance metrics, set goals for performance improvement, and conducted SIPOC (Suppliers, Inputs, Process, Outputs, Customers) analysis and created a CTQ (Critical to Quality) Tree.

Business case: The scheduling process significantly affects faculty, staff, and students. The current process faces numerous challenges, leading to frequent complaints from all stakeholders. Every semester, faculty and staff must address last-minute changes while many students anxiously wait to enroll in their desired courses. An improved scheduling process would streamline operations, allowing students to register for the courses they need while reducing the burden on faculty and staff, who often find themselves resolving issues at the last minute.

The following performance metrics were identified to measure the process's effectiveness:

1. Number of students unable to register for courses the week before first day of class, potentially delaying their graduation.

2. Number of scheduling issues identified the week before first day of class.
3. Number of unresolved issues on the first day of class.
4. Time schedulers must spend in scheduling and resolving problems.

In previous semesters, Performance Metric #2 simply referred to the total number of scheduling issues. However, during the fall 2024 scheduling, it became evident that the timing of issue identification was equally critical. If issues are identified months before the semester begins, there is usually sufficient time to resolve them effectively. Conversely, issues identified the day before classes start leave limited options, often resulting in suboptimal solutions.

The project aims to achieve the following goals:

- Reduce the performance metric #1 by 50%.
- Reduce the performance metric #2 by 50%.
- Reduce the performance metric #3 to 0.
- Reduce the performance metric #4 by 50%.

These goals were set based on preliminary data that were available. They reflect significant improvement over the existing process and seem to be feasible to achieve.

A SIPOC analysis was conducted to map and better understand the current scheduling process, helping to identify pain points and areas for improvement.

SIPOC

Suppliers	**I**nputs	**P**rocess	**O**utputs	**C**ustomers
Office of Registrar	available classrooms/lab rooms	Scheduling Process	classroom/lab room schedule	students
College of Engineering	courses offered		available seats for registration	faculty
Program coordinators	lecture time		instructor/TA assignments	TAs
	lab time		major restrictions	
	student data			
	scheduling phase deadlines			
	instructors/TAs			
	room capacities			
	past schedules			

Figure 1. SIPOC

The current scheduling process is illustrated in Fig. 2.

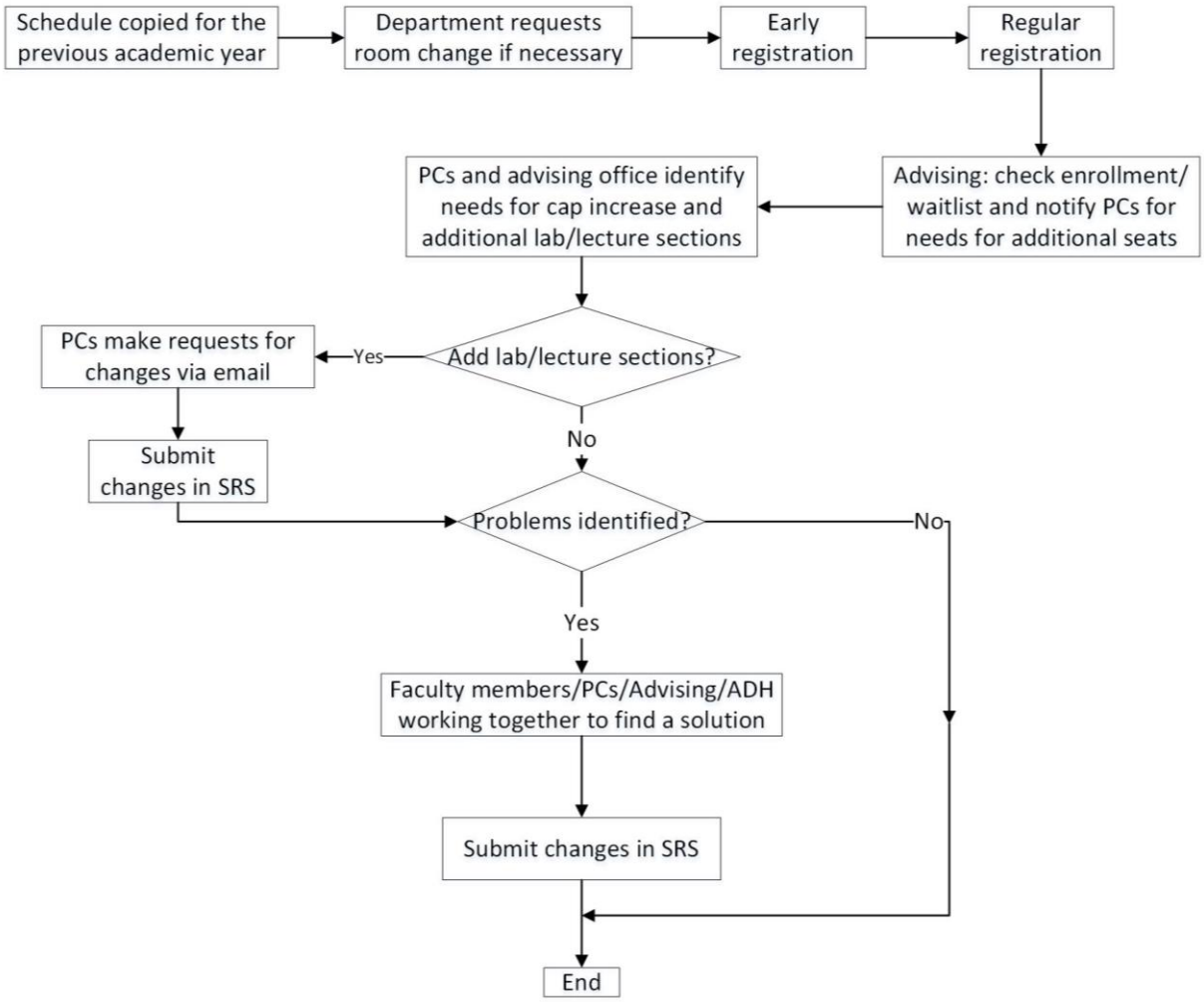

Figure 2. Current Scheduling Process

Next, a Critical to Quality Tree was created, as illustrated in Fig. 3. This analysis leads us from the customer needs to more specific desirable requirements.

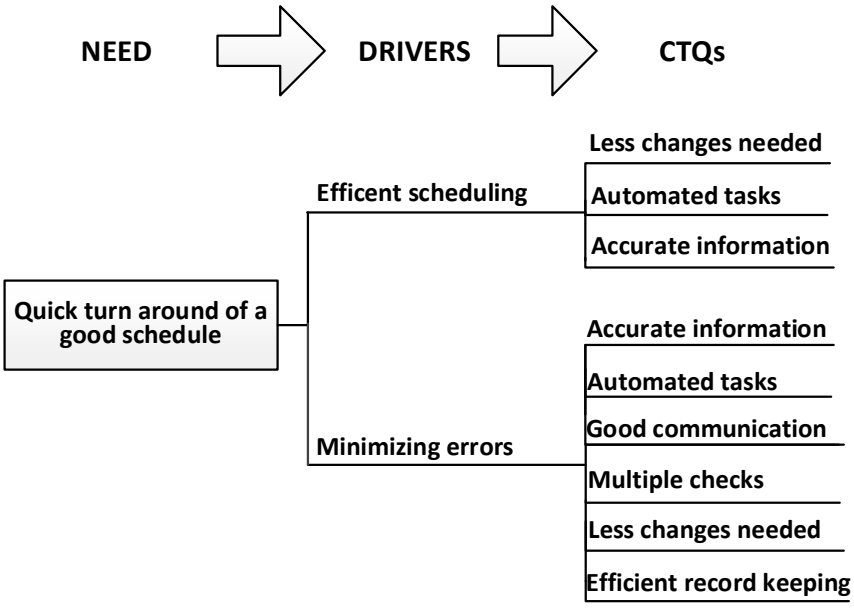

Figure 3. Critical to Quality Tree

Measure

After establishing performance metrics and goals in the Define phase, data collection began to support further analysis. Faculty members teaching courses with scheduling issues were interviewed by one of the authors, and student input was gathered during Lean Six Sigma lectures. Faculty members and students were asked to provide the issues they had related to scheduling and registration.

Voice of Customers (VOC) Analysis

The VOC analysis revealed widespread dissatisfaction with the current scheduling process from various stakeholders:

- **Students**: Complained about not being able to register for desired courses, long waitlist processing times causing anxiety, and confusion about classroom assignments. Some students went to the wrong room for the first lecture due to outdated syllabus information.
- **Faculty Members**: Reported last-minute classroom changes without notification, leading to incorrect syllabus information. In some cases, classrooms assigned were too small, forcing students to sit on the floor.
- **Advisors**: Struggled with a high volume of students seeking help the day before the semester began. Many students were frustrated, and advisors had limited options to assist them effectively.

- **Administrative Staff**: The Associate Department Head and staff responsible for scheduling, along with five program coordinators, worked around the clock to address emergent issues. However, the scheduling process for the next semester began shortly afterward, creating a perpetual cycle of crisis management.

Specific Cases:

1. **Inappropriate Room Assignments**:
    - A course requiring specialized computers and software was assigned to a standard classroom. Due to a last-minute change, the class had to be rescheduled to a late evening slot to avoid conflicts with other courses and labs.
2. **Last-Minute Communication Failures**:
    - A larger classroom was assigned to a course at the last minute. However, the instructor was not informed, and students arrived at the wrong location due to outdated syllabus information. New program coordinators assumed instructors would check the university's scheduling system, but not all instructors reviewed the system before the first lecture.
3. **Bizarre Assignments**:
    - Classes were assigned to a storage room, a small faculty office, or even a room on a different campus.
4. **Overcapacity Issues**:
    - A lecture exceeded the room capacity, which is prohibited for safety reasons. However, the registration system did not flag the violation. These issues were often discovered on the first day of class when students could not find seats.
5. **Recurring Problems**:
    - The Registrar's Office copies schedules from the same term in the previous year (e.g., fall 2025 copied from fall 2024). Although some issues were identified and fixed in one semester, they reappeared the following year due to this process.

Key Findings from VOC Analysis

The VOC analysis highlighted several systemic problems with the current scheduling process:

- Inconsistent communication and lack of clear notification protocols.
- Manual tasks prone to human error, including room assignments and capacity checks.

- Repetition of previously resolved issues due to reliance on outdated scheduling practices.

The insights gathered from the VOC analysis served as the foundation for the next phase, **Analyze**, where root causes and potential solutions were explored.

The performance metrics for spring 2024 were evaluated as

1. Number of students unable to register for courses the week before first day of class, potentially delaying their graduation (324).
2. Number of scheduling issues identified the week before first day of class (32).
3. Number of unresolved issues on the first day of class (7).
4. Time schedulers must spend in scheduling and resolving problems (260 hours).

Analyze

When the schedule from the previous year was copied over, recurring issues often reappeared due to a lack of documentation from the previous semester. Unless specific problems were recorded, they were quickly forgotten. Many faculty members were unaware of how the schedule was copied, leading to frustration and misplaced blame on program coordinators and schedulers for repeating past mistakes.

Key Issues Identified in the Scheduling Process

1. **Lack of Responsibility for Error Checking**
   It was often unclear who was responsible for verifying the schedule for errors. For example, when a lab section reached its predetermined capacity and additional students were waitlisted, program coordinators might request advisors to increase capacity or create new lab sections. However, both parties might assume the other had verified that room capacity would not be exceeded. Since the scheduling software does not flag such violations, these issues were often discovered too late, such as on the first day of class, making it difficult to find a larger room.
   - Example: A class with six lab sections capped at 12 students each (total enrollment: 72) was assigned to a room with a capacity of only 65. This error went unnoticed until students arrived for the first lecture.
2. **Communication Failures**
   When classrooms were changed, program coordinators sometimes forgot to inform instructors, leading to incorrect classroom information in syllabi. This caused confusion and chaos on the first day of class as students arrived at the wrong locations.
3. **Enrollment Estimation Errors**
   Enrollment estimates for certain classes were often inaccurate, leading to overcapacity

issues when registration opened. If additional seats could not be provided, some students faced delays in their graduation timeline.

    - Complication: University policy mandates that enrollment numbers must fall between 65% and 100% of room capacity. Overestimating enrollment could result in losing a classroom to another course requiring a large room.

4. **Lecture Time Changes**
   Faculty requests to change lecture times for personal reasons occasionally caused conflicts with other courses or labs. Similarly, adjusting lecture times to address overcapacity issues often led to complaints from students who had already registered and now faced schedule conflicts.

5. **Lab Section Preferences**
   Even when seats were available in a course, some students could not register due to lab section conflicts. While multiple lab sections were offered, overlap between lab and lecture times was unavoidable. Certain lab times, such as Friday afternoons or evenings, were less popular, leaving students with limited options during regular registration.

    - Early registrants (students with disabilities, student workers, or seniors) often filled the preferred lab sections, leaving less desirable options for other students.

6. **Honor Section Overcapacity**
   Overcapacity issues also arose in honor sections. Since students cannot self-register for these sections, their caps are set to zero, requiring advisors to manually add students. In one case, an advisor added an honor student without checking the room capacity, causing an overcapacity violation.

7. **Email-Based Requests**
   Requests from program coordinators to department schedulers were managed via email. This system often led to overlooked requests or delays. Even when processed, locating these emails later was time-consuming, especially if the request was not addressed immediately.

Summary

The scheduling process was fraught with manual tasks, communication gaps, and unclear responsibilities, all contributing to repeated errors and inefficiencies. These issues underscored the need for a systematic approach to documentation, verification, and communication to prevent recurring problems and improve the overall scheduling process.

<u>Improve</u>

Based on the information gathered during the Analyze phase, the following changes to the scheduling process were proposed:

- The department will provide program coordinators with historical data and student degree plan information, encouraging them to create more accurate enrollment projections for each course.
- Before the registration starts, the department scheduler will ensure that the enrollment cap does not exceed room capacity.
- When a program coordinator requests a cap increase, he/she must first verify that the room capacity is sufficient.
- Whenever an academic advisor places a student into a class, they must check that the room capacity is not exceeded.
- In case of potential issues, the instructor should be involved and informed of any changes.
- A request form will be created for program coordinators to use when making changes to a class. This form should be filled out and emailed to the department scheduler. The form will be downloaded and placed in a shared folder, allowing the requester to check the status of the request at any time. This process will save time spent on emails or phone calls for status updates.
- The enrollment cap for each lab will be intentionally lowered during early registration and raised afterward. This adjustment will make seats in popular lab sections available for students during regular registration.
- The department will remind all faculty members to check the course information before registration begins. Program coordinators will be asked to document any issues and solutions so that they can be addressed early in the next semester's scheduling process.

Based on these considerations, a new scheduling process is proposed, as illustrated in Fig. 4.

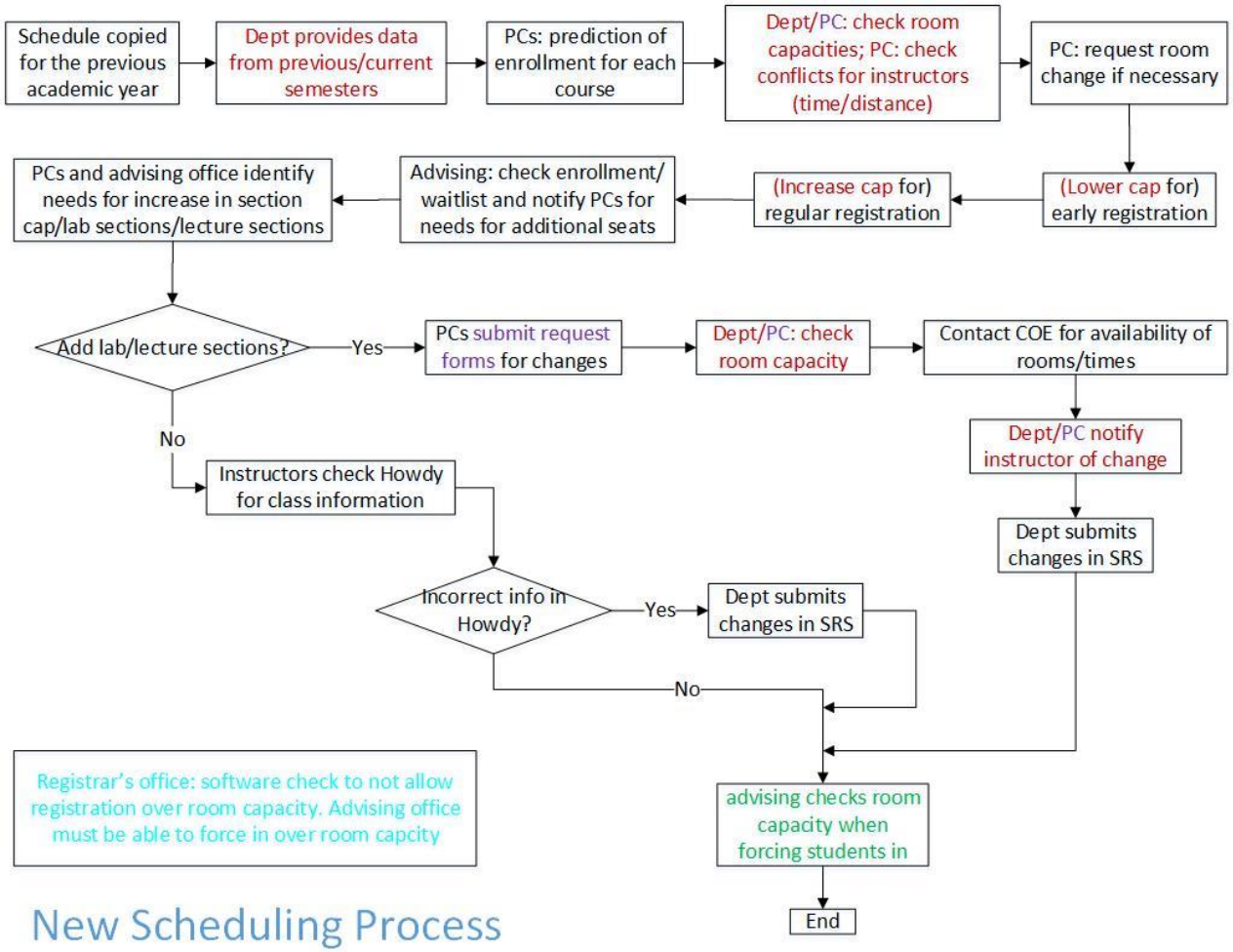

Figure 4. New Scheduling Process

Control

Currently, the new scheduling process is being formalized. People tend to stick to familiar methods, and it's easy to revert to old habits. At times, email requests for changes that did not include the required request form had to be rejected.

The performance metrics for spring 2025 were evaluated as follows:

1. Number of students unable to register for courses the week before first day of class, potentially delaying their graduation (110).
2. Number of scheduling issues identified the week before first day of class (3).
3. Number of unresolved issues on the first day of class (1).
4. Time schedulers must spend in scheduling and resolving problems (280 hours).

Performance Metric 4 has worsened compared to previous years. This is due to our decision to align the spring and fall schedules, which required a one-time investment of time but will make future scheduling more efficient. The four performance metrics are plotted in Figure 5 for before and after the Lean Six Sigma project.

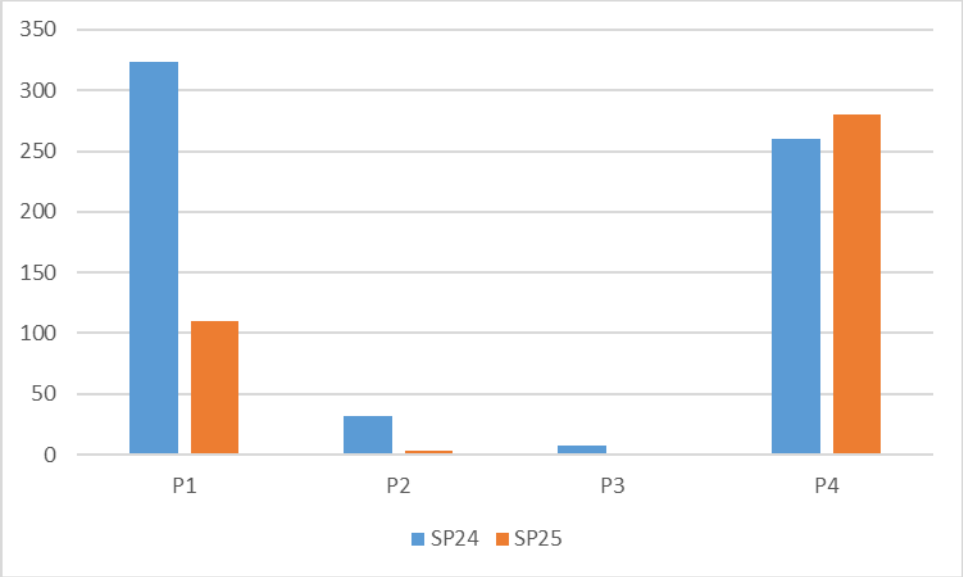

Figure 5. Before and After Analysis

The authors will continue monitoring the scheduling process and identify new issues. The initial effort focused on addressing the "low-hanging fruit." Another round of the DMAIC process to drive further improvements in being planned.

If this new process proves successful, it can serve as a model for other departments within the College of Engineering and eventually be adopted by other colleges at Texas A&M University to improve their scheduling processes as well.

Conclusions

Lean Six Sigma was used to improve the scheduling process in the Department of Engineering Technology and Industrial Distribution at Texas A&M University. Following the DMAIC process, the project was defined, data were collected and analyzed, and several root causes of the problems were identified. Improvement steps were implemented, resulting in a new, more efficient scheduling process with fewer errors. This is an ongoing improvement effort, and the effects of the new process are currently being evaluated. Future work will focus on developing better enrollment prediction models and exploring the use of AI to optimize the scheduling process. Successful implementation of this new process can be replicated in other departments and colleges.

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