Using TQM to Implement Sustainability in Supply Chain Management

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The BRC Academy Journal of Business 6, no. 1 (2016): 31–55.

http://dx.doi.org/10.15239/j.brcacadjb.2016.06.01.ja02

Web Appendix

DOI: http://dx.doi.org/10.15239/j.brcacadjb.2016.06.02.wa02

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Table 1. Quality Gurus: Their Philosophy & Relationships/Implications for Sustainability

Quality Guru	Quality Philosophy	Relationship & Implications to Sustainability
W. Edwards Deming (Deming; 1986)	Top Management responsibility for good systems. Employee cannot produce quality that exceeds what the process is capable of. 14 Points developed TQM quality System and continuous improvement culture. Promoted Plan-Do-Check-Act cycle	Top management responsible for implementing sustainability. Employee training. Processes and system to support sustainability. Sustainable processes and culture. Continuous improvement philosophy beneficial to sustainability implementation.
Joseph Juran (Evans & Lindsay, 2002)	Top management commitment, support and involvement in quality. Financial trilogy relating economic performance to quality planning, quality control, and quality improvement. Team work.	Top management responsible for implementing sustainability. Willard's (2012) demonstrated a positive relationship with sustainability. Sroufe & Melnyk (2013) demonstrate the positive implications of Juran's philosophy in sustainability. Team work.
Philip Crosby (Crosby, 1979)	Quality must be led by top management. In trade-off between cost of poor quality and cost of quality, cost of poor quality is understated. Zero defects. 14 Points developed quality system for Western societies.	Top management responsible for implementing sustainability. Need for COQ and performance measures to capture sustainability efforts. Need for system that encourages sustainable efforts and reduces the 'trade-off' mentality. Culture must address different global cultural perspectives.
Armand Feigenbaum (Feigenbaum, 1956)	Steps to Quality improvement. Quality is a field that integrates processes.	Continuous sustainability improvement Sustainability needs to be addressed from a systems and process perspective.

	Foundations for cross-functional teamwork.	Sustainability improvements need to be addressed through cross-functional teams.
Genichi Taguchi (Evans & Lindsay, 2002)	Quality robustness, quality loss function and target-oriented quality.	Address sustainability scope. Specific sustainability metrics and targets.

Table 2. TQM Approaches and Sustainability

Quality Approach	Description (APICS, 2010 * except as noted)	Relationship to Sustainability
Benchmarking	Selecting a demonstrated standard of performance that represents the very best performance for a process or an activity (Heizer & Render, 2014).* Comparing a company's costs, products, and services to that of a company thought to have superior performance.	Assess and monitor sustainability performance (Sroufe & Melnyk, 2013). A comparative analysis (Fargnoli & DeMinicis, 2014). SCOR framework can assist in enviornmental benchmarking (Sroufe & Melnyk, 2013).
Continuous Improvement	The act of making incremental, regular improvements and upgrades to a process or product in the search for excellence.	Focus sustainability on process-thinking and root causes, correcting the problems, perpetual improvement, problem identification, and then take action to bring about positive results (Sroufe & Melnyk, 2013).
Employee Empowerment	The practice of giving non-management employees the responsibility and the power to make decisions regarding their jobs or tasks.	Treat employees as value-added assets (Fish, 2015; Ozcelik & AvciOzturk, 2014). A workforce, committed to continuous improvements and innovation, can assist in attaining sustainability goals (Wu & Pagell, 2011). Training employees in sustainability provides a competitive advantage (Allen et al., 2012; Delai & Takahashi, 2013).
Six Sigma Quality	Concepts and practices that focus on reducing variability in processes and reducing deficiencies in the product. A business process that positively impacts upon bottom-line business performance, creating and monitoring processes to reduce waste and resource requirements	Focus on customer requirements for sustainability using data-driven decision making, risk assessment, critical inputs, processes and outputs (McCarty et al., 2011).

	while increasing customer satisfaction.	
DMAIC	Acronym for Define-Measure-Analyze-Improve-Control	Six Sigma Quality can be used to implement sustainability (Sroufe & Melnyk, 2013).
DMADV (variation of DMAIC to address sustainability)	Acronym for Define, Measure, Analyze, Design and Verify	Variation of DMAIC to address sustainability implementation (McCarty et al, 2011)
Just-In-Time	A philosophy of manufacturing based on planned elimination of all waste and on continuous improvement of productivity. It includes all manufacturing activities from design to delivery to produce a final product.	Sustainability efforts should focus on products, processes and packing (Sroufe & Melnyk, 2013). Consider waste as a symptom, link waste to processes, and relate sustainability to economic efforts.

Table 3. TQM Tools & Examples of Sustainability Use.

TQM Tool	Description	Example of Tool Use for Sustainability
Affinity Analysis	Employees generate in an unbiased way ideas that are later categorized. Typically form the input into the House of Quality.	A financial services company interested in evaluating its building asset used an affinity analysis to identify several factors that influenced whether a building would be a good candidate for re-commissioning (McCarty et al., 2011).
Brainstorming	Technique that encourages every individual to participate and generate ideas in an unbiased manner. Encourages creativity and numerous ideas.	Jones Lang LaSalle used brainstorming to develop factors that affected the energy demand and cost at the data centers (McCarty et al., 2011).
Cause & Effect analysis	A diagram that illustrates the main causes and sub-causes leading to an effect (symptom).	Jones Lang LaSalle used the brainstormed results to analyze the causes and effects associated with energy demands (McCarty et al., 2011).
Check Sheets	Identify frequency and location of problems as a data-recording device.	
Histogram	A graph of contiguous vertical bars representing a frequency distribution which can be used to uncover patterns in data to direct problem-solving (useful in Pareto analysis).	
House of Quality (HoQ)	A structured process that relates customer-defined attributes (may be gathered through brainstorming and	A financial services company interested in evaluating its building asset used a HoF to capture information that linked

	presented through an Affinity analysis) that transforms customer requirements into product design requirements. Part of QFD process.	critical categories to ratings (McCarty et al., 2011). HoQ (along with analytic network and zero-one goal programming) to determine design requirements in SSCM (Buyukozkan & Berkol, 2011). Improve sustainability for Norwegian fishing fleet (Utne, 2009). Used in a garden trimmer redesign (Fargnoli & DeMinicis, 2014).
Pareto Chart ('80-20 rule')	A graphical tool for ranking causes from most to least significant, and as a result, assists in identifying most critical causes of observed problems.	A financial services company interested in evaluating its building asset used Pareto principle to demonstrate the highest opportunities for cost savings (McCarty et al., 2011).
Plan-Do-Check- Act Cycle (Deming or Shewhart Circle)	A four-step process for continuous quality improvement – plan (identify problem and plan to address the gap), check (plan is carried out), check (observe and verify plan works) and act (study results and act to standardize throughout). Then repeat the process.	
Process Capability Analysis	A procedure to estimate the parameters defining a process.	
Process Control Charts	A graphic comparison of process performance data with predetermined control limits. Its primary use is to detect assignable causes of variation.	
Process Flow Analysis	A procedure to evaluate the effectiveness of a sequence of business activities with a focus on value-added elements and elimination of non-value added activities.	Review steps to use process flow analysis to implement sustainability (Sroufe & Melnyk, 2013).
Quality at the Source	A producer's responsibility is to provide 100% acceptable quality material to the consumer. Seeks problem prevention.	
Quality Function	A method to ensure that the customer's requirements are	

Deployment (QFD) Quality and Environment Function Deployment (QEFD) Green Quality Function Deployment (G-QFD)	identified and met or exceeded through the resulting product and process design. QFD tries to eliminate the gap between what the customers wants and what the product is capable of delivering.	QFD method that includes environmental concerns and the Voice of the Customer (Ernzer & Birkhofer, 2002) Based upon QFD approach, simultaneously develops Houses of Quality whereby each house focuses on different aspects of the product (Bovea & Wang, 2007)
Scatter Diagrams	A graphical technique to analyze the relationship between two variables.	
Value Stream Mapping	Used to analyze the flow of material and information to bring a product to a customer through assessing the extent to which the current process adds value and identify opportunities to reduce lead time and costs and attain sustainability levels.	Timberland conducted to Timberland used value stream mapping to evaluate emissions and work towards reduction (Sroufe & Melynk, 2013).