Data Analytics Capstone Project

Capstone Project Name: Tool Failure Analysis and Capacity Planning for Test Work Center

Project Topic: Tool Failure Analysis and Capacity Planning for Test Work Center

- [x] **This project does not involve human subjects research and is exempt from WGU IRB review.**

Research Question: To what extent does demand and parts-per-tool usage affect tooling (or equipment) failure?

Hypothesis: Demand and parts-per-tool usage statistically significantly affect tooling (or equipment) failure.

Context:

In a test work center, efficient predictive tool usage, optimal reorder point management, and effective capacity planning are essential for minimizing downtime, controlling costs, and optimizing resource allocation. Traditionally, these tasks rely heavily on manual approaches and tribal knowledge, often leading to suboptimal outcomes such as unexpected equipment failures and inefficient inventory management. Implementing a data-driven approach through advanced analytics and visualization tools like Tableau can revolutionize these processes, providing substantial benefits across various operational aspects. By leveraging historical data and machine learning algorithms, models can forecast tooling failures before they occur. This proactive approach not only reduces unplanned downtime but also extends the lifespan of test tools by enabling timely interventions and maintenance. Consequently, organizations benefit from enhanced reliability, reduced repair costs, and improved operational continuity. Optimizing reorder points for inventory management is another area where data analysis plays a pivotal role. By analyzing usage patterns, lead times, and failure predictions, organizations can determine the optimal inventory levels needed to meet demand while minimizing the risk of stockouts or overstocking. This precision in inventory management leads to reduced holding costs, improved cash flow utilization, and a more streamlined procurement process. Visualizing demand and capacity constraints through interactive tools like Tableau empowers planners to make informed decisions, ensuring optimal resource utilization and operational efficiency. The integration of these functionalities into a comprehensive system, supported by an interactive Tableau dashboard, amplifies the benefits of data analysis. A dashboard provides a centralized platform for visualizing key metrics, exploring data trends, and simulating different scenarios. Its interactive features, such as sliders and filters, enable users to perform detailed analyses and facilitate collaborative decision-making across teams. In conclusion, the adoption of data analytics and visualization tools in test work centers not only enhances operational efficiency and reduces costs but also strengthens decision-making capabilities. By transforming raw data into actionable insights, organizations can proactively manage maintenance schedules, optimize inventory levels, and allocate resources effectively. This strategic use of data not only mitigates operational risks but also positions organizations to achieve sustainable growth and competitiveness in their respective industries.

Data:

To effectively address my project’s objectives, I will need relevant data that can provide insights into tooling (or equipment) performance, inventory levels, and operational demands.

The key types of data I will consider collecting or finding in a dataset include:

1. Equipment usage and performance metrics: Data on tooling (or equipment) usage patterns, such as runtime hours, operational cycles, and performance metrics such as temperature readings or vibration levels. This will help to identify patterns that may indicate potential failures and optimizing maintenance schedules based on actual usage.

2. Inventory and Supply Chain data: Information on inventory levels of test tools, spare parts, and materials, along with procurement and lead time data. This will be essential for optimizing reorder points, ensuring adequate stock levels without excessive holding costs or stockouts.
3. Capacity and Demand data: Data on demand, production schedules, and resource allocation metrics (e.g., machine utilization rates, staffing levels). This will facilitate effective capacity planning by aligning resource availability with anticipated demand fluctuations.

To find suitable datasets for my project, I plan to search platforms like Kaggle or UCI Machine Learning Repository for datasets that include a combination of the data mentioned above. By collecting comprehensive and relevant datasets, I can effectively leverage data analytics to develop robust models, optimize operational processes, and enhance decision-making in the test work center.

Data Gathering:

To gather the necessary data, I plan to follow a structured methodology that ensures I capture relevant information efficiently.

Here is the step-by-step outline of the data-gathering methodology:

1. Identify data sources: Start by exploring platforms like Kaggle, UCI Machine Learning Repository and other publicly available databases. Look for datasets that include maintenance logs, equipment metrics, inventory data, and capacity planning information.
2. Data Requirements: Ensure the data collected is comprehensive, covering historical records, and metadata that describes the context of each dataset.
3. Data Extraction: Manually extract and download data from sources like online websites such as Kaggle and utilize spreadsheets and/or CSV files.
4. Potential Data Creation: If datasets containing demand, inventory levels, and lead time data are not available to integrate with equipment data, I will create a randomized dataset. This dataset will be designed to simulate realistic scenarios and will be used to augment the equipment data.
5. Data Integration & Preparation: Integrate collected data from various sources into a unified dataset suitable for analysis. Merge datasets as needed to create a comprehensive dataset that covers all required variables. Prepare data for analysis by cleaning, transforming, and structuring it according to the analytical requirements of the project.
6. Continuous Monitoring and Iteration: Monitor data quality throughout the project lifecycle and iterate data collection methods as needed to address challenges or changes in project requirements. Maintain flexibility to incorporate new data sources or refine data collection processes based on ongoing analysis.

Data Analytics Tools and Techniques:

A variety of data-analysis techniques will be required to address predictive tool usage, reorder point optimization, and capacity planning. Each aspect of the project may require different methods and tools. Regression models like linear regression can predict the time until the next failure based on historical data. To determine optimal reorder points that minimize stockouts and holding costs, I can employ safety stock calculations, which will determine the appropriate level of safety stock based on demand variability and lead time. Lastly, I intend to design an interactive Tableau dashboard that includes visualizations for predictive maintenance and reorder points based on demand. This dashboard will visualize key metrics and insights, and will include interactive features such as sliders, filters, and drill downs to allow users to explore data dynamically. By employing these data-analysis techniques, I can effectively analyze the data, providing valuable insights and enabling data-driven decision-making.

Justification of Tools/Techniques:

The data-analysis techniques chosen are appropriate due to their ability to handle the specific types of data and address the unique requirements of each aspect of the project. Machine learning models, such as regression analysis are adept at identifying complex patterns and relationships within large datasets. This is crucial for predicting equipment failures, which often depend on multiple factors. These models can be trained on historical maintenance logs, sensor data, and performance metrics, allowing them to learn from past equipment behavior and make accurate predictions about future failures. By predicting failures before they occur, machine learning models enable proactive maintenance, reducing unplanned downtime and maintenance costs. Techniques like safety stock calculations are designed to balance the trade-off between holding costs and stockout costs. This optimization is essential for effective inventory management. These calculations use historical demand data and lead time variability to determine optimal reorder points, ensuring inventory levels are aligned with actual usage patterns. Moreover, Tableau is a powerful data visualization tool that allows for the creation of interactive and intuitive dashboards. This makes it easier for planners to understand complex data and insights at a glance. Tableau can integrate with multiple data sources and update visualizations in real-time, providing up-to-date information for decision-making. Interactive features like sliders, filters, and drill downs enable users to explore data dynamically, facilitating deeper analysis and better decision-making.

Project Outcomes:

1. Predictive Tool Failure Model: Development of a model that accurately forecasts equipment failures based on historical data. This machine learning model will be trained and validated on the historical maintenance data. Additionally, a performance report of the model performance metrics, including accuracy, precision, recall, and F1 score will be included. I will also assess the model's performance based on a low Root Mean Squared Error (RMSE) to ensure its accuracy and reliability.
2. Reorder Point Optimization system: Implementation of an inventory optimization system that determines optimal reorder points to minimize stockouts and holding costs. A brief report outlining the optimal reorder points and the expected impact on inventory costs and service levels will also be included.
3. Interactive Tableau Dashboard: Development of an interactive Tableau dashboard that visualizes key metrics related to predictive tool failure, inventory management, and capacity planning, enhancing decision-making for test work center planners. A well-designed Tableau dashboard that includes visualizations such as line and bar charts, and interactive elements like sliders and filters. Integration of data from various sources into the Tableau dashboard, ensuring seamless updates. Furthermore, adding a comprehensive guide for using the dashboard, including instructions for interacting with the visualizations and interpreting the insights will be provided.
4. Comprehensive Project Report: A comprehensive report documenting the entire project process, methodologies employed, findings, and recommendations will be provided. This report will encompass an overview of the project objectives, research question, and significance. It will include a detailed explanation of the data collection process, data analysis techniques, and models utilized. Key findings from the tool failure model, reorder point optimization, and capacity planning analysis will be presented. Additionally, practical recommendations for implementing the findings to enhance operational efficiency and reduce costs will be provided. Finally, the report will conclude with a summary of the project outcomes and their potential impact on work center operations. This structured approach ensures that all critical aspects of the project are thoroughly covered, providing clear insights and actionable recommendations.
5. Presentation: A professional presentation summarizing the project's objectives, methodologies, key findings, and recommendations, aimed at stakeholders and decision-makers.

By achieving these anticipated outcomes and deliverables, the project will provide valuable insights and tools to enhance the operational efficiency and decision-making capabilities of the test work center.

Sources: There were no sources used for this write-up. Data sources have not yet been finalized for the project.

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