QUALITY EXECUTION STRATEGIES FOR WORLD-CLASS STATUS

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SUMMARY

The quality movement throughout the world in the last twelve years has accelerated at a pace unparalleled in history. New concepts to improve quality continue to surface and explode as the top management, desperate to get handle on quality is willing to spend money. The latest explosions are ISO 9000 standards and TQM.

How should world's nations view these explosive rates of new quality concepts? Most of the growth is initiated in the United States and spreads throughout the world by means of various media. The nations begin to believe that these concepts actually work. The fact of the matter is that the investments made in the United States to understand and implement the quality concepts are far outpacing the results. The United States has been able to afford such experiments due to its inherent richness. Can other nations afford similar experiments? The analysis suggests that random copying of popularized quality concepts will lead to wasteful use of critical resources. A framework is proposed that would allow any nation to formulate a quality strategy unique to its own circumstances.

INTRODUCTION

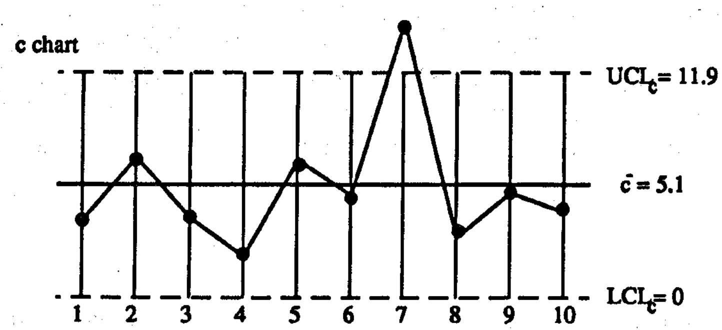
The quality concepts glamorized in the United States are blindly copied by the world's nations in a race toward establishing global player status. Even though the quality movements are conceptually attractive, there are serious fundamental flaws in executing their concepts. The paper illustrates through examples that the quality ideas are universal, but the execution of them is not. The paper describes the hierarchy of improvement opportunities that are much broader in scope than just product and service quality. It also offers recommendations on developing quality execution strategies unique to the nation. The nations wishing to put quality on their agenda will benefit from the perspective developed in the paper.

QUALITY CONCEPTS AND FUNDAMENTAL EXECUTION FLAWS

Let us examine some of the fundamental quality ideas and the flaws in their execution.

Statistical Process Control (SPC). SPC is an extremely important concept in supporting any form of quality initiative. However, execution of SPC has universally been a farce. We just won't admit it. On the scientific side, even the basic premise of SPC is not well-understood. People who teach SPC have been bookish and have never actually executed SPC themselves. As a result, they have taught and plagued the system with many erroneous SPC applications. Let us look at two examples. Figure 1 shows an application of the c chart and Pareto chart as a single entity. The purpose of the c+Pareto chart is to select a problem category and solve it. Without getting into mathematical details, it is possible to assess the data on day 7 as an unusual occurrence compared to the data from the other days. This will force one to examine in closer detail what exactly happened on the 7th day. In the words of Dr. Shewhart, one can say that the assignable cause is present. Now when the question is asked to SPC teachers as to which category should be selected as a problem-solving candidate, 9 out of 10 responded Category 1. Another possible response is Category 5 for the following reason. Category 5 is symptomatic of instability. Anytime instability is present, it represents a malfunction. On the other hand, Category 1 is symptomatic of incapability. Incapability is present either due to a lack of process understanding or due to process structure limitations. According to Dr. Shewhart s principle, physical laws do not apply in the presence of a malfunction. That is, until the malfunction is removed, it is difficult to enhance the understanding of process physics. Which is the right answer? It is the author s interpretation that Category 5 is the first choice and Category 1 is the second choice. Why then is there an overwhelming response in Category 1 by SPC teachers?

Here is another scientific misunderstanding. There is an argument among SPC teachers as to the meaning of SPC. The argument is whether to control process variables or to display product variables on control charts. Here is a quote taken from a piece of SPC seminar literature: (1) э*Too many*



Day	1	2	3	4	5	6	7	8	9	10	Total
Defects per unit (unit size = 20)	4	6	4	2	6	4	13	3	5	4	51
Category # 1	/	//	/	/	//	/	///	/	/	/	14
Category # 2		/		/		/	/		/		5
Category # 3	/	/	/						/	/	5
Category # 4		/			/		/			/	4
Category # 5	/						/////				6
Category # 6		/				/	/			/	4
Category # 7	/		/		/		/		/		5
Category # 8			/			/	/		/		4
Category # 9					/			/			2
Category # 10					/			/			2

Pareto chart

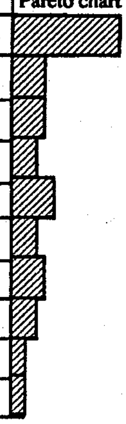


Figure 1. c+Pareto Chart

companies still do not apply SPC correctly. They monitor product variables instead of process variables, and, as a result, they find production quality problems too late..........Our SPC seminar will help you avoid such mistakes and show you how to proceed with confidence. Let us compare Dr. Shewhart s statement about the control charts with the preceding quote. ∍*Based upon evidence already presented, it appears feasible to set up criteria to determine when assignable causes of variation in quality have been eliminated so that the product may then be considered to be controlled within certain limits.* It is evident that Dr. Shewhart is referring to displaying product characteristics on the control chart and using them as indicators of process conditions. Why then are SPC experts talking about display of product variables as after-the-fact SPC or a mistaken way to apply SPC? If you examine different processes, it would be almost immediately clear that only a certain class of process variables can be plotted. Secondly, from those that can be plotted an even smaller subgroup has been proven beyond a doubt to be directly related to the end result. On the contrary, product characteristics displayed on the control chart should help in the determination of which process variables need to be controlled and in what order of priority. Why is it then that controlling process variables became synonymous with SPC? If one wants to control process variables, call it good manufacturing practice and don t mess with the strategic idea of SPC.

The absurdity of SPC is extended on the execution side as well. Overwhelmingly, management considers SPC to be a tool for an operator. For this to be true, there are six action elements to be realized by the operator almost on an instantaneous basis. These six elements are measurement of output, summarization of output in statistical terms, graphical display of statistical summaries, interpretation of the graphical display, determination of physical action, and execution of that action. In less than one percent of the cases, the operator is in a position to execute all six elements instantaneously. Actually, with proper training and or computer assistance, the first three elements at most can be made instantaneous. However, the execution of the remaining three elements would extend over time. In addition, many more people would need to be involved. Why is this scenario not recognizable by management? The operator role should be more realistically defined as a custodian of SPC information rather than a controller. The side effects of calling the operator a controller are mostly negative.

With all this confusion about SPC, any nation should doubt a claim that SPC has delivered returns above and beyond investment. SPC is too important to be treated superficially as has been the case in many companies.

Design of Experiments (DOE) and Taguchi Experiments. We can talk about these two ideas together without demeaning the importance of either one. For the purpose of discussion, we can describe DOE as a way of investigating a certain class of problems in the most mathematically efficient way. We can describe Taguchi methodology as a subset of DOE with some philosophical emphasis. For the purpose of readers not accustomed to statistical terminology, we can describe DOE as a method of covering maximum investigative space with minimum tests possible. There is so much philosophical fuss about DOE that the true problems go begging. On a broader platform, the success of DOE depends on the translation of the actual problem from physical circumstances to statistical descriptions. If the translation of the actual problem is inaccurate, the whole DOE exercise delivers nothing. In fact, it has been said that the problem well-defined is half solved. One would think then that half of any DOE book would be devoted to a translation of the physical problems into statistical problem descriptions. This is generally not the case. The DOE books assume, and quite incorrectly, that the user of the DOE technique would somehow know that a statistical problem definition is an important prerequisite before benefiting from the DOE exercise. In general, a large number of DOE books even fail to warn the reader about this. In fact, to the best of the author s knowledge, there is no good book on how to translate physical problems into statistical descriptions. Thus, we accumulate large numbers of DOE exercise failures, directly attributable to improper problem definitions.

The second problem with DOE is more strategy oriented—meaning business strategy. Often in business we ask, how do we know we are not already operating at an optimum level of hardware? To answer this question we will only have to look for certain classes of DOE designs. In business situations, we like to minimize the investigative expense. To support this notion we first select those variables that require practically no expense. Then, we select those variables that require minor hardware modifications. Finally, we select variables that may require major hardware modifications. Thus, in business, we like to spend our money wisely by selecting variables in a hierarchical fashion. Another question which often arises in business, is it really necessary to do a full-fledged mathematical DOE exercise or can we do a simple experiment based on what we already know? In that sense, the DOE is more of a thinking tool rather than the execution of a complete mathematical arrangement laid out at the beginning of the experiment.

A couple of comments on the Taguchi class of experiments: To a statistician, there is no drastic difference between so-called Taguchi experiments and DOE. It is a glamorization of the DOE concept under a different name rather than another DOE science. The more we talk about Taguchi experiments as a separate entity than DOE, the more we get closer to admitting our lack of understanding of quality methods, our ineffectiveness to integrate and execute quality ideas in our daily operations, and our wastefulness in debating the issues beyond their useful values. Let us talk about at least three ideas that are directly associated with Taguchi discussions.

The first idea is *uniformity around target* as an operational definition of quality. In numerous engineering applications, this definition is a proven fact. One does not need to indulge in a one-day Loss Function seminar to understand the concept. A general lack of understanding is evidenced by the poor execution of this concept by the big three automotive companies in the United States on their suppliers and subsuppliers. These companies have imposed a $C_{pk} \geq 1.33$ requirement on the system. This is an incorrect translation of the *uniformity around target* concept. A proper reflection of the *uniformity around target* concept would require $C_p - C_{pk} \approx 0$. The *uniformity around target* is a two-dimensional phenomena and it cannot be controlled with a single entity, namely, C_{pk}. Thus exists a dichotomous situation and a feeble argument in favor of $C_{pk} \geq 1.33$. The only interesting point is that the same people who advocate *uniformity around target* have imposed the $C_{pk} \geq 1.33$ requirement.

The second idea is ***Robust Product or Process Designs***. That means designing products or processes such that they are least sensitive to uncontrollable variations of the influencing factors. To execute this idea effectively, we must elaborate on the word robust. To get robust product or process designs we must seek out or develop the latest technology and apply it at the most economical point in a system. In yet more micro-terms, what robust means is that one must understand the interaction between two influential variables, and design hardware in such a way that the least controllable influencing variable is inherently compensated by the product or process without human intervention. Let us see how industry has used this concept. All products at some point of initiation start as raw materials. We can claim that the variation in raw materials was created by God. Anyone interested in using raw material must develop processing methods that can deal with raw material variation downstream from the source. Thus, for those involved in developing processes to convert raw materials into finished products, it becomes an additional challenge to deal with the natural variation found at the source. Ultimately, the finished products arrive in the hands of the consumer and sometimes they fall outside his or her expectations. Thus, a problem develops to be dealt with. Therefore, any problem can be defined as elements bouncing between God and the customer. Where does the search for robustness begin? It is really a matter of execution strategy guided by the economics of investigation and ultimately the economics of implementation. It is not that we are unfamiliar with the idea of robustness, but it requires engineering competence to come up with creative ideas, and putting statistical investigation efficiency behind them to prove their worth. In the author s experience, in nine out of ten cases, for a chain of events that exists between raw materials and the finished products, it is economical to begin the search for the solution near the finished products and travel upstream toward the raw materials. This is equally true when seeking robust ideas to deal with issues of product design or issues of business. The industry does not apply the idea of robustness effectively in the business cycle. To business customers, robustness has meant imposing tighter tolerances on suppliers above and beyond what makes economical sense.

The final idea associated with Taguchi discussions is *orthogonal arrays*. Most DOE are orthogonally arranged. In fact, orthogonal arrangement is synonymous with DOE. It simply means any pair of variables viewed simultaneously must cover the investigative space fully. The fame of the Taguchi orthogonal arrangement is that it requires fewer trials than the full factorial experiment. This is true of all fractional factorial experiments, not just Taguchi experiments. So what is so unique about things like the Taguchi L8 arrangement? Nothing mathematically. Actually, looking for uniqueness in the Taguchi L8 arrangements, users have really missed two other more important and costly issues. These two issues are somewhat interrelated. Let us say that there are seven factors being investigated in the L8 arrangement. People who have not solved many problems are not used to thinking about the cost of investigation. Can you imagine the cost of arranging seven variables as + and ≡ eight different times in one experiment? Everybody thinks that the investigative variables come in the form of knobs that can easily be turned either + or ≡ at whim. Suppose one of the variables is a die material. Is it affordable to have two dies made for the experiment? Rather, one must look for an alternate way to execute the same investigation with the idea of minimizing the investigation cost. Multiple regression is a well known technique for the class of problems where outcomes and variable fluctuations can be observed rather than experimented with in the DOE sense. In the author s personal experience, careful execution of regression studies have solved many engineering problems where DOE would have cost a great deal of money. Thus, the two issues are why don t Taguchi teachers talk about execution expenses in the conduct of the experiment, and why is multiple regression not taught along with Taguchi teachings?

Thus, the DOE discussion leads us to believe that even though DOE is an excellent philosophy and tool, its poor execution has not allowed the users to enjoy its full potential and associated claim.

Thus, we arrive at yet another conclusion. Investments in DOE and Taguchi discussions have cost U.S. companies far in excess of the benefits. Can nations of the world afford to invest similar amounts by copying exactly the United States idiosyncrasy?

ISO 9000 Quality System Standards. ISO 9000 standards are the latest and greatest of global competitive tools which has spread like a Japanese kudzu. It has vividly demonstrated the existence of two quality camps in the United States much more so than any other quality movements of the past. The whole world is racing toward earning the ISO 9000 status. ISO 9000 series is a system designed to deal with quality issues rather than improve quality. The race toward the ISO 9000 status basically indicates that the world at large still does not understand quality improvement versus a quality system. Having earned ISO 9000 certification does not mean quality will improve nor does it mean that your market share will improve. Not having ISO 9000 status may eliminate some businesses from earning a new business only a conjecture at this point.

What was true all along was that there were two quality camps in the United States. And for that matter, all over the world. One quality camp is system oriented. The other quality camp is improvement oriented. System orientation talks about perfecting a paperwork system that supports quality. Improvement orientation is more interested in raising the level of quality in a productive manner. System orientation is philosophical whereas improvement orientation is action oriented. Improvement orientation not only produces immediate results but acts as a seed for further gains. Quality improvement and ISO 9000 quality system development are two entirely different directions. The presence of the ISO 9000 status neither guarantees quality improvements nor does it guarantee more customers. Many third world nations erroneously believe that having the ISO 9000 status is their ticket to world markets. What they lack, however, is the grade of quality and productivity consistent with international expectations. The quality system camp has been obsessed with perfecting the quality system since the early 1940s. It has not succeeded in perfecting a paperwork trail for numerous reasons. ISO 9000 standards are simply another attempt by the system camp to prove its existence and worth. Quality improvement, of course, has a more scientific tone. United States companies have not been able to perfect their approach to the class of problems which can be efficiently solved by quality methods either. People in this camp are frustrated with many issues related to quality science. The question boils down to a couple of strategic options. Improve the paperwork system and the quality will improve. Or improve quality which will force you to improve the system to hold the solutions in place. Quality professionals in the system camp seem to be winning as evidenced by the mad rush toward earning the ISO 9000 status. Actually, valuable resources of the world are occupied in ISO 9000 standards mania without any strategic considerations that can provide a balance treatment between improving quality and earning the ISO 9000 status. It seems like nobody wants to go there, but everybody is heading in that direction.

It would not be too out of line to say that an unbalanced investment in earning the ISO 9000 status robs money from technological improvements. Only businesses that can benefit from ISO 9000 quality system models are the ones with entrepreneurial style businesses where an informal handshake used to earn the business. In the world market, such informality has now reduced to a pleasantry not good enough to prove sound quality practices or to earn a significant market share.

Total Quality Management (TQM). Another concept that engulfed the United States in the late 1980s was TQM. The resources tied up in trying to rearrange business under the TQM umbrella far exceeded the benefits that were realized. You can get only the conceptual description of TQM from the TQM teachers and nothing more. TQM advocates are talking about rearranging the business without any experience of ever running any business. Actually TQM, when correctly applied, has such penetrating power that it will reveal the wasteful habits and profitable shortcuts in any business. Which business or industry is willing to rearrange the beneficial shortcuts and correct wasteful habits? Most of the TQM talk is SEMINARial in nature, full of airport seminars and very little inherent change in the way the world thinks about quality.

DEVELOPMENT OF AN EXECUTION STRATEGY UNIQUE TO THE NATION

If the quality truly were to be on the national agenda, then each nation must first have an integral quality strategy at the national level. A group that can form such a strategy must represent government interests as well as commercial interests. This group can define the constraints and prerequisites needed to embark upon such a program. Generally these items are unique to the nation. Many times a removal of constraints or meeting prerequisites might create an environment where quality will improve due to natural forces at work. For example, many nations have strict rules on the importation of goods. This breeds incompetence within the local producers and deters the quality initiatives. By removing the restrictions on importation of goods may form a competitive environment where quality is likely to improve due to natural market forces. Once the group has gone beyond talking about restrictions and prerequisites, the nation must form a serious agenda for quality improvement. There are many broad improvement categories that can fit under the umbrella of the quality improvement discussion. At the top level, these categories consist of improving quality, improving productivity, and reducing waste. The quality category can be subdivided into conformance quality and grade of quality. Then these categories become guidelines for the nation to focus on improvement efforts productively.

IMPROVEMENT CONCEPTS BEYOND COPYING THE POPULAR MOVEMENTS

Once the nation has agreed on the quality agenda and framework, she can begin to examine quality issues in a local context. A local interest can start with any product or service issue which is of interest to the customers. The customer can be the next person downstream, a citizen, a government agency, or the community in general. Now we find an index and a measurement criteria that will reflect the level and the behavior of the customer s interest on an ongoing basis. We can now display this index in a graphical form as shown in Figure 2. Next, we determine what level we would like to achieve. The level to be achieved can be market-driven or leadership driven. We are now in a position to set out a quality direction. Our quality efforts can be divided into three categories: (1) curb or control operational disturbances, (2) reduce variation, and (3) create a systematic movement toward a desired target. Each one of the categories requires a different type and degree of effort. Control of *Operational disturbances* requires us to understand their nature, frequency, predictability, etc. Some disturbances are so obvious that all of these answers are readily known. Other disturbances are such that nothing is obvious and the investigation must follow. Nonetheless, once we know everything we need to know about the disturbances, we set out to prevent, control, correct, or contain these disturbances by using the latest technology possible. *Variation* reduction requires that we understand the variables involved in the current system. The variation problem can be divided into two subcategories: understandable and not understandable. The understandable variation can be further divided into economically correctable or not economically correctable. DOE strategies allow us to investigate these components effectively. Once the knowledge of the variation reduction is established, we once again seek the technology to upgrade the system to the next level. *Off-target* improvement can only be achieved by the system or the process which is much different than the one in current use. That means the introduction of new technology or an entirely different way of doing things. The current vocabulary that has entered the management arena is *reengineering*. It can also be referred to as raising the grade of quality meaning meeting different expectations or different specifications than in previous use. Operational disturbances and variations together can be labeled as *problems of today* because they are related to the systems, designs, and processes that are in place today. Off-target problems can be referred to as *problems of tomorrow* because they can only be solved by changing the grade of quality, reengineering, or infusing new technology.

Once this framework is understood, it provides a no nonsense strategic path toward product or service quality improvement. The whole process is equivalent to nuclear fusion. Each elemental improvement not only satisfies the immediate objectives but also acts as a seed for the next elemental improvement.

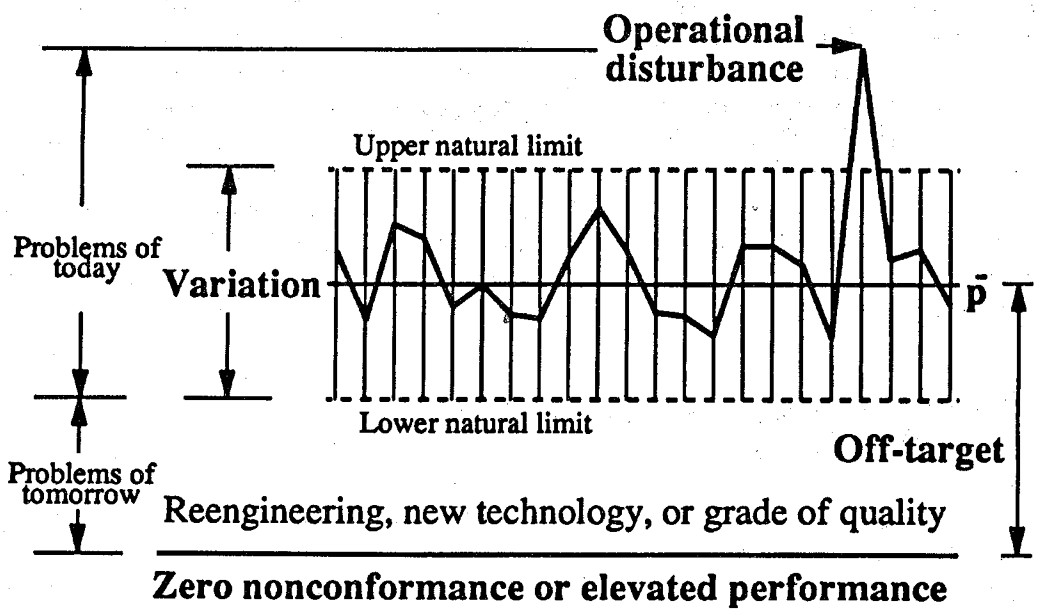


Figure 2. Problem Definitions From a Quality Perspective

CONCLUSION

We can say that quality has become a global issue. We can further state that it must be defined in much broader terms than just the quality of manufactured goods. Each nation needs a unique strategy to determine the balance between the government and industry sector. Furthermore, within each sector, the nation must determine the balance between product quality and service quality. The nations must recognize three components of quality: Condition of output (quality in the traditional sense), speed of output (productivity), and an undesirable byproduct during the generation of output (waste). The nations must further learn to find a middle ground between conformance quality and grade of quality.

Once the strategy is established, the quality science helps us to focus on the output condition to be improved, upgraded, or reengineered. The specific elements of the quality sciences are: SPC, DOE, TQM, ISO 9000 standards, etc. These elements can be applied productively or wastefully. The explosive spread of these concepts in the United States and the media coverage should not be treated as a successful strategy to be copied by other nations. As illustrated in the paper, the quality ideas can easily be applied wastefully. Each nation must develop its own strategy within the context of its own circumstances and goals.

In the competitive world markets, we don t necessarily subscribe to the idea that one nation can win at the cost of another nation s loss. The main idea of quality is to raise the overall quality of life for the human race. As the nations compete, the beneficiaries are the citizens who can now access the better output than they did before when the world was restrictive to protecting local interests.