

# Developments In Business Simulation & Experiential Exercises, Volume 19, 1992

## IMPLEMENTING TOTAL QUALITY MANAGEMENT IN A COMPUTERIZED BUSINESS SIMULATION

Richard D. Teach  
Georgia Institute of Technology

### ABSTRACT

This paper describes an incomplete process. It deals with the beginnings of the development of a business simulation that includes a quality control feature.

### WHAT IS QUALITY MANAGEMENT

“Total quality management is a strategic, integrated management system for achieving customer satisfaction. It involves all managers and employees and uses quantitative methods to continuously improve an organization’s processes’. Quality leaders manage their organization by using statistical data rather than ‘gut feeling2.”

All too often, gamers insist that students run their simulations doing little or no extensive statistical analysis. Much of the current vernacular seems to conclude that “gut feeling’ provides the way to operate a firm. The popularity of book titles such as ‘The One Minute Manager’ seems to emphasize this point. Doing statistical analysis in games is frequently frowned upon by many game administrators because it takes too much time. In addition, the participants frequently have only rudimentary knowledge of statistics. Thus, all too frequently, business simulations are designed with very simplistic algorithms. Demand curves with constant elasticities are common. Products are frequently assumed to be totally interchangeable with the only differences being in the amount of funds expended on advertising, the number in the sales force, the product prices and sometimes the amount spent on R&D.

Games need to have more complex demand as well as production functions. It should not be difficult to include some or all of the following in a game:

- Quality control
- Customer focus
- Long term strategic planning
- Measurement and analysis of products and processes

### INTRODUCING QUALITY CONTROL

Most current total enterprise games, even relatively complex ones, simulate simple production operations. The *Business Management Laboratory* (1980) has only a two-stage production process which utilizes Two raw materials and manufacturers two products without goods-in-process” inventories.

Designing a game with a production process that generates output units with flaws based on 1) random occurrences and/or 2) processes that gets out of control need not be difficult but would defiantly change the current methods.

Let’s examine how this might be done. The Gold (1991) production function defined a simple economic relationship where:  $Q = f(L,M)$ ; that is, where the quantity produced was a function of the inputs of labor and materials. The Total Variable Cost function was established as:

$$TVC = k \cdot (pl)^c 1 \cdot (pm)^c 2 \cdot (Q)^{c3 + c4 Q}$$

Where:

- TVC = Total Variable Cost
- pl = per unit price of labor input
- pm = per unit cost of materials input
- Q = product quality
- c<sub>i</sub> = parameters
- k = a scalar constant

‘The cost of product quality in this algorithm has excellent characteristics as the model allows for controlling the marginal cost elasticities by altering the parameters c<sub>3</sub> & c<sub>4</sub>

### Actual Quality vs. Desired Quality

While this function provides for product quality it does not include a quality control feature. The Gold model has explicitly included a desired product quality “Q’. However, as in most business games, the production output matches whatever has been requested. In simulations, quality control never screws up while, in reality, errors often occur. It simply assumes the desired quality is, in fact, produced.

### Comparative statics vs. dynamics in simulations

Virtually all business simulations are periodic in nature. That is, decisions are made for one period, usually a month, a quarter, or even sometimes a year and no changes can be made during this time period After the decisions for all teams are made and turned in to the simulation administrator, the game is run, the results are calculated and revealed to the participants as a set of Balance Sheets, Income Statements and Operating and Sales Reports. By comparing two consecutive statements, the participants deduce how well the firm is being managed and what corrective measures must be made in the next set of decisions. Little or no information is available as to what transpired during the period.

In order to bring quality control into simulations, the process must revert to something similar to a flow or continuous process, not comparative statistics. Even if the games remain periodic, data needs to be provided as to what is taking place over the period of time being simulated. The data needs to represent the dynamics of the process, not just the end results.

### A Suggested Change

In most business games, the decisions are made and then entered. One period is simulated, results are calculated and produced, and then simulated time stops to await the next set of decisions. Simulations are usually designed to perform calculations as follows:

- 1.) the decisions are made and entered,
- 2.) the purchases and inventories of raw materials are calculated,
- 3.) the manufacturing process is simulated,
- 4.) finished goods available for sale are determined,
- 5.) demand is simulated,
- 6.) sales, stock-outs and/or excess ending inventory is determined,
- 7.) the income streams are determined ... and then,
- 8.) the financial reports are produced.

This method portends to simulate the business for an accounting period, but does it? If one is only concerned with financial outcomes and not about the processes themselves, this periodic-type simulation seems to work well enough. But the Total Quality Management concept emphasizes continuous monitoring and statistical sampling and measurement to maintain quality. If business games are to encompass the TQM process, business game designers need to recognize that a business is more than a set of quarterly or annual financial statements.

## Developments In Business Simulation & Experiential Exercises, Volume 19, 1992

One approach to producing business simulations with more of a continuous approach would be to reduce the simulated time period of the operations. This is not the same as reducing the length of time between decision periods. Instead of simulating an accounting period all at one time, break it up into parts. For instance, if the desired accounting period was three months or one quarter of a year, simulate the 65 working days of operations one day at a time. Each simulated day can produce a quality control data point for analysis by the managers. For example:

Quality of the goods produced could follow a process such as:  

$$Q_t = Q_{t-1} + [R_1(m,s)] + R_2$$

Where:

- $Q_t$  = the quality of the goods produced in period  $t$ .
- $R_1$  = a random number with
  - $m$  = the mean of the random number and a function of the adequacy of the maintenance expenditures.
  - $s$  = the standard deviation of the random number and a function of the Quality Control budget.
- $R_2$  = a rarely occurring random disturbance that represents a machine failure or other quality problem with no particular controllable cause.

The possibility of disturbances strongly suggests that the participants monitor the QC process at the end of every reporting cycle and take corrective action whenever it occurs. Although not told to the participants, this disturbance feature could be programmed to occur only toward the end of a reporting cycle in order not to overly penalize any one team due to a random occurrence early in their reporting cycle.

A game designer could make this quality disturbance a controllable but stochastic function. It could be made as a function of inspection levels of incoming raw materials or sub-assemblies used in the final product or have any other designed-in relationship the designer desired to replicate.

$$m_t = m_{t-1} - f(\text{up})$$

Where:

- $m$  is the mean of the  $R_1$  distribution.
- $t$  is the time period, in days, for the production function.
- $f$  is some, preferably, non-linear function.
- $\text{up}$  is the cumulative number of units produced to date in the time period being simulated. ("up" could also be used elsewhere in the game to create an experience curve affect.)

If the mean of  $R_1$  ( $m$ ) is set to a negative value, it would cause a deterioration in quality over time. The size of this negative number could be a function of units produced per day, simulating wear on tools as a function of units produced. Thus, it gets smaller (more negative) with each passing day. Functionally:

$$s = f(1/QC)$$

At the beginning of each decision period, the value of  $m$  would be function of the amount of the funds budgeted for machine maintenance. Thus, the machines could be brought up to standard (or above) at the beginning of each reporting period, but wear would occur throughout the simulated accounting period. Spending a higher than necessary amount on maintenance of equipment would produce better than needed quality, thus wasting money and reducing the overall profits of the *firm*.

The parameter  $s$  represents quality control or the variance in quality. Its magnitude would be an inverse function of the amount budgeted for quality control.

The greater the budgeted amount in QC, the smaller the variance in the quality of output.

Given these characteristics, the value of  $Q_t$  could be plotted over time, one point per day of the operations during the accounting period being simulated, producing a Quality Control Chart as shown in Chart 1. Quality control charts like these are a commonly used device to insure that the production processes are under control. This chart shows a process that is under control.

**CHART 1**  
**QUALITY CONTROL CHART WITH THE PROCESS UNDER CONTROL**

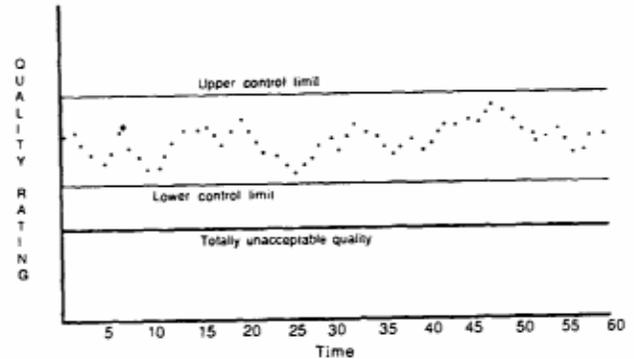


Chart 2 on the other hand, shows a process that is out of control. Note that quality has both exceeded and fallen below acceptable limits during the 3 month period. The solution would be to increase spending on quality control. Also note that the general slope is negative. This indicates too little is being spent on plant maintenance.

**CHART 2**  
**QUALITY CONTROL CHART WITH THE PROCESS OUT OF CONTROL AND POOR MAINTENANCE**

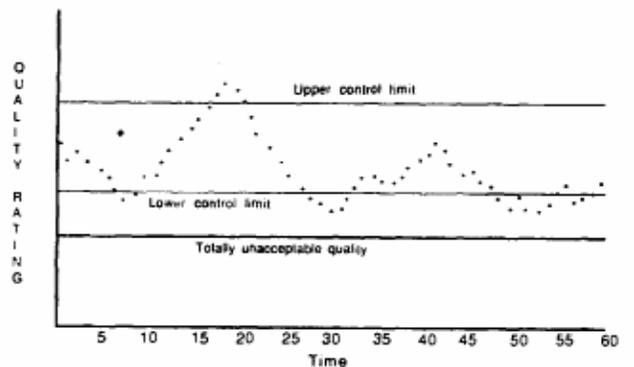
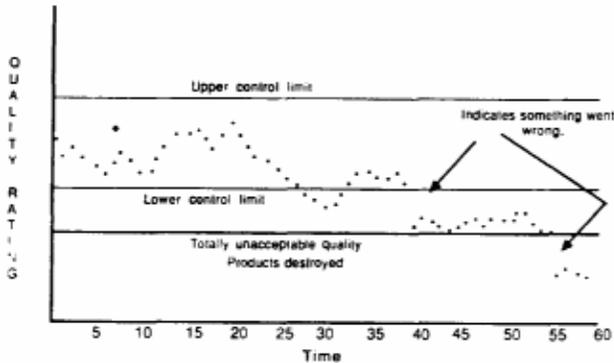


Chart 3 shows a process that is out of control (the quality fell below the lower control limit), inadequate maintenance (general, the slope is negative), and two major disturbances occurred that reduced quality. The disturbances could be the result of a disabled tool or inadequate controls on input materials. The management team would need to further review the list of outputs before they could determine the specific cause.

# Developments In Business Simulation & Experiential Exercises, Volume 19, 1992

CHART 3

QUALITY CONTROL CHART WITH THE PROCESS OUT OF CONTROL AND SHOWING THE RESULTS OF TWO DISTURBANCES



THE MARKETING PROCESS

Since one of the major tenets of Total Quality Management is customer focus, the marketing part of the simulation needs to reward good quality control processes and punish teams with out-of-control quality systems. But quality, like beauty, is in the eyes of the beholder. This simulation needs to have two or more market segments. There needs to be at least one market segment that demands high quality output and will pay a premium for it and require rebates (or some form of penalties) on units that were delivered with less than expected quality. There also needs to be a second segment willing to take a lesser quality product, but is only willing to pay low prices. Other segments could exist showing attributes such as sensitivity to advertising, sales pressure, and/or other marketing variables.

A different approach to the market place

Since this is the beginning of a new game, maybe the market place should also represent a departure from what most current business simulations provide. Most simulations, not all but most, simulate the consumer market place and not the distribution channels into which almost all manufacturers sell. One approach this new quality control game could use would be to utilize a defined set of multiple buyers representing the middleman in the products' distribution channel.

Let us assume there are N buyers and a manufacturer may attempt to sell to an M subset of these buyers, where  $M \leq N$ . In this scenario, each buyer presents a set of product specifications for their desired purchases to the sellers in either the game description at the beginning or as an invitation to bid as a part of the output for every accounting and reporting cycle. (One of the attributes in this Spec' sheet needs to be product quality.) The seller chooses which buyers to approach and checks the desired set of distributors as a decision in the simulation. Thus, one or more sellers may select the same distributors.

The distributors, in turn, select the amount to purchase from each available supplier based upon several characteristics. One is the quality of the offering, another would be the reliability of the seller as defined as the number of stock-outs, delivery of less than requested quality in the past, etc. The exact mechanics of this demand process has been described in a paper by Teach (1990) and will not be repeated in total here. The primary conditions for determining the amounts sold by each supplier include these facts:

- 1) each distributor has an alternative source of supply outside of the suppliers in the simulation,
- 2) the buyer purchases from multiple suppliers in amounts proportional to the fit of the products offered by the seller to the needs of the buyer,
- 3) the reliability of the supplier is measured by the previous dealings with the buyer and affects the number of units demanded from that particular supplier, and
- 4) the other marketing variables such as price, advertising and the number and allocation of the sales force also affect sales

Frequency of purchase

The frequency of purchase could be daily, weekly, monthly or even quarterly. In fact, different buyers could have different purchase cycles. The particular purchase cycle(s) utilized in the simulation would depend upon how much intermediate data the designer wanted to provide the game participants.

One of the features of a purchase cycle different than the decision or accounting cycle is a more complex and realistic inventory problem.

## CONCLUSIONS

The procedures described in this paper can be included in a business simulation to represent some of the problems and benefits of quality control. QC is not a manufacturing process; it encompasses matching the product and its determined quality to a buyer who needs the product in the quality produced. It is, in essence, the juncture of production, engineering and marketing.

## SOURCES AND REFERENCES

Federal Total Quality Management Handbook: How to Get Started Implementing TOTAL QUALITY MANAGEMENT June, 1990

Jensen, Ronald L. (1977), The Business Management Laboratory, Business Publications, Inc. Plano, Texas

Gold, Steven C. (1991), "Modeling Short-run Cost and Production Functions Using Shepard's Lema in Computerized Business Simulations," Wheatly, Walt and Jerry Gosenpud editors, Developments in Business Simulation and Experiential Exercises Vol. 18, pages 33 - 37

Teach, Richard D. (1990), "Demand Equations for Business Simulations With Market Segments," Simulation and Gaming Vol. 21, No. 4 pages 423 - 442.