Needs Assessment to Improve Torque Accuracy in Aerospace Manufacturing: A Case Study

The Organization:
Spacely Sprockets (a pseudonym) specializes in the manufacture of aerospace products. The mission of Spacely Sprockets is “client success”, which drives the expectation that every product must work the first time, every time. Spacely Sprockets relies on accurate application of torque when tightening mechanical fasteners during the manufacturing process. Torque is a twisting force; too little or too much torque applied in the manufacturing process can lead to unreliable and unsafe products and failure to meet its mission.

Background:
In the 1st quarter of 2013, a lead calibration technician observed inaccuracies in performance of a majority of the employees using various torque tools. One of the actions in response to the observation was an implementation of a revised torque certification training for all individuals who use a torque tool in 2013, with mandatory recertification every 24 months.

Opportunity:
Recertification training began in 2015 and included a pre-training evaluation of torque applied with 5 common types of torque tools. Individuals were required to use all five tools on a torque analyzer; a device that measures the actual amount of torque applied.

Initial torque certification trainees demonstrated proficiency (within 5% of the applicable torque value) with all the five torque tools. Data obtained during the recertification pre-training evaluation indicated that the trainees demonstrated proficiency with an average of only 3 out of 5 tools. All trainees were required to pass the recertification post-training evaluation on the analyzer to receive recertification.

Rationale:
In the fall of 2015, Team Accuracy that comprised of a group of graduate students at Boise State University conducted a Needs Assessment for Spacely Sprockets to determine the factors contributing to the observed decline in torque accuracy and recommend interventions to close the performance gap. Team Accuracy identified the performance gap using the pre-training evaluation data as follows:

- **The current level of performance**: Individuals demonstrate proficiency in applying torque (within 5% of the applicable torque value) with an average of only **3** out of **5** torque tools (**60%**) on the recertification pre-training evaluation.
- **The optimal level of performance**: Individuals are required to demonstrate proficiency in applying torque (within 5% of the applicable torque value) with all the **5** torque tools (**100%**) on the recertification pre-training evaluation.

Optimal performance will enable Spacely Sprockets to achieve its **mission** of “*client success”* and **vision** of “*making the world a safer place”*.

Objectives:
The objectives of needs assessment were as follows:
- Identify the potential causes of the existing performance gap at the operational, tactical, and strategic levels (Watkins et al, 2012, p. 39-40), using systematic and systemic methods, and tools for data collection and analysis.
- Develop recommendations for performance improvement interventions to address the root causes and close the performance gap.
- Prioritize the recommended performance improvement interventions to meet the immediate needs of the client organization.
- Identify areas that lie beyond the scope of the project for further investigation and assessment by the client for continued performance improvement.

Application:
Team Accuracy planned a systematic needs assessment, in which each stage of data collection and analysis provided an input for the next stage (Rossett, 2009, p. 42). The team decided to apply two frameworks; Gilbert's Behavior Engineering Model (BEM) and Langdon's Language of Work (LOW) Model, to design data collection instruments and analyze the data collected at each stage.

Gilbert's BEM provided an accessible and systematic framework for examining the factors related not only to the individual qualities (repertory of behavior) such as knowledge, capacity, and motives of the Spacely employees, but also the environmental supports in which the work is done such as data, instruments, and incentives (Gilbert, 2007, p. 87).

Langdon's Language of Work model laid out fundamental elements of performance (Langdon, 2000, p. 15):

- **The *Proforma*** (Input, Conditions, Process Element, Outputs, Consequences, and Feedback)
- ***The Layers*** (Behavior, Standards, Support, and Human Consonance) and
- ***The Levels*** (Business Unit, Core Processes, Individuals, and Work Groups)

Performance is a factor of alignment between all of the elements.

Gathering data related to the performance gap:
Team Accuracy used a multi-stage process of data collection as shown below.

Stage 1: A review of existing training data and open-ended interviews conducted to gather insights on a broad range of factors, without closing off unexpected directions. The participants interviewed were:

- The Training instructor
- Manufacturing engineers
- Manufacturing technicians
- The Supervisor

Stage 2: A performance observation of technicians, which included posing structured follow-up questions, based on the stage 1-interview responses.

Stage 3: A detailed 23-question survey administered to individuals returning to torque recertification training. The questions on the survey sought to confirm the trends identified during the previous two stages and pursue new issues that emerged in the earlier stages.

We uncovered new aspects at each stage from the data collected. For example, the interviews consistently pointed to the newly introduced daily torque verification process. Similarly, the performance observation uncovered a number of factors in the physical environment affecting torque accuracy. We explored these emerging factors in detail with a series of questions on the stage 3 survey.

Data Analysis:
Team Accuracy applied the following techniques to analyze data collected during all the three stages:

- Coded the data obtained during open-ended interviews using a codebook based on Gilbert's BEM and Langdon's LOW Model, to convert interview and observation data into usable qualitative data
- Conducted preliminary analysis between stages to guide the design of the next stage
- Compiled and analyzed quantitative data from survey responses
- Triangulated the responses from all stages to identify the probable root causes
- Visually organized the coded data of both the BEM (Figure 1) and LOW (Figure 2) to identify trends and potential root causes

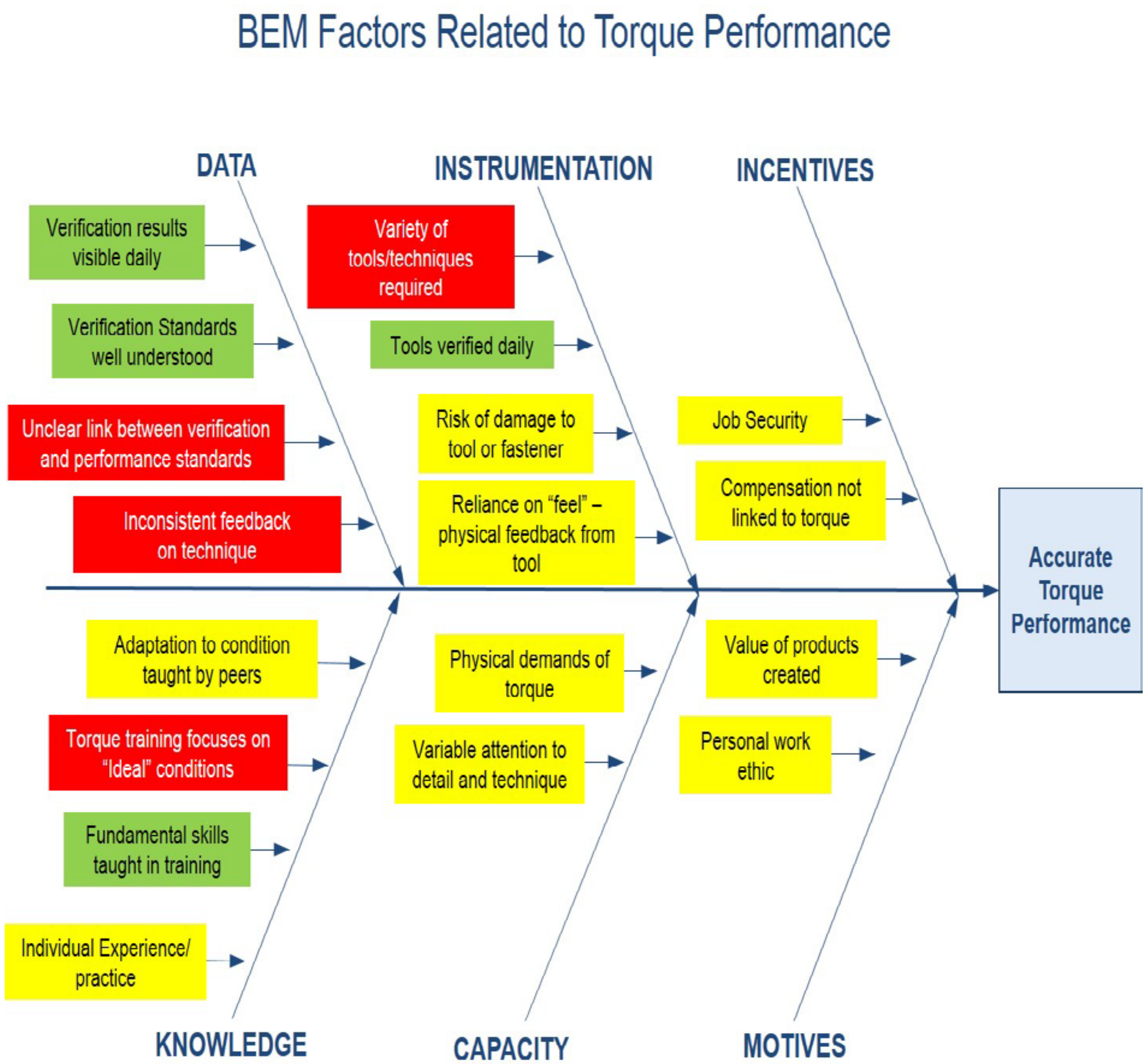

Figure 1. Fishbone diagram Demonstrating data trends in the BEM framework

Figure 1 illustrates data analysis using Gilbert's BEM related to the various factors affecting performance.

- **Green**: Well-aligned factors that contributed to effective performance.
- **Yellow**: Factors that did not provide a clear link to the performance gap, due to either mixed behaviors or lack of sufficient data that informed our recommendations for further study.
- **Red**: These misaligned factors assisted us to identify the root causes by linking directly to the performance gap identified.

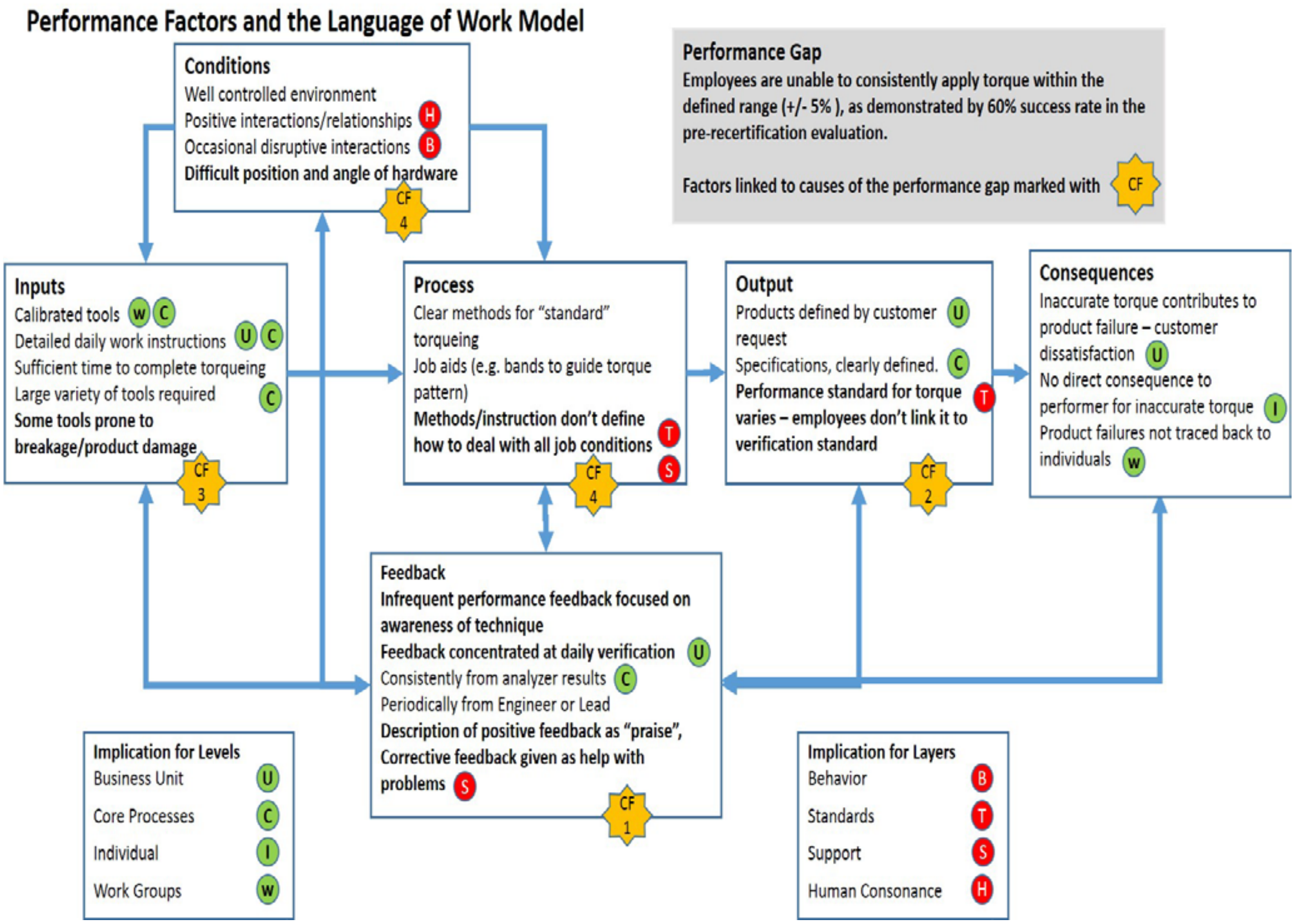

Figure 2. The Proforma of Langdon's LOW model with linkages to Levels and Layers

Figure 2 illustrates data analysis using Langdon's LOW model. Our observations of the ***proforma*** are in a flowchart form. Observations linked to the causal factors are in bold text and tagged to the four potential causal factors of the performance gap. Factors linked to the ***layers*** and ***levels*** of performance are round in shape, along with an indicator for the specific layer or level, to capture the systemic nature of the LOW model.

The LOW model shows the concentration of data related to **feedback** (CF1) which occupies a central position in the proforma. It also clearly calls out the lack of clarity of the **performance standard** (CF2), **challenges with tools** (CF3) and **gaps** between **work conditions** and **training** (CF4).

Results:
The team identified four **potential root causes** as an outcome of data analysis.

Primary Cause:

- Performance feedback on tool holding position is insufficient to maintain torque accuracy

Contributing Cause:

- Unclear/Mixed Standards for torque performance
- Variety/Performance of Tools
- Variable performance conditions are not reflected in training or verification

Each cause was broken down into sub-factors for identifying possible interventions to address the performance gaps.

Recommendations of Performance Improvement Interventions:
The team considered a number of performance improvement interventions to eliminate the potential root causes. We then conducted a Multi-Criteria analysis (Watkins et al, 2012, p. 171) to prioritize the following recommendations of interventions to meet the immediate needs of our client:

- **Improve performance feedback**: Develop guidelines for performance feedback at the operational level, including key points of technique that Manufacturing Engineers and Working Leads should reinforce. Consistent augmented feedback on accurate torque technique will further improve performance.
- **Communication for reinforcement**: Provide communication to all employees to reinforce the relationship between proper technique, feedback from the tool, and accurate torqueing. Many survey respondents indicated that sensory feedback is their primary guide for torque. However, incorrect technique skews the sensory feedback.
- **Monitor daily torque verification data**: Monitor the daily verification data of torque operators to gauge the improvement in torque accuracy **at the operational level**, and provide a consistent way to measure the effectiveness of interventions.

We concluded that the above listed interventions would work effectively in a complementary manner than as separate interventions (Watkins et al, 2012, p. 176).

Recommendations for Further Assessment:
We recommended a number of interventions that were beyond the scope of the project, but warranted further investigation by Spacely Sprockets, as listed below.

- Establish a clear performance standard for torque performance
- Investigate the reasons why many individuals believed that the click from a click-type torque tool is associated with accuracy
- Compare product test results to implementation of torque verification, to establish a relationship between torque verification and product failure.
- Investigate the potential positive impact of torque controllers to reduce tool related challenges

Challenges and Lessons Learned:
Financial and performance data was inaccessible to the team due to issues of confidentiality and strategic sensitivity. However, we recommended performance improvement interventions to add value using available access to data and informants.

Organizational value:
The client began monitoring daily torque verification data since 2016, along with verifying torque tool calibration tolerance, operator technique, and accuracy of applicable torque.

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