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Teaching Case

Using Tableau to Visualize Data for a Six Sigma Improvement Project

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Hook

By using the Six Sigma Define-Measure-Analyze-Improve-Control (DMAIC) process, Tableau can create visualizations that bring the case's data alive and can be structured into a Dashboard for resolution and presentation.

Abstract

The Six Sigma DMAIC process is a structured management method that engages students in data driven-decision making using visualizations of the data with Tableau. By using data gathered from a class field trip to a local aircraft overhaul and repair facility, structured into a case problem, students can follow the DMAIC process creating visualizations from the descriptive, diagnostics and predictive analytics needed to represent the stages of the DMAIC process. Tableau, a free-for-students business intelligence software, integrates the data and the stages to build visualizations that can be analyzed and structured into a presentation. Throughout the project, Tableau is used not only as a tool for data visualization, but to enhance data-driven decision-making and uncover actionable insights at each stage. As students' progress through the case, they develop core Six Sigma competencies including problem definition, root cause analysis, and solution implementation. Visual analytics play a central role, enabling students to transform raw data into interactive dashboards that reflect both their findings, and the process improvements achieved. The case culminates in the development of a comprehensive Tableau Dashboard that communicates the project's results to stakeholders. This hands-on experience bridges theory and practice, equipping students with valuable skills in continuous improvement, data analysis, and data visualization in a business context. To date 139 undergraduate students have completed this case as part of the Business School's Management Exit Assessment.

Keywords: Data Analytics, Six Sigma, DMAIC, Data Visualization, Descriptive Data, Diagnostic Analytics

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1. CASE SUMMARY

Situation: You are working for Large Blue Airline as a Logistics Operations Analyst in the engine repair and overhaul center. The Program Manager for repair and overhaul has asked you to analyze data concerning fuel pump repair deliveries to global customers. Market feedback has indicated that the customers are dis-satisfied with the timeliness of deliveries. The current target is to have the repaired fuel pump "pick-pack-shipped" within two hours of the repair completion. A late shipment is counted if the pump has not been packaged and shipped within two hours of repair.

Your direction is to complete a DMAIC project dashboard using Tableau. The Program Manager has specified she wants the problem defined with a line chart, measured and analyzed with Pareto Methods, root cause analysis with the "5 Whys", improvement alternatives chosen with simple regression analysis, and the project controlled with Earned Value Management and scheduled with a Gantt Chart. Text boxes can be used as necessary to explain the visuals, but the intent is for the resulting dashboard to show understanding "at a glance".

2. BACKGROUND AND LEARNING OBJECTIVES

The case is created for an undergraduate operations management class to teach Six Sigma process improvement methods as a DMAIC project, an undergraduate data analytics class to teach data visualizations, graduate analytics classes and graduate operations classes. The Earned Value Management data can be used in both project management and finance classes at all levels. The students need not have exposure to the topic of process improvement, or to any business intelligence software other than Excel. The learning objectives for the assignment are to:

- Apply Six Sigma methods to make a data-driven solution.
- Analyze the data using the DMAIC process to build a case for an improvement.
- Create Visualizations and a Dashboard with Tableau
- Draft a written report detailing the specific business problem, the structure of the data, analysis of the visualizations and a descriptive of the proposed countermeasure.

The case study integrates lecture notes for Six Sigma, but the students are expected to use assigned readings and recorded lectures to build the Tableau visualizations.

3. THE SIX SIMGA PROJECT METHOD

The Six Sigma DMAIC process is a methodology for process improvement widely used in various industries to enhance efficiency, reduce defects, and ultimately, improve customer satisfaction (Cox, Gaudard, & Stephens, 2016). Six Sigma is a systematic methodology used by organizations to improve processes, reduce defects, and enhance overall quality. It originated in the manufacturing sector but has since been adopted across various industries, including healthcare, finance, and services.

At its core, Six Sigma strives to minimize variation in processes and outputs, aiming for near-perfect performance levels. The term "Six Sigma" refers to a statistical concept that represents a level of quality that allows only 3.4 defects per million opportunities. Achieving this level of quality requires rigorous data analysis, process improvement, and a commitment to continuous learning and adaptation.

The Six Sigma approach is typically structured around two key methodologies: DMAIC and DMADV. DMAIC stands for Define, Measure, Analyze, Improve, and Control, while DMADV stands for Define, Measure, Analyze, Design, and Verify. DMAIC is primarily used for improving existing processes, while DMADV is focused on creating new processes or products (Cox, Gaudard, & Stephens, 2016).

Overall, Six Sigma provides organizations with a structured framework to identify areas for improvement, implement changes, and monitor results systematically. It emphasizes the importance of data-driven decision-making, customer focus, and teamwork to drive sustainable improvements and achieve business objectives.

1. The Define Stage

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The Define stage serves as the foundation of the DMAIC process. Its primary goal is to clearly define the problem or opportunity for improvement and establish the project's objectives. This stage sets the direction for the entire project and ensures alignment with organizational goals (Cox, Gaudard, & Stephens, 2016).

Key Components of the Define Stage:

Project Charter: At the onset of the Define stage, it's essential to develop a project charter. This document outlines the project's scope, objectives, timeline, resources required, and key stakeholders. The project charter serves as a roadmap, guiding the team throughout the DMAIC process.

Voice of the Customer (VOC): Understanding the customer's requirements, expectations, and preferences is paramount in the Define stage. Through techniques such as surveys, interviews, and data analysis, organizations capture the Voice of the Customer (VOC) to identify critical-to-quality characteristics and prioritize improvement efforts accordingly.

Critical-to-Quality (CTQ) Identification: Building upon the VOC, the Define stage involves identifying Critical-to-Quality (CTQ) metrics. These are the specific parameters that directly impact customer satisfaction and define success for the project. CTQ metrics serve as the focus areas for measurement and improvement efforts throughout the DMAIC process.

Process Mapping: Another crucial aspect of the Define stage is process mapping. This involves creating detailed flowcharts or diagrams to visualize the current state of the process under investigation. Process mapping helps identify bottlenecks, inefficiencies, and potential areas for improvement. It provides a clear understanding of how the process operates and where interventions may be necessary.

For the case study the Program Manager has directed the use of a Line Chart to visually describe the problem. She only requires you to work on the Line Chart at this point. She has instructed that a Line Chart should be created since it is performance over time, and the coefficient of determination, or the R2, should be visualized as well. Tableau should be used for the visualization (Richardson & Watson, 2024). Please find instructions to complete a line chart here.

The following data is given for the Line Chart:

Month	Number of Late Shipments (Line Chart)
Jan-24	22
Feb-24	30
Mar-24	33
Apr-24	35
May-24	38
Jun-24	55
Jul-24	67
Aug-24	50
Sep-24	48
Oct-24	67
Nov-24	69
Dec-24	104

Table 1. Number of Late Shipments by Month

4. THE MEASURE PHASE

The Measure phase is the second step in the DMAIC process. Its primary goal is to establish a baseline understanding of the current state of the process or system being analyzed. This phase involves collecting relevant data, quantifying the performance of the process, and identifying potential sources of variation or defects. The objectives of the Measure Phase are to:

- Define process metrics: Identify key performance indicators (KPIs) and measurement criteria that align with the project goals and customer requirements.
- Gather data: Collect accurate and reliable data to assess the process performance and understand its variability.
- Validate measurement systems: Ensure that the tools and methods used to collect data are accurate, precise, and consistent.
- Establish baseline performance: Determine the current process capability and identify areas of improvement.

Common tools used in Six Sigma for the Measure Phase are (Cox, Gaudard, & Stephens, 2016):

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Process Maps: Visual representations of the process flow, highlighting key steps, inputs, outputs, and potential areas of inefficiency.

Data Collection Plan: A structured approach to gathering relevant data, specifying what data to collect, how to collect it, and who will collect it.

Measurement System Analysis (MSA): Evaluates the reliability, accuracy, and precision of measurement systems to ensure that data collected is valid and trustworthy.

Descriptive Statistics: Basic statistical techniques such as mean, median, range, and standard deviation used to summarize and describe data.

Probability Distributions: Analyzing the distribution of data to understand its characteristics and variability.

The Program Manager has specified use of the Pareto Principle, or the 80/20 Rule for the Measure Phase. The Pareto Chart is a graphical tool used to prioritize and focus improvement efforts by identifying the most significant factors contributing to a problem or outcome. It is based on the Pareto Principle, also known as the 80/20 rule, which states that roughly 80% of effects come from 20% of causes (Richardson & Watson, 2024). By identifying the 20% of the causes, the significant opportunities for improvement can be identified. Please find instructions to create a Pareto Chart in Tableau here.

Use the following data to create a Measure Pareto Chart:

Reasons for Late Shipments (First Pareto)	Number for Late Shipment Reasons (First Pareto)
Lack packing eqipment	
Short Staff	
Inspection Rejection	
Box failed	
FEDEX Late Pickup	

Table 2. Reasons and Numbers for Late Shipment

5. THE ANALYZE PHASE

The Analyze Phase acts as Diagnostic Analytics and seeks to understand why the problem. It focuses on Root Cause Analysis (RCA), which is a systematic approach used to identify the underlying factors or causes contributing to a problem or undesired outcome. The goal of RCA is not merely to address symptoms but to dig deep and uncover the fundamental reasons behind the issue. By addressing the root causes, organizations can implement effective corrective actions to prevent the problem from recurring. Identifying and eliminating root causes can lead to streamlined processes, reduced waste, and improved efficiencies. By tackling underlying issues, organizations can enhance product or service quality, leading to increased customer satisfaction (Cox, Gaudard, & Stephens, 2016).

The Pareto Method, also known as a "drill down" Pareto in the Analyze Phase, is a technique used to prioritize efforts by focusing on the most significant factors contributing to a problem. In the context of RCA, the Pareto Method helps identify the vital few causes that have the most substantial impact on the issue at hand and helps process improvement teams concentrate their efforts on the most critical factors driving the problem. RCA with a Pareto allows organizations to allocate resources effectively by prioritizing actions based on their impact and provides a clear and visual representation of the problem's key contributors, aiding in decision-making processes (Cox, Gaudard, & Stephens, 2016). Please find instructions on how to create a Pareto Chart in Tableau here.

Use the following data to create an Analyze, or a "drill down" Pareto to visualize the key reasons for the late shipments:

Why Late Packing Reasons (Root Cause Pareto)	Number for Late Packing (Root Cause Pareto)
Order not placed for material to pack	357
Lost order	75
Poor quality of packing caused reject by FEDEX	50
Untrained People	30
Receiving lost paperwork	20

Table 3. Data showing why there was no packing equipment

6. IMPROVE PHASE

The Improve phase is the fourth step in the DMAIC process and focuses on implementing solutions to address the root causes identified during the Analyze phase. This phase is all about testing and refining potential solutions to achieve the desired improvements in process performance by generating potential solutions to address the root causes and test them to determine their effectiveness. Once tested the solutions can be validated with controlled

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experiments. Commonly used tools for the Improve Phase are Design of Experiments, Regression Analysis and simulations (Cox, Gaudard, & Stephens, 2016).

A simple form of experimentation and simulation can be found in Scatter Plots, and the use of simple regression. A scatter plot is a graphical representation of data points in a two-dimensional coordinate system. It is commonly used to display the relationship between two variables and to identify any patterns or trends in the data.

In a scatter plot, each data point is represented by a dot, with one variable plotted along the horizontal axis (x-axis) and the other variable plotted along the vertical axis (y-axis). The position of each dot on the plot corresponds to the values of the two variables for that data point (Richarson & Watson, 2024).

Hours to pack (Dependent)	Boxes Available (Independent)	Staff to pack (Independent)
3	13	3
3	12	3
4	10	2
4	11	2
5	8	1
5	8	1
6	2	1
5	8	1
5	8	1
4	10	2
4	10	2
3	12	3

Table 4. Data showing dependent variable, hours to pack and independent variables, staff and boxes.

In the fuel pump case, data has been collected as to buying more boxes to speed up packaging or hiring more staff. The program manager has asked you to evaluate both these options from a business perspective and as to the R2, or coefficient of determination (Richardson & Watson, 2024). Please find instructions on how to create a Scatter Plot in Tableau here.

Use the following data to create two scatter plots and evaluate which one is the best business solution:

7. CONTROL PHASE

The 'Control' phase is the last phase of the Six Sigma DMAIC model. The focus of this phase is to ensure that all the items that were created and the gains that were obtained in the 'Improve' phase of the DMAIC cycle are maintained long after the project has ended. Before this phase begins, one has a clear idea of the process and where it needs improvements using the Define phase. The data are collected in the 'Measure' phase and assessed to determine the root causes in the 'Analyze' phase. Also, a viable solution is obtained in the 'Improve' phase. The 'Control' phase is the conclusion of the team's journey and of the DMAIC cycle. This phase is not so data intensive, being more focused on information, in comparison to the previous phases of the DMAIC cycle but holds great importance in project completion (Cox, Gaudard, & Stephens, 2016). The activities in the Control phase are as follows:

- Establishing Statistical Process Control (SPC) and other controls.
- Maintaining control.
- Sustaining improvements.

In Six Sigma methodology, the Control Phase is the final phase of the DMAIC process. Its primary objective is to ensure that the improvements made during the Improve phase are sustained over time. The Control Phase involves implementing monitoring and control mechanisms to prevent the recurrence of defects or issues and to continuously improve the process.

For this case study the program manager has provided additional requests. She would like you to create a Gantt Chart for the proposed improvement process using Tableau. A Gantt chart is a visual project management tool that maps out a project's timeline and serves as a high-level schedule control tool. Tasks are listed on the left, dates run across the top, and each task is represented by a horizontal bar that spans from its start date to its end date. The length of the bar shows how long the task will take (Cox, Gaudard, & Stephens, 2016). Please find instructions on how to create a Gantt Chart in Tableau here.

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Please use this data to create a Gantt Chart:

PHASE	Task Name	STATUS	ASSIGNED TO	START DATE	END DATE	DURATION in days
Define	Agree on objectives	Complete	Anna	1/1/24	1/2/24	2
Define	Research	Complete	Kate	1/2/24	1/23/24	22
Define	Requirements	Complete	Karl	1/2/24	1/11/24	10
Define	Projections	Complete	Karl	1/9/24	1/20/24	12
Define	Stakeholders	Complete	Kate	1/2/24	1/29/24	28
Define	Guidelines	In Progress	Anna	1/19/24	2/1/24	14
Define	Project Kick-Off	In Progress	Anna	1/22/24	1/23/24	2
Measure	Scope of Logistics	In Progress	Karl	1/28/24	2/6/24	10
Measure	Shipment Data	In Progress	Anna	1/26/24	2/2/24	8
Analyze	Pareto	In Progress	Karl	1/31/24	2/10/24	11
Improve	Regression	In Progress	Meg	2/4/24	2/9/24	6
Improve	Solution Selection	In Progress	Sam	2/6/24	2/12/24	7
Control	Gantt Chart	In Progress	Karl	1/9/24	2/21/24	44

Table 5. Tasks, Owners and Durations for Improvement Project

8. EARNED VALUE MANAGEMENT SYSTEM

The company uses Earned Value Management (EVM) to track and control project status. The program manager has provided some data show would like to visualize in the form of Line Charts. Earned Value Management is a project management technique that integrates scope, schedule, and cost performance (Fleming & Koppelman, 2016). It provides a comprehensive and objective way to track project progress and performance by comparing planned work against actual work accomplished.

Planned Value (PV), also known as Budgeted Cost of Work Scheduled (BCWS), represents the authorized budget assigned to scheduled work to be accomplished by a specific point in time. PV is typically established at the task level and aggregates to the project level to show the planned cost over time.

Earned Value (EV), also known as Budgeted Cost of Work Performed (BCWP), represents the value of the work actually performed up to a specific point in time. EV is determined by assessing the progress of completed tasks according to predefined criteria, typically measured in terms of completed deliverables or milestones.

Actual Cost (AC), also known as Actual Cost of Work Performed (ACWP), represents the total cost incurred to complete the work up to a specific point in time. AC includes all direct and indirect costs associated with the project, such as labor, materials, equipment, and overhead expenses.

When these numbers are compared project status can be assessed. Using a Cost Variance (CV), CV=EV-AC. If at any point in time CV is negative, at that point in time the project is over budget. Schedule Variance (SV) is calculated as SV=EV-PV. If SV is negative at any point in time the project is behind schedule at that point in time (Fleming & Koppelman, 2016).

Using the following data to create a labelled 3-line chart, with running totals on a single Tableau worksheet so the program manager can calculate CV and SV:

START DATE	Budget Value (PV)	Actual Expenditure (AC)	Work Completed (EV)
1/1/24	300	250	300
1/2/24	13200	15000	13200
1/2/24	6000	5700	6000
1/9/24	7000	7200	7000
1/2/24	8000	8600	8000
1/19/24	7500	3600	4200
1/22/24	1000	1200	500
1/28/24	6000	4500	3000
1/26/24	5000	4000	4100
1/31/24	7000	6000	5300
2/4/24	4000	3000	3600
2/6/24	4000	4000	4000
1/9/24	5000	3000	2500

Table 6. Earned Value Management Numbers

9. CASE REPORTS

Using the visualizations, create a Tableau Dashboard and Storyboard presentation, including the Gantt Chart and the Earned Value charts. In a separate Word document, single spaced, take the reader through the stages of DMAIC describing the problem, defining trends with a line chart, describing measure with a Pareto, diagnosing causes with a second Pareto, and then the improvement results from the simple regression experiments. Provide a recommendation to the Program Manager.

10. REFERENCES

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