Southern Business Review

Volume 18 | Issue 2 Article 7

October 1992

Key Issues in Quality Improvement

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Quality Interpretations and their Strategic Consequences

Current trends toward the internationalization of operations and the liberalization of trade barriers have meant that, in addition to domestic rivalry, companies are faced with more head-on competition from foreign-based manufacturers. Consequently, "quality" has become a "hot" issue, in the same sense that product safety, environment protection, or material and energy conservation dominated managerial thinking a few years ago.

By quality, one perceives a vaguely defined set of attributes which establishes some degree of excellence. Quality is normally described by referring to certain characteristics (e.g., reliability, accuracy, and simplicity) exhibited by a product. These characteristics, known as the "quality evaluation criteria," must be further explained and means of assessment must be developed. Current methods of measurement of quality tend to produce uncertain and dimensionless results. Often, the set of criteria used is not complete and an element of overlap exists. Furthermore, not all criteria apply with equal weight to every situation. The greatest problem with this interpretation of quality is that there is still no precise meaning and, consequently, no specific measure to serve as a benchmark.

Quality interpretation problems not only lend to semantic controversies, but they may have a profound impact on the operation of a company and its strategic positioning. The importance of certain quality evaluation criteria is perceived differently by specialists in the various functional departments, hence causing them to give higher priority to some characteristics of quality at the expense of others. Three areas of operation may be distinguished in the majority of companies (R&D, manufacturing, and marketing), and their specializations contribute to three basic approaches to quality (Garvin, 1984).

The product-based approach reflects differences in the degree of certain attributes a product exhibits. For example, products which are durable, reliable, and multi-purpose are perceived as better. They can also provide more service over time. Since there is a price for supplying these attributes, the better the quality of the product, the higher its price may be set (Gerstner, 1985). From this approach, design excellence can be perceived as fundamental to achieving high quality.

The manufacturing-based approach focuses on conformance to requirements; any deviation from a design or specification implies a reduction in quality since preventing deviations is cheaper than repairing, reworking, or covering warranty claims. Consequently, simplicity of design, serviceability, elimination of defects, and results of the statistical process control are emphasized.

Marketing, the third basic functional department, may favor the user-based approach. This approach assumes that high quality products are those which meet the needs and preferences of customers. Application of this approach is recommended when growth and profits dominate the company's objectives. In this approach, quality may also be observed from a broader, social perspective. An assessment of the social aspects of quality is defined as the systematic study of the consequences on a society, a company, or an individual, when a technology (or a single product) is introduced, extended, or modified. The value-based approach is often used as a measure of the social perception of product quality. This concept regards quality as a function of price. A purchasing agent wishing to buy a certain product is prepared to pay as much as he/she feels the product is worth. In such a case, however, quality, which is a measure of excellence, is equated with value, a measure of worth.

Due to cognitive and economic factors, not all approaches to quality may be adopted simultaneously. At times, there is even no need, since different product requirements exist in the various stages of the product life cycle. Typically, one concept of quality tends to dominate the culture of an organization and its operations.

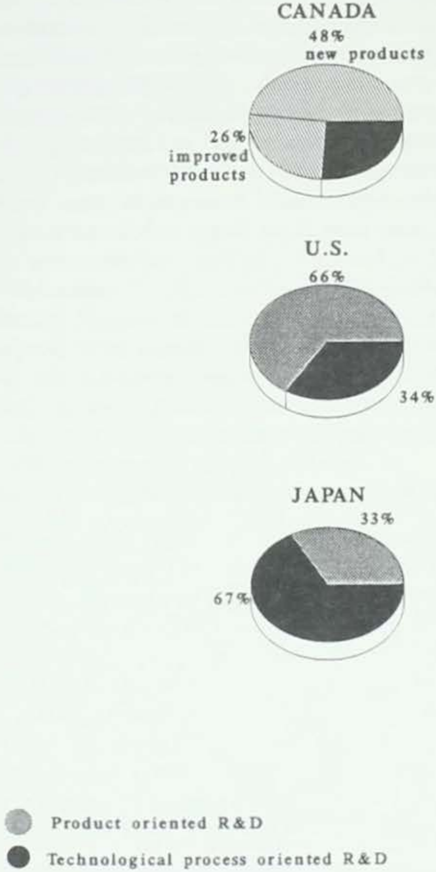
Problems between design and manufacturing quality may be traced by studying expenditures for, and concentration on, R&D efforts. For example, basic research accounts for 12% of R&D spending in the U.S. (NSF, p. 1) and for 9% in Canada (SCa, 1989, p. 3). In most OECD countries, basic research accounts for 3-5% of the total industrial R&D. Also, significant differences are perceived among countries when orientation of R&D is studied (see Fig.1). Such structures may be associated with the dominant perception of quality in a national culture (Berger et.al., 1989; Feldman, 1989; Graves, 1989; Johnson, 1984; Papadopulos & Heslop, 1989; Smothers, 1989).

Numerous examples support a statement that design excellence rather than technological process is the focus of management in the U.S. and Canada. For example, video equipment was invented in the U.S. It was perceived to be too expensive to be manufactured for commercial purposes. The rights to this invention were sold to Japan, and today Japan dominates the video equipment market. Computer chips were invented in the U.S., but through manufacturing process improvements, Japanese firms have already captured the market (Baetz, 1987, pp. 201-203).

Concentration on product/design excellence causes a lack of emotional commitment to process improvements and results in a drain on financial resources which otherwise might be used to improve technological processes. The Japanese solution to this problem should be considered. The Japanese Ministry of International Trade and Investment was a catalyst in the acquisition of Western technology at a fraction of its development cost. Specifically, 42,000 technology contracts were purchased from 1951 to 1983 for $17 billion. It is estimated that these technologies cost between $500 billion and $1 trillion to develop (Reich, 1989, p. 43).

Figure 1

A Comparison of Product Oriented R&D Expenditures with Technological Process Oriented R&D Expenditures in Canada, the U.S., and Japan (estimates)



Manufacturing and product-based approaches to quality, although they cause significant differences in operation, are correlated in two ways. First, there are similarities in the specialists' educational and engineering background as well as in their perception of reality. Jointly, these two approaches are referred to as the engineering approach to quality. Second, design characteristics have a direct impact on problems experienced by manufacturing departments. For example, Japanese companies introduce more changes in the original design before production is started as opposed to their U.S. counterparts. However, once manufacturing is started changes are virtually "frozen" in Japan, while in the U.S., they are still under way (Sullivan, 1986, p. 39). Such changes do not help to eliminate problems in the organization of manufacturing processes. Moreover, it seems that changes introduced by U.S. manufacturers reflect mainly the feedback received from dealers and the market, which also indicate deficiencies in design and in marketing.

A more fundamental conflict in the area of quality management exists between the engineering and marketing approach. The first concentrates on excellence in engineering terms and the second on broad socioeconomic aspects where technological concerns are only one of many points to be examined. Since quality decisions can also be considered as a means for policy generation, the conflict between the technological and marketing approach to quality is surprising. Marketing, an activity through which a firm identifies customer needs, should be the engineers' strongest ally; yet, marketing is often referred to as little more than advertising, selling, promotion and packaging, and, some say, "marketing is what you do when you run out of ideas." It should be stressed that "technologists need to learn that professional marketers are generally proficient in an increasingly rigorous discipline, while marketers must realize that technologists are capable of perspectives considerably wider than their lab benches. The goal must be a true collaboration between marketing and technology that maximizes customer satisfaction in both the short and the long-run" (Star, 1989, p. 3).

Reconciling the Interpretations of Quality

Observations regarding various approaches to quality show that reliance on a single, across-the-board interpretation may fuel serious disagreements. The strength of a certain department may result in too much emphasis on a particular definition. Yet, it is the role of the chief executive officer and his/her staff to control power within the organization and to make decisions regarding methods to improve upon quality. Lascelles and Dale (1990) argue that restart situations can create opportunities to improve quality; competition and a need to reduce costs can serve as catalysts, and demanding customers and the chief executive officer serve as change agents. Such observations indicate that quality improvement, although it may be initiated and/or forced from outside, must be managed from inside a company, e.g. by executives.

Quality is a very broad, transcendental concept which must be analyzed in a systematic manner. Quality considerations are not a branch of engineering, a sub-division of economics, political science, or of the law. They draw upon all of these areas for components; yet, each decision must be individually structured. Given these creative components, the quality assessment process should not be approached as a search for formulas or models, but rather as an art, having both the unity and the diversity which depends upon the talent, experience, and finesse of company executives (Coates, 1975).

Quality management involves all aspects of organizational life: culture, methods of operation, goals, strategies, and structures. Therefore, quality management does not simply translate into a decision to adopt statistical process control, "the house of quality" method, "quality circles," or to purchase "the Juran" or "the Deming" package. Quality management must be perceived as an organizational process involving all employees. This process must be supported by building into the organizational culture a positive attitude toward quality, sound educational programs, and a strong and systematic commitment. No exceptions should be permitted even if short-term effects of performance are compromised. Quality concept implementation takes time and results will not occur overnight. Determination and time are required in order to improve quality.

The elements of a comprehensive approach to quality can be found in "Ford's Total Quality Excellence" method (White, 1990) and the Four Seasons "7C" concept (Sharp, 1990). However, there still remain aspects to which executives must pay attention when managing quality. Executives have to select and assure a consensus with respect to a dominant perception of quality within a company. Patterns of such choices are evident within a company and within a nation. For example, Japanese manufacturers have succeeded in producing products which meet the objectives of conformance and reliability at a low cost stressing the importance of the market-approach and the manufacturing-approach. Americans, on the contrary, tend to be more oriented to product and market definitions of quality. This difference might have also contributed to a common acceptance of Japanese products as being superior in quality to U.S. markets.

Effective operation of any organization requires coordination of all functions toward a commonly respected goal. Lack of consensus as to the interpretations of quality may fuel conflicts. R&D departments lean toward a product-based interpretation and may aim at excellence without concern for costs. Manufacturing departments are more concerned with the costs of reworking and repair claims and, thus, concentrate on the manufacturing approach to quality. Finally, marketing departments interpret quality according to the user-based approach since it reflects customer perceptions of the product. These differences may be real; however, they may be used to cover up a struggle for power which takes place in the majority of organizations. And here, the executives' role comes into play again. Executives have to balance the influence and the requirements of R&D, manufacturing, and marketing functions within an organization in order to improve the efficiency of operation and to avoid delays and unwelcome conflicts (Ansoff & Steward, 1967).

Serious discrepancies occur between product vs. technological process orientation and concentration. Structures of R&D spending and some cultural elements are indicative of a threat that an excellent "concept" will not be economically manufactured due to drawbacks of technological process. It is also a mandate for executives to balance efforts for product development with development of technology. Problems in this area are particularly marked in countries with centrally planned economies. Activities of research/design institutes are not coordinated with industry needs and capabilities. In some research/design areas, solutions from these countries reach high-level standards. Yet, when realization of design concepts comes into play, technological process drawbacks put them decades behind firms which operate in the free market economies. Such problems may also exist in companies with large autonomous structures. General Motors, a company with the world's largest R&D budget of more than $4 billion, is well known for design innovations. However, it becomes more and more difficult for GM to compete with overseas car manufacturers and with Ford in terms of quality. Coordination among departments involved in improvements and problems on manufacturing/assembly lines are some elements responsible for this situation.

CAD/CAM link is one of the means used to counteract inconsistencies between design concepts on one side and technological constraints on the other. Application of this solution allows a shorter time lapse from invention to customer. However, CAD systems are used more often and are substantially cheaper than CAM systems (**Business Week**, 1990; **Making Technology Work**, 1988).

The balance of power between various departments (and concentration of innovative activities) should be perceived dynamically; it should be changed as the product reaches various phases of its life cycle and should fit to the strategic position determined for the company. Also, there may be a need to re-define quality as the product moves from the design stage, to manufacturing, and, thereafter, to distribution.

Various interpretations of quality may contribute and be useful to the accomplishment of different sets of organizational goals. For example, an increase in market share and a higher return on investment usually call for higher product quality; yet, better quality may result in higher R&D spending, thus deteriorating short-term profitability. Quality and direct costs are positively correlated in a product-based approach; yet, they are inversely related in the manufacturing-based approach (Kaplan, 1982, pp. 11-14; PIMS, 1988, p. 3-4).

Finally, it should be noted that diverse types of products call for emphasis on different aspects of quality (e.g. a difference between products with a long life cycle and those with a short life cycle). A study by Lehmann and O'Shaughnessy (1974) has shown that for routine order products (i.e., calculators), reliability and price are the most important dimensions of quality. For procedural problem products (i.e., microcomputers), the most important aspects of quality are technical service offered, ease of operation/use, and training offered by the supplier. In the case of performance problem products (i.e., the new generation of microcomputers), the quality features include the technical service offered, the flexibility of supplier, and product reliability. Finally, for political problem products (i.e., a mainframe), price, reputation of supplier, reliability of delivery, and flexibility of the supplier are sought. It is also worthy of note that the basis of evaluation differs from one country to another.

In addition to the above-mentioned responsibilities of executives with respect to quality management, the means by which quality may be improved upon should be discussed.

Computer-Based Technologies as a Means to Improve Quality

Faced with a disadvantage of no uniform approach by which to interpret quality, it is advisable to keep any assessment framework flexible and comprehensive. Building on this element, however, increases the complexity of any method adopted. As a result, it may be questioned as to whether it is possible to solve the problem of quality assessment on the basis of terminological grounds. It may prove more useful to search for a way to reconcile the various demands associated with quality rather than to concentrate on the differences in its meaning. One of the determinants of quality is the tools used to improve quality in the field of design, manufacturing, or marketing. All three areas utilize a common denominator — the application of Computer Based Technologies (CBT).

University courses teach that CBT can benefit companies through increased flexibility, productivity, economies of scope (i.e., variety and not volume), and through companies being proactive rather than reactive. The rewards of such developments are far reaching. For example, as of the 1980's, planners were able to reconcile demand for flexibility through mass-manufacturing advantages with little penalty in terms of higher costs; thus, manufacturing has become a source of elastic alternatives. All of these elements contribute to the increased competitiveness of a firm. Moreover, they add to the quality of products/services, whether it is evaluated by a firm or by its customers.

Decisions to invest in CBT and R&D are strategic and should be made in an overall context and not singularly represent the best possible solution for the R&D department (CAD/CAM technique), the manufacturing department (FMS), or the marketing department (computer-based information system on customers). A high degree of flexibility in designing and manufacturing will not help much if a company is operating in a stable, conservative market, or if it is not supported by a market analysis. Also, any forecast conducted by the marketing department on the specific and changing consumer needs and preferences will not be met if R&D and manufacturing cannot respond in time. CBT can be considered as a competitive weapon mainly when a firm's marketing strategy emphasizes customized products and frequent product change, and when the sales department is prepared to handle such products, should R&D provide a constant stream of product modifications and process improvements (Goldhar & Jelinek, 1983). If a company assumes the role of an innovator, it will incur greater costs and risks, but it may gain a competitive advantage more quickly.

Overemphasis on technology is likely to give a short-lived advantage as a result of challenges from similarly effective or superior products offered by competitors. Furthermore, the technology push increasingly poses the problem of profitless prosperity, a condition under which industries register impressive growth, but profitability is minimal or negative. The cause is a premature technological obsolescence of successive generations of products, before firms have an opportunity to recover their R&D investment (Ansoff, 1984, pp. 101-128, 472). It is not an exception that companies from this type of industry spend in excess of $36,000 per employee per year, which translates to more than 20% of their sales, or more than 100% of profits (**Business Week**, 1990). However, when technology becomes part of a comprehensive business strategy, including marketing strategy, sustained productivity may be achieved.

The cost involved in obtaining innovative technology is usually high and the capital required is not readily available. Changes in operation are difficult to implement, cause delays, and result in cost overruns. Conventional methods used to justify the effectiveness of high-tech projects do not take into account many unquantifiable benefits, such as reduced waste, lower material and direct labor costs, and most of all, improved quality. These problems are salient especially in the U.S. and Canada where there is a tendency to evaluate the performance of managers on the grounds of short-term results. New technology is normally a costly capital investment which does not instantly contribute to the improvement of ROI. Under the circumstances, authorization of large amounts of capital expenditures, for example, for an automatization project of which the benefits would materialize in the future, would be the same as swallowing a poison pill. However, such poison pills are being swallowed by executives in the majority of OECD countries, with Japan, Sweden, and the Low Countries as the sterling examples, and have turned out to be a source of vitality for the economies of these countries.

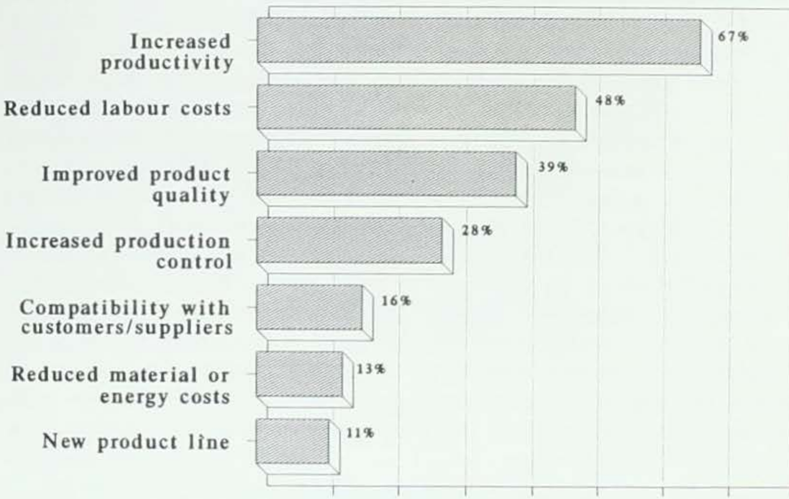
Some Statistics on Computer-Based Technology Adoption Rates

Computer-based technologies are commonly used by U.S. and Canadian manufacturers. For example, in Canada, 75% of firms reported that they had experience with computer-based technologies between 1980 and 1985; 85% of firms had plans to introduce such technologies by the end of 1990; 50% of companies use more than 1 out of 18 solutions classified as CBT; 66% of establishments use programmable controllers; 42% introduced personal computers/workstations; 34% use word processing; and, 15% - 41% use CAD and CAM. Overall, 64% of Canadian companies introduced office automatization (e.g., personal computer workstations and office networks) and 25% introduced manufacturing technologies (e.g., CAM, CAD, computer numerical control, automated materials handling, and automated inspection and quality control) between 1980 and 1985. It can be concluded that the use of office automation was facilitated by the relatively low financial investment required (personal computers/workstations $25,000; word processing $20,000), whereas process automation was disadvantaged by the high financial investment required (CAM $200,000; CAD $100,000; computer numerical control $400,000). Technological change was motivated by a number of issues. This intensity is shown in Fig. 2.

It may be expected that due to implementation of CBT, short production runs have increased and now account for the larger part of added value. Seventy-one percent of all production runs lasted less than a month and resulted in 52% of the value of 1986 shipments; 9% of the runs lasted longer than 3 years and contributed 28% of value shipment. No doubt, the adoption of manufacturing technology has played some role in this transformation. These

Figure 2

Motives for Technological Change

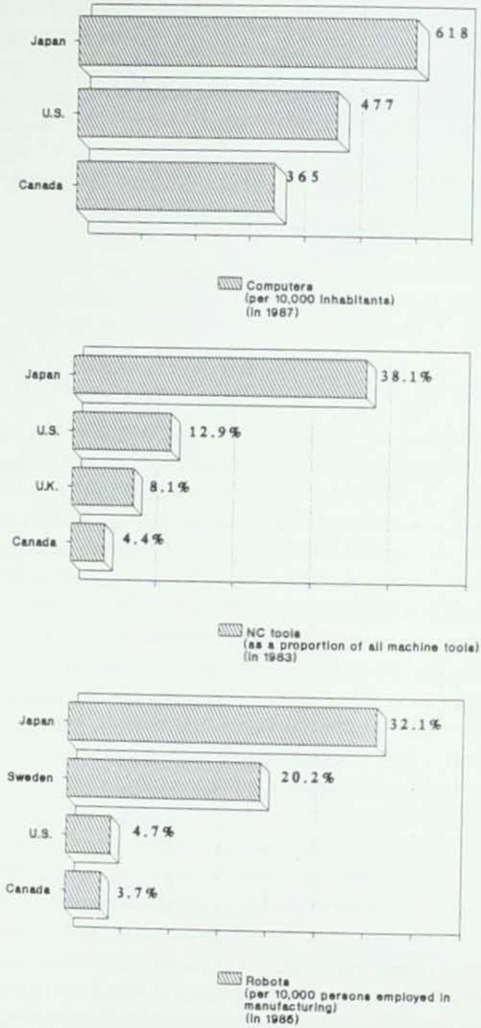


numbers reflect adoption rates of CBT in the U.S. and in Canada. They are impressive as long as they are not compared to international standards — e.g., the number of computers (which nevertheless are the heart of CBT), the number of numerical controlled machine tools, and number of robots used (see Fig. 3). Moreover, 60% of Japanese manufacturing establishments employing 100 or more workers were using some type of microelectronics equipment in 1982. A similar level (58%) was reached in Canada two years later. The use of microelectronics technologies in process applications was higher in Germany, the U.K., and France in 1983 than in Canada in 1985 (**An Ontario Market Profile**, 1985; **A Comparison of Canadian and U.S. Technology Adoption Rates**, 1989; **A Report on Human Resources**, 1988; **Business International**, 1990; **Evans Research Corporation**, 1985, p.68; **SC**b, 1989, p.93; **Training for Technological Change**, 1987).

As of 1989, there were no substantial differences in the rate of use of robots between Canada and the U.S. in four groups of industries which were investigated (i.e., electrical and electronic products, transportation equipment, machinery industries, and metal fabricating industries). It is true not just on average, but for almost all types of technology, in all the sectors studied. The differences that do exist put Canada ahead of the U.S. as often as it is behind. The information about the samples points to the American version being, if anything, more large-firm oriented than the Canadian sample. This would suggest that the Canadian adoption rates are biased downward relative to the corresponding U.S. rates (**An Ontario Market Profile**, 1985; A Comparison of Canadian and U.S. Technology Adoption Rates, 1989).

Figure 3

Comparison of Number of Computers, Numerical Controlled Machine Tools in Use, and Robots in Various Countries



As compared with the Japanese systems, those in American plants produce less of a variety of parts. Furthermore, the American machinery cannot run untended for a whole shift, are not integrated with the rest of their factories, and are less reliable. The average number of parts made by an FMS in the U.S. was 10; in Japan the same figure was 93. The annual volume per part was 1,727 in the U.S. and 258 in Japan. For every new part introduced into a U.S. system, 22 parts were introduced in Japan. Japan has outspent the U.S. two to one in automation. Fifty-five percent of machine tools introduced in Japan were computer numerically controlled; in the U.S., the figure was 18%. To conclude this painful comparison, 40% of FMS is installed in Japan; two-thirds are in small-and medium-sized companies (Jaikumar, 1986). Given these developments, Japanese products have changed, in both perception and in reality, from poor to excellent quality products.

The adoption of CBT serves mainly to improve process technology in order to increase cost-effectiveness and/or the quality of its production processes and is often purchased from other companies. In contrast, the R&D performed by firms is known to be primarily product-oriented. Statistical data series provide evidence that the U.S. and Canada are behind many countries with respect to the rate of adoption of CBT. Canada is also behind other countries with respect to R&D commitments. These imbalances translate directly into higher unit costs, lower productivity, quality disadvantages, and slower market responsiveness (Canadian Labour Market and Productivity Centre, 1990).

Computer-Based Technologies and Education/Training Implications

Though technology was widely recognized as a competitive weapon, the manpower and employment implications have been less understood. Respondents to surveys stress that the cost of new technology, the lack of worker skills, and management know-how in implementing new technology slow down the rate of adoption. Respondents believe that many occupations would require higher skills, including a broader knowledge of the organization. Current training costs are already between 2 and 5% of total labor costs. This translates to between 5 and 13 days a year of training per employee; yet, little change in levels of training to 1995 is expected (**Currie, Coopers & Lybrand**, 1985; Productivity in Industry, 1986, p. 49). Application of CBT may also have a profound impact on employment structure. For example, a distribution between engineers, accountants, and lawyers in Canada and in Japan (per 10,000 workers) is 112/400, 43/3, 39/1, respectively, and is expected to evolve more towards the Japan model because it works better (**Competing in the New Global Economy**, 1988).

The U.S. occupational training is informal and voluntary. In Canada occupational training is the basis of industrial skills. It is obtained generally after obligatory schooling when "students" begin their professional life and is provided (financed and organized) by companies. Fifteen percent of training is purchased from outside and 53% is performed within the firm. The U.S. and Canadian systems, though different in their approach, attach great importance to the role played by companies as a major locus of training, as does the Japanese system with strong emphasis on in-company training. However, 37% of representatives of Canadian companies say that they experience no difficulties in hiring high-skilled personnel, 32% find it difficult, and 22% very difficult. At the same time, 32% of firms modify their technologies, which call for a change of the structure of skills of employees (SCc, 1989, pp. 3-5).

If the U.S. or Canadian systems are going to be evaluated as inefficient, experience of other OECD countries may be recommended. There exist a variety of approaches whereby occupational training is obtained. There are apprentice systems, sometimes highly structured and with legal basis, as in Germany, Austria and Switzerland. In other countries, such as Belgium, France, and Sweden, occupational training is a matter for schools rather than industry, and the emphasis is less on practical than on the theoretical aspects involved. These solutions, especially when CBT use is concerned, require a strong governmental involvement in eduction and training for skills.

Computer-Based Technology and Perception of Quality

Through the use of CBT, marketers are able to trace customer needs more accurately. Information on the requirements and preferences of customers are faster translated by R&D into a new product. The engineering department is able to elaborate technological and organizational processes, which manufacturing is performing with the use of FMS. All departments are able to operate faster, more accurately, and with "on-line" cooperation of all other departments.

An investment in CBT contributes to the improvement of product "quality," productivity, and services offered. What is overlooked is that when the advantages of CBT are realized, the question of interpretation and measurement of quality shifts into other areas. As a result of optimization procedures, it is possible to characterize a product, and its single features, as a function of price and customer preferences. Design skills of engineers, production experience of shop floor managers, and insights of marketers are still valuable and contribute to the competitiveness of operations. The accuracy and timeliness of information, as well as sophistication of optimization software in fields of design, manufacturing and market forecasting, are becoming more-and-more responsible for a future market success or failure. Thus, the quality of a product, however it is perceived, depends and reflects the quality of information and software. Consequently, a value-based approach, supported by a system-oriented social assessment of product quality, may gain popularity with an increase in the use of CBT. Such solutions are apt to benefit both companies and customers.

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