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The Paradigms of Variation: Effects on Identifying Opportunities for Quality Improvement

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Abstract Among the many rediscoveries accompanying the quality revolution of the 1980's were the acknowledgment of the concept of paradigms and a renewed interest on the topic of variation. Together, these two concepts can provide quality improvement opportunities that are visible to only a few in the 1990ís. This lack of visibility can be explained by the essence of what paradigms are known to do, which is to cause information to become expected. Since variation is commonly defined as but one of several dimensions of quality, the role of one's variation paradigm is critical to oneís ability to recognize opportunities for quality improvement. The objective of this paper is to present a variation paradigm model and explain the role it may play in the delivery of higher quality products and processes.

1) Introduction

A variation paradigm model that addresses the aforementioned issues forms the basis of the observations presented in this study. Theoretically, this paradigm model affects certain mental models for the definitions of variation, processes, quality and costs of quality. The study was conducted as part of a ìvariationî training program. Over 300 students from engineering, manufacturing, quality, and other support functions from several industries were questioned using a variety of scenarios. These questions tested their responses to issues related to quality and variation. Examples of these questions are provided in section 2 of this paper. Consistent with the prior experience of the authors, the answers to these questions revealed the presence of three coexisting paradigms of variation, termed "paradigms A, B, and C". For the most part, each student was found to respond to one question from "paradigm A", to another from "paradigm B", and to yet another from "paradigm C". The students were responding to these questions with three fundamentally differing paradigms of variation and migrating between them unknowingly. The significance of this result is that while operating from "paradigms A or B", an individual is opportunity-limited when given a task of improving product quality, by comparison to when the same individual operates from "paradigm C". This limitation stems from the "paradigm A and B" assumptions individuals develop through experience - fostered by the quality culture of their workplace.

The "paradigm A, B, C" model that forms the basis of this study evolved over several years of observations made by the authors while guiding variation control and reduction efforts in industry. This model is based in large part on the literature and teachings of noted quality consultants Dr. W. Edwards Deming and Dr. Genichi Taguchi. Since 1960, when Dr. Taguchi received the coveted Deming Prize in Literature, these paradigm pioneers have championed the notion that quality improvement efforts, as interpreted by variation, be driven by the desire to "reduce variation from target". An introduction to this concept is presented in Figure 1, indicating the context of the traditional form of transmitting product performance requirements between a supplier and a customer. Such may be the communication mechanism between internal suppliers (design) and internal customers (manufacturing engineers). In a broader sense, this figure represents a request made of a company by an external customer. The request is transformed into specification limits. In figure 1, upper value (21) and lower value (9) are the specification limits. In addition, a target value (15) would be specified. In essence, the customer requests products that conform to the range defined by 15±6.

Given a set of specification limits and a target, the supplier response depends on their variation paradigm. Suppliers that concentrate on the requirement of the specification limits will focus on these values and strive to deliver products conforming to them. These products are said to be "defect-free" and the consequence of an attitude of "acceptability". By contrast, suppliers that concentrate on exceeding requirements focus on target values to deliver products that vary minimally about those targets - well within the specification limits. With these limits in their "peripheral view", these suppliers are driven by an attitude of "desirability". In doing so they are responding to the generally lesser valued requirement of proximity to a target value. Their actions are the result of systemic thinking that suggests that "if one goes beyond requirements and delivers what is not asked for, at competitive prices, then good things will happen". Such "good things" include recognition as a preferred supplier and higher profits.

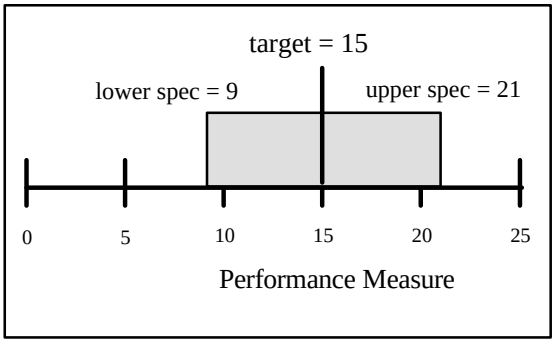

Figure 1: Specification limits and a target value are used to transmit requirements between a customer and a supplier.

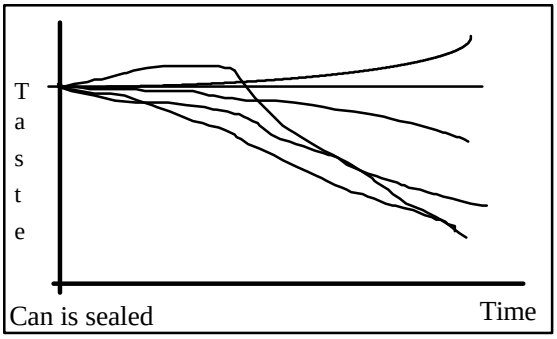

Figure 2: The responses to question 2 always reflect a continuous taste vs. time relationship.

It is the difference between the attitudes of "acceptability" and "desirability" that underlies the three paradigms of variation presented in this study. At comparable prices, consumers have demonstrated that they value "desirable" products more than "acceptable" products. Examples include color televisions produced by Sony (Sullivan, 1984) and transmissions manufactured for use in Ford automobiles (Neave, 1990). At equivalent prices,

customers were found to prefer the "desirable" over the "acceptable" products in the referenced examples. The competitive desire to achieve such allegiances provokes the question of how much more it costs to produce "desirable" products. The surprising answer is that with better thinking such products can be delivered with lower costs than "acceptable" products. A clue to this better thinking lies in the presence of three paradigms of variation. Experience with one of these, termed "paradigm C" reveals that individuals who utilize the rules and regulations of this variation paradigm are better positioned to uncover such economically-effective strategies. This type of economic thinking lies at the heart of Dr. W. Edwards Deming's last book, entitled The New Economics.

2) Questions and Answers

The discovery of the paradigm model presented in this study resulted from a variety of observations that were considered to be related. Among them was the realization that a given student in a "variation" training program could respond to a series of questions on quality and variation using more than one variation paradigm. In doing so the individual was unknowingly responding with coexisting paradigms of variation. Examples of these questions and answers, with an accompanying background, follow. Observations about these answers follow in section 3.

Background (1): A recent business journal article reported that a Japanese auto company had honored a US supplier for the delivery of parts that were "100% defective-free".

Question (1): Given the admirable quality status of this supplier, could these parts be delivered with even higher quality level while offering the existing price and delivery schedule ?

Answer (1): While the "yes" answers were much more frequent, "no" answers were not an insignificant percentage (20-25%).

Background (2): Consumers of dairy products are known to sort through these products to compare the expiration dates on them. In this manner consumers are purchasing products with the longest shelf life remaining. Many brands of soft drinks are similarly date-labeled. As part of a recent marketing campaign, cans of Pepsi include the following notification, "FOR BEST TASTE Drink by Date on Bottom of Can".

Question (2): Consider an unopened can of Pepsi sitting on a table. If you could accurately measure flavor, how would you expect the taste of this soft drink to change over time ?

Answer(2): The students' answers to this question are recorded using a standard set of preprinted x and y-axes, where the x-axis is time and the y-axis is taste. A tick-mark on the y-axis represents the taste level of the soft drink when the can is sealed. The collected responses can be divided into 4 categories. By far the most frequent response (87%) is that the flavor will decrease over time. Less frequent answers include taste that will remain constant over time (8%), taste that will increase over time (4%), and taste that will increase and then decrease (1%). Sample of these answers are presented in Figure 2. As shown, all distributions possess 2 common traits, namely the starting point on the y-axis and a continuous flavor over time. By contrast, none of the 300+ responses to this question, has ever suggested an instantaneous change in taste, as might be reflected by a step-change increase or decrease in taste.

Background (3): A data generation exercise in the "variation" training program results in the collection of 20 distance measurements by each of 3 "*teams*". This data results from "*drivers*" releasing small toy cars from an incline and down a 12 foot plastic track. "*Data analysts* " on each of the teams determine the average and standard deviation for each data set. Specification limits and a target value are provided to the teams *after* the data has been collected. The target value is carefully defined to coincide most closely to the data set with the largest standard deviation. Specification limits are defined around this central value such that each team's data will achieve "zero defect" status. Given the raw data and the average and standard deviation and derived from it, 6 "*buyers*" (2 per team) will caucus to answer the following question.

Question (3): Given specification limits and a target value, equal prices and delivery schedules, as well as the assumption that each team will continue to deliver distance data with an average and standard deviation identical to the first 20 products, who would you select as a supplier ?

Answer(3): In 20 out of 23 training sessions, which is a rate of 87%, the buyer's preference has been to select the team whose data set has the smallest standard deviation.

3) Variation Paradigms A, B, and C

The differentiation between variation paradigms A, B, and C can be explained by comparing their focuses, attitudes, and goals. This comparison follows in the table below:

	Paradigm A	**Paradigm B**	**Paradigm C**
Focus	Specification limits	Specification limits	Target
Attitude	Acceptable	Acceptable	Desirable
Goal	Zero-defects	Use a targeted fraction of the specification range	Minimum economic-effective variation from target

As defined in this table, paradigms A and B reflect an attitude of "acceptability" and a focus on specification limits. In reality, this focus and attitude are inseparable. The distinction between A and B lies in the desire of paradigm B thinking to go *beyond* zero defects. That is, instead of delivering products that fall anywhere within the entire specification region, paradigm B thinking would promote the consumption of a predefined percentage of this region. Rather than being satisfied with using all (100%) of this zone, paradigm B thinking would resume improvement activities until products fell within a targeted percentage of this zone, such as 50%. Such a goal would be assigned to every specification range within an organization, much like paradigm A thinking would have an organizational goal of zero defects. In reference to question 1, a "no" answer ("zero defects" defines the ultimate quality level) is a response from paradigm A. In reference to question 3, the "buyers" predictable decision to select the team with the smallest standard deviation is consistent with the rationale of paradigm B that the "best" supplier is the one that consumes the smallest percentage of the specification range.

The underlying assumption of paradigms A and B is that quality changes instantaneously as performance measures transition from slightly inside a specification limit to

slightly outside it. The implication is a step-change in quality, from "good" to "bad" or from "go" to "no go". This is synonymous with the perception that the taste of Pepsi changes instantaneously across an expiration date. In reality, the taste of Pepsi changes *continuously* over time, without any step changes. Similarly, product quality changes continuously as a performance measure deviates further and further from a customer-defined target value. Recall that this response reflects the thinking behind all recorded answers to question 2.

4) Conclusions

While the quality revolution of the 1980's has promoted the value of continuous improvement, the ability to achieve rapid rates of improvement is limited by the awareness of opportunities. Paradigm A thinking would overlook situations with "zero defect" status as promising opportunities. Likewise, paradigm B thinking will disregard areas where paradigm B goals have already been met. Paradigm C thinking, however, will allow an individual to perceive such situations as potential opportunities for valuable additional improvement. The explanation is that paradigm C thinking is driven by the reality that quality changes are gradual across a specification limit, rather than step-like in nature. As such, opportunities for continued quality improvement exist wherever paradigm A and B goals have already been met. Since an individual is very likely to utilize all 3 variation paradigms, definitive use of paradigm C thinking can be better accomplished if it is understood to be a choice that differs from A and B. The variation paradigm model presented in this study can serve to promote the existence of these 3 paradigms as well as initiate discussions that could result in more widespread use of paradigm C thinking .

5) References

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6) Acknowledgments

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