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2 Quality Assurance Practices by Yemeni Manufacturing Organizations: A Conceptual Framework and Empirical Investigations

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Abstract

The purposes of this study are two-folds. First, critical factors necessary to achieve effective quality management were identified. The second purpose was to obtain Yemen managers' perceptions of the quality assurance programs in their organizations. Seventy-three persons from different organizations participated in this study. The overall conclusion that emerged from this study was that, contrary to what was hypothesized, it is not necessary for all factors to be present to insure the success of the total quality program of the organization.

Keywords: empirical, framework, Yemen, quality.

الملخص

هناك هدفان رئيسيان لهذه الدراسة. أولا تحديد العوامل الحرجة الضرورية للوصول إلى إدارة الجودة الفاعلة، وثانيا الحصول على إدراك المدراء اليمنيين لبرامج تأكيد الجودة في مؤسساتهم. شارك في هذه الدراسة ثلاثة وسبعين مشارك من مؤسسات مختلفة.

الخلاصة الكاملة التي ظَهرتْ من هذه الدراسةِ (على نقيض الذي افترض) تبين انه ليست بالضرورة اخذ كافة العوامل لتأكيد نجاح برنامج الجودة الشاملة في المؤسسة.

1. INTRODUCTION

During the past decade, managerial concern for quality reached unprecedented levels. Today, an increasing number of managers in more organizations than ever before view "quality as of bedrock strategic importance, rather than an abstract to be pulled out of the platitudes file and given lip service at the annual general meeting" [Guaspari, 1987]. Research has confirmed the strategic benefits of quality. Quality has been shown to contribute to greater market shares and return on investments United States General [Accounting Office, 1991; Cole, 1992 and Morrow, 1997] as well as lower manufacturing costs in the long run and improved productivity [Garvin, 1983]. Although instilling higher quality characteristics in a product may result in higher manufacturing costs in the short run, and there by result in higher prices for a product, this will not necessarily have a negative impact on consumer demand. When confronted with substitutes for products, consumers would prefer to pay moderately higher prices to ensure the purchase of a quality product [Coulson-Thomas, 1991 and Coulson-Thomas, 1992], for a company or country to compete effectively in the global economy, its products must meet a certain standard of quality. Distribution of inferior products can harm firms and nations, both at home and abroad, and can have severe implications for

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balance of payments [Scagoline, 1988]. In Yemen, too, industrial and service organizations are concerned with the need to upgrade the quality of their products and services in order to keep pace with competition within and outside the country.

The purpose of this study is to identify the degree to which quality assurance is being practiced in Yemen manufacturing organizations and to locate the organizational areas where better management control can make the quality assurance system more effective. Specifically, this paper attempts to answer the following research questions:

1. What are the major manufacturing objectives of Yemen organization? How does top management rank these objectives?
2. Do Yemen manufacturing organizations have their own quality departments? What role does the department play?
3. Do Yemen manufacturing organizations maintain clear, well-defined quality policies?
4. What are the major causes of quality problems faced by Yemen manufacturing organizations?
5. Do Yemen manufacturing organizations employ a quality cost reporting system? What are the major components of the total cost of maintaining quality?
6. Are there suitable training programs for the purpose of enhancing the effectiveness of quality assurance?
7. Do Yemen manufacturing organizations work with their vendors to improve their quality systems?
8. Do Yemen manufacturing organizations use employee involvement programs for tackling quality problems? If yes, are they effective?

In order to answer the above questions, the following two steps were undertaken.

First, based on the synthesis of literature on quality concepts, critical factors that must be practiced to achieve effective quality management in an organization were identified. A framework to be used by organizations to evaluate their quality management practices was developed. Identifying and measuring the critical factors of quality management can be very useful. Managers can use the critical factors to:
(1) obtain a better understanding of quality management practices;
(2) determine the current quality position of an organization;
(3) assign responsibilities within an organization; and
(4) monitor quality and improvement programmes [Badri et al., 1995 and Motwani et al. 1989].

Decision makers can thus isolate the critical factors that are necessary for organization-wide improvements in quality environments [Saraph et al., 1989] . Researchers can use the critical factors to build theories and models that relate these factors to the quality performance and quality environment of an organization.
Second, a field survey was conducted to identify the degree to which quality management practices are present in Yemen manufacturing organizations and to locate the organizational areas where better management control can make the quality programmes more effective. The results of the field study can be used to:

(1) test the reliability and validity of the instrument developed by Saraph *et al.* 1989 in an international environment;
(2) establish priorities for the quality control programmes;
(3) develop an adequate database for future cross-cultural comparisons; and
(4) provide guidelines to Yemen manufacturing organizations for planning and organizing effective control of their quality programmes. This will not only help to increase the quality of their products and services and reduce costs but also help to utilize more effectively the availability of raw materials, equipment and human resources [Black and Porter, 1996].

2. PRESCRIPTIVE LITERATURE

Much of the literature on quality focuses on the following areas: Japanese quality management practices [Juran, 1978 and Schonberger 1982] ; the development of organization-wide quality improvement programmes [Crosby, 1979] ; the application of various statistical quality control techniques [Deming, 1981; Deming, 1982; Deming 1986; Gitlow and Hertz 1983 and Wood 1981] ; the concept of organization-wide and total quality control [Feigenbaum, 1983] and the importance of critical factors such as top management leadership, process management, employment training and employee involvement in quality [Feigenbaum, 1986; Flynn et al., 1994; Flynn et al. 1995; Langevin, 1977; Reddy and Berger, 1983; Snee 1986; Takeuchi and Queslch 1983], . Research also highlights the Malcolm Baldrige Award, and the European Quality Award given to companies which have pursued and achieved excellence in this area. The criteria for the award are reflective of the highest, most comprehensive quality standards [Black and Porter, 1996; Stundza, 1992 and Application Guidelines MBNQA, 1991].

For the purpose of identifying critical factors, the philosophies of quality experts such as [Deming, 1981, 1982, 1986; Juran 1974, 1978, 1981, 1986, 1988, 1989 ; Crosby 1979, 1989 ; Ishikawa 1976, 1988 ; Feigenbaum 1983,1986, 1989 ; and Garvin 1983, 1984] were reviewed.
Deming stresses the necessity to top management involvement, attention to customers' needs, involvement of all employees in the process of continual improvement, and the need to pay close attention to the entire manufacturing process as keys to corporate success [Mann, 1988; Scherkenbach, 1988]. The 14 points comprising Deming's philosophy are designed to improve all aspects of manufacturing. Juran is famous for developing the "Juran Trilogy", as a new model of strategic quality management. His trilogy states that managing for quality entails three quality-oriented processes:

1. quality planning and the annual quality programme;
2. quality control and the control sequence;
3. quality improvement and the breakthrough sequence.

The essence of Crosby's quality involvement process is embodied in what he calls the "Absolutes of Quality Management" and the "Basic Elements of Improvement". Ishikawa is popular for his emphasis on the concept of total quality control. According to Ishikawa, the quality function is the responsibility of all departments. Feigenbaum's approach promotes the view that no quality improvement is obtained from a system that is not dedicated to quality in every aspect of its operation. Lastly, Garvin conducted an

exploratory study to identify the causes of quality problems in the United states and Japan.

From the literature review several organizational requirements for effective quality management are generated. All the requirements can be classified into the following nine major critical factors:

1. top management;
2. quality policies;
3. role of the quality department;
4. training;
5. product design;
6. vendor quality management;
7. process design (statistical quality control);
8. quality data;
9. feedback and employee relations.

Each of these factors is supported by all or nearly all of the authors in their philosophies as shown in Table 1. When combined, these factors define the important aspects of quality management practice.

The entire model developed for the purpose of this study is illustrated in Figure 1. The model presents, in a single schematic diagram, the dependent and independent variables that relate to quality management practices in organizations.

Specifically, the nine critical factors in quality assurance are the independent variables. To enable managers to indicate the degree or extent of practice of each item by their organization, a five-point Likert-type scale was used to measure these independent variables. For each critical factor, the level of practice was represented by the mean reported score for that factor. The effect of these independent variables on the dependent variable, or the level of quality, is measured in terms of the latter's surrogates; assembly-line reject rate is defined as the percentage of total defects per unit produced. The term after delivery reject rate is represented by the percentage of defective items which require field service during the warranty period and/or which are returned by customers.

3. METHODOLOGY

In this section the methodology utilized in this research is presented. First, the research hypotheses are stated. Next, the subjects and the instrument used in the measurement of quality are defined. Finally, the data analysis procedures used are addressed.

Research Hypotheses

The review of relevant literature suggests the following specific null hypotheses:

H1. There is no association between corporate management support for quality and the level of quality achieved.

H2. There is no association between specific quality policies and the level of quality achieved.

H3. There is no association between the role performed by the quality department and the level of quality achieved.
H4. There is no association between the emphasis placed on training and the level of quality achieved.
H5. There is no association between systematic product design and the level of quality achieved.
H6. There is no association between the emphasis on vendor quality management and the level of quality achieved.
H7. There is no association between process design and the level of quality achieved.
H8. There is no association between the availability and use of quality data and the level of quality.
H9. There is no association between the extent of employee involvement in quality efforts and the level of quality.

Research Subjects

According to Nunally,1977 when a measuring instrument is used for data collection, the subjects used should be those for whom the instrument is intended. The organizations' quality assurance managers or the general managers were the subjects used in this study because they are likely to be the most knowledgeable about quality management.

For the purpose of this study, only manufacturing organizations were considered since the quality management practices of such organizations were relatively more sophisticated, or at the very least more completely developed. The main source for the preparation of the sampling frame was *Industrial Guide of YEMEN* 1998 Published by Yemen Commerce body.

For reasons of practicality, managers were chosen from organizations in the four major cities of Yemen: Aden, Taiz, Sanna, and Hodedha. General Managers, Quality Assurance Managers, and Production Manufacturing Managers of these manufacturing organizations were personally contacted twice. First, to participate in this study, and subsequently to assure response to the survey questionnaire.

Research Instrument

For the purpose of this study, the instrument developed by Saraph *et al.* 1989 to evaluate quality management practices in manufacturing or service organizations was used. This instrument was used because the measures are empirically based and shown to be valid and reliable, and the instrument measures directly or indirectly all the critical factors identified in this study.
The internal consistency method was used to test the reliability of the instrument. Internal consistency was estimated using the reliability coefficient Cronbach's alpha (*a*). The reliability coefficients (*a*) of the measures ranged from 0.79 to 0.91 (see Table 2). Reliability coefficients of 0.70 or more are considered adequate [Nunally, 1977; Cronbach, 1951; Murphy and Balzer 1989].

Data Analysis Procedure

For the purpose of analyzing the data, frequency distribution and basic statistics such as mean, standard deviation, and variance were computed. The means and standard deviation were calculated using Fisher's Least Square Difference (LDS). Fisher's least

square difference procedure provides a measuring stick for comparing the amount of separation necessary between any two-sample means before a significant difference can be declared to exist between the corresponding population means.
The nine hypotheses formulated for this study were tested for statistical significance using the correlation coefficient. The Pearson coefficient of correlation is a measure of the strength of the linear relationship between two variables *X* (dependent variable - level of quality) and *Y* (independent variable - nine critical factors).

4. DATA ANALYSIS AND INTERPRETATION

The results of the statistical analysis are presented in this section. First, a summary of the characteristics of the sample is presented. Next, results pertaining to research questions and hypotheses testing are reported. Finally, the results are interpreted and discussed.

Characteristics of the Sample

The participated different Managers of Yemen manufacturing organizations served as respondents in this study (representing a response rate of 97 percent). The high response rate was a direct result of the personal contact approach used. Although this method is time-intensive and impracticable in many cases, it proved effective for this study. Table 3 provides summary information, in the form of frequency distributions, for the respondents who participated in the survey.

5. INTERPRETATION OF THE RESULTS

Manufacturing Objectives

The questionnaire used in this study identified for major manufacturing objectives: producing quality products, meeting production schedules, manufacturing low-cost products, and improving work productivity. Managers were asked to assign ranks to each category on the basis of their rating of its importance as a manufacturing objective. Though producing quality products and services is not the primary manufacturing objective, it does not lag for behind, as depicted in Table 4. In contrast, the objectives of low-cost production and improve work productivity were ranked lower. The respondents felt that these objectives had already been implemented successfully.

Causes of Quality Problems

The questionnaire identified seven causes of quality problems: workmanship or workforce, materials or purchased parts, maintenance or adjustments of process or equipment, poor design of process or equipment, poor product design, inadequate systems of controls, and management errors [Garvin 1984].
Managers were asked to assign ranks to each category on the basis of their rating of its importance as a cause of their organizations' quality problems. Table 5 indicates the rank order of the causes of quality problems faced by Yemen manufacturing organizations. Out of the seven causes stated in the questionnaire, materials or parts purchased and maintenance or adjustment of process of equipment were the most important causes of quality problems while an inadequate system of control and management errors were ranked the least important.
In order to solve the quality problems, Yemen manufacturing organizations are adopting the concept of sharing or joint responsibility. Purchasing, design, marketing and

productions departments are working together to achieve quality goals. Many organizations are also trying to involve vendors as part of this integral system.

Testing the Research Hypotheses

Tables 6 and 7 show the results of correlation analyses for these variables. From Table 6 it can be seen that there is a highly significant negative correlation between assembly-line rejects and quality policies, the role of the quality department, and quality data. Since training, vendor quality management, and process design were independent variables that resulted in decreased assembly line rejects, there exists a positive relationship is brought about by the reduction in the level of rejects.

Similar results existed when studying the relationship between after-delivery reject rates and the independent variables - quality policies, role of the quality department, quality training, vendor quality management, process design and quality cost data (see Table 7). On the other hand, no significant relationship was found between after-delivery rejects and the independent variables - top management involvement, product design, and feedback and employee relations.

Factor 1: Top Management

According to quality experts, successful quality performance requires that top management is dedicated to that goal Crosby 1979, Juran 1989 . In other words, those in top management must provide the initiative for successful quality assurance practices and must support the quality programme in the organization if such a programme is to be successful. This study suggests that top management of Yemen manufacturing organizations was involved in developing quality policy; however, implementation was strictly accomplished by the efforts of the quality department personnel. This could be attributed to several reasons, First the primary manufacturing objective of Indian organizations surveyed is meeting the production schedule. Second, the quality department personnel are responsible for quality performance rather than the top management. Third, cost and schedule objectives take precedence over quality objectives at the top management level. Finally, quality issues are not reviewed on a regular basis at top management meetings.

Factor 2: Quality Policies

Research has shown that attitudes and philosophy alone are seldom enough to improve quality. A company's programme, policies and systems are the practical representations of its attitudes towards quality Garvin 1983, Juran 1978, Mohanty 1988 . Quality policies give substance to more ethereal attitudes and philosophies, providing support and directions. Ninety-six percent of the organizations studied maintained formal quality policies (Table 3). These policies were in written form and were approved and endorsed by top management. Also, a consistent operational definition of quality existed throughout the organization.

This study offers significant statistical support for the hypothesis that specific quality policies are the practical embodiments of an organization's attitudes towards quality, and therefore help in improving the level of quality. This can be attributed to several reasons. First, in the Yemen organizations surveyed, well-documented quality policies with clear objectives existed for each and every department in the organization. The

quality policies were oriented mainly towards customer satisfaction. Second, the organizations' policies concerning quality were determined by the achievement of the following goals: compliance with government regulations and profitability. In order to satisfy customer needs, the organizations tried to meet the specifications provided by the customers and the standards stipulated by the Yemen Standard Committee. Finally, these quality policies were reviewed periodically. According to the respondents, all levels of personnel were aware of their responsibilities towards quality.

Factor 3: Role of the Quality Department

Research has shown that for organization to be efficient, the quality department should be visible, autonomous and have direct access to top management [Crosby, 1989; Leonard and Sasser, 1982 and Mondon, 1982] . Ninety-six percent of the organizations studied operated independent quality departments (Table 3). In most organizations the quality assurance department was managed by the General Manager of Quality Assurance. In others, it was under the control of the Industrial Engineering or Manufacturing Manager. Some organizations also had separate inspection departments in each plant directly under the Technical Manager of that plant.

This study offers significant statistical evidence to support these results. The major responsibilities of the quality departments in Yemen manufacturing organizations include formulating and improving major quality improvement programmes and working closely with other departments. Procedures for quality control covered the entire business, from development to marketing, purchasing, manufacturing and distribution. The quality departments also prepared various types of summary reports of defects and failures at the various stages of processing and final inspection.

Factor 4: Training

This study extended significant statistical support for the hypothesis that emphasis on quality training improves the level of quality. This evidence is consistent with the finding of [Juran, 1978; Crosby, 1979; Deming, 1986 and Mondon, 1982] that, if an organization is to grow and prosper, a formal quality training programme must exist. Effective and efficient training programmes to educate and communicate a focus on quality to managers and employees were present in each of the organizations studied. In addition to on-the-job training, off-the-job training programmes, specifically in the form of classroom exercises, were being used. Training in special processes, advanced statistical methods, and the use of sophisticated measuring equipment also existed. Even though some managers complained that the training programmes were merely academic exercises and were not understood by the illiterate workers, most of the respondents to the survey indicated that the training programmes played a significant role in improving the quality of the organizations' products and services.

Factor 5: Product Design

This study provided no significant statistical support for the hypothesis that systematic product design improves the level of quality. This contradicts earlier results reported by [Adam et al., 1981 and Mondon, 1982], that product design practices provide the ideal starting point for a study of quality performance. In Indian organizations, the development of products and the establishment of product and process design are the activities of the research and development department. However, about 30 percent of the participations surveyed did not operate their own independent research and

development department. Research and development activities were present only in some organizations at corporate level, whilst in most they were at lower levels. This supports the finding of [Mohanty,1988]. Other complaints included the lack of sufficient interaction between the research and development department and the quality assurance and manufacturing departments.

Factor 6: Vendor Quality Management

Most Yemen organizations have realized that working with vendors to improve their quality systems, as well as improving their own systems, is a key to success. This study provided significant statistical support to indicate that organizations that worked closely with their vendors had fewer problems with materials or parts purchased and had a higher level of quality, and vice versa. This evidence supports the findings of [Adam et al., 1981; Juran, 1978]. In Yemen, unlike other Arab contries, there is a desire to have alternate vendors (in relation to a single source) for as many materials as possible in order to ensure availability of supply and to provide purchasing leverage. More than 90 percent of the respondents indicated that price, given a certain minimal level of quality, was yet the foremost criterion for selecting vendors. However, respondents also indicated that a standard system of providing feedback to suppliers concerning the quality of their raw materials existed, that technical assistance was also provided to vendors, and that plant personnel often visited vendors to help in problem definition and resolution.

Factor 7: Process Design (Statistical Quality Control)

Statistical quality control provides means for analyzing the process, continually improving the process, and controlling the product quality through control of the process [Deming, 1982] . This study offered statistical support for the hypothesis that a comprehensive process design improves the level of quality, thus supporting the earlier findings of [Crosby, 1979; Deming, 1981; Garvin, 1983; Juran, 1978 and Mondon 1982].

Quality control activities in Yemen are based mainly on the application of statistical quality control techniques. Most organizations studied maintained an effective system for monitoring incoming raw materials, checking in-process production, and reviewing finished products. Statistical quality control techniques were extensively used by these organizations to:

(1) decide whether to accept or reject lots of products purchased or made within the company; and
(2) spotlight and correct process discrepancies.

The Yemen Standards Committee also helps these organizations by providing services for the installation of statistical process control systems and also providing training for personnel involved with such systems.

Factor 8: Quality Data

Availability and the use of quality data, especially quality cost data, is an essential ingredient of a strong quality programme [Crosby, 1979; Deming, 1979 and Juran, 1978]. This study provides significant statistical support to the hypothesis that the availability and use of quality cost data improves the level of quality. This could be attributed to several causes. First, most of the organizations surveyed reported having an efficient quality cost reporting system that maintained data on vendors, defect or

failures, error rates, scrap, warranty reports, cost of prevention, cost of appraisal, and customers' complaints. Second, these data were available for all divisions and were updated on a regular basis, Third, the quality data were not only available to managers and supervisors but also were displayed in the form of control charts at employee workstations for full-time and hourly employees to examine. Finally, quality data were used by organizations as tools to manage quality and to make necessary quality improvements.

Factor 9: Feedback and Employee Involvement

This study offers no statistical support for the hypothesis that proper feedback and employee involvement in quality efforts improves the level of quality. This contradicts earlier findings of [Ishika, 1976; Leonard and Sasser, 1982 and Mondon, 1982] and supports the findings of [Mohanty, 1988]. This may be attributable to the following causes. First, among the organizations which had introduced employee involvement programmes such as quality circles for tackling quality-related problems, some indicated that their circles had become non-functional. Second, in most organizations what was most lacking was the appreciation for quality performance at all levels. in most organizations, employee promotions were not based solely on quality performance. Finally, even though individuals in some organizations were honored with rewards for superior performance in their tasks relating to quality, this was often done on a random basis and did not form a part of the documented quality policy.

6. MANAGERIAL IMPLICATIONS

The model and the research methods used in this study have several important implications for managers. First, this method can be very useful to an organization attempting to identify those characteristics often mentioned in the quality literature that may provide an opportunity to increase the level of quality in a specific environment. The model developed in this article (see Fig. 1) illustrates one approach to implementing quality assurance programmes. The approach described in this research begins by identifying these significant operating variables to obtain a better understanding of the existing quality management practices and to assign responsibilities within the organization for achieving organization-wide improvements in quality. Finally, after plans for improvement have been made and implemented, the methodology reported in this study can again be used by managers to re-evaluate the organization's position and to evaluate the cost-effectiveness of further improvements. The analysis of the new organization position may point to variables where further actions could bring about quality improvements.

7. CONCLUSIONS AND FUTURE DIRECTIONS

Two major conclusions emerged from this study. First, contrary to what was hypothesized in the model, it is not necessary for all the factors to be present to ensure the success of the total quality programme of the organization. In other words, even if a few of the factors were not present, it was possible to obtain the required level of quality. For example, in the organizations studied effective quality levels were obtained even in the absence of top management support, proper product design and continual feedback about quality processes.

The second conclusion relates to the practical application of some of the findings. Managers, regardless of their position, expect an organization to implement these

critical quality factors to a great extent. Thus, the factors seem to be somewhat universally acceptable and consistent with the findings of [Garvin, 1984; Saraph, 1989] and other quality philosophers. To remain competitive in quality, managers must carefully review how these critical areas of quality assurance fare in organizations and must constantly improve practices in areas where deficiency is perceived.

In an exploratory study such as this, recommendations for future research should address the issues generated in this study. First, a replication of this study should prove helpful in re-examining the validity of its findings. Further empirical studies using larger sample and greater geographical diversity may be helpful in validating specific parts of the model proposed in this study.

Another area of future research should be to expand on this study and include more variables so that the applicability of the findings could be improved. This study did not include behavioural and cultural factors in the formulation of the propositions. Future researchers should use the same general format of this study, and include some of the variables mentioned above.

Finally, based on the results of the study and the data collected, cross-cultural comparisons of Indian quality management practices with quality management practices incorporated by manufacturing organizations in other countries can be useful for both organizations and countries wanting to compete effectively in the global market. Studies of such a nature would help in identifying successful organizational factors or successful quality practices that lead to superior quality performance.

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Table 1: Organizational Requirements for Effective Quality Management

Concepts	Deming	Juran	Crosby	Ishikawa	Feigenbaum	Garvin	Saraph
Top management	X	X	X		X		
Quality policies	X	X	X		X	X	X
Role of the quality department	X	X	X	X			X
Training	X	X	X	X	X		X
Product design		X	X		X	X	X
Vendor quality management	X	X				X	X
Process design	X	X	X	X		X	X
Quality data	X	X	X	X		X	X
Feedback and employee relations	X	X	X	X	X	X	X

Table 2: Reliability of Factors Affecting Quality

	Number of Items	
Factors	per factor	Alpha(α)
Top management	7	0.7989
Quality policies	6	0.8870
Role of the quality department	5	0.8763
Training	8	0.7978
Product design	6	0.8146
Vendor quality management	8	0.7988
Process design	11	0.9066
Quality data	8	0.8487
Feedback and employee relations	8	0.8500

Table 3: Respondent and Organization Information

	Number	Percent
Respondent Information		
Position or Title		
General Manager	37	50.7
Quality Assurance Manager	21	28.8
Director (Manufacturing)	15	20.5
Total	73	100.0
Years of experience		
> 16	29	39.7
16 to 20	28	38.4
11 to 15	15	20.2
< 11	2	2.7
Total	73	100.0
Characteristics of the Organization		
Industry type		
Food processing	27	37.0
Engineering	24	32.9
Other manufacturing	22	30.1
Total	73	100.0
Total sales volume (in million of Reyals)		
251-750	15	20.6
751-1250	19	16.0
1251-1750	19	16.0
1751-2250	10	13.7
>2251	10	13.7
Total	73	100.0
Number of employees		
500-999	29	39.7
1000-2499	19	26.1
2500-4999	9	12.3
>5000	16	21.9
Total	73	100.0

Quality policy		
Formal written	70	96.0
Informal	3	4.0
Total	73	100.0
Quality department		
Organized/separate	70	96.0
No Separate	3	4.0
Total	73	100.0

Table 4. Relative Importance of Manufacturing Objectives
(N= 73)
Rank of Objectives Mean Score [ab]
1. Meeting Production Schedule 1.671(μ_1)
2. Producing Quality Products 1.822(μ_2)
3. Low Cost Production 2.795(μ_3)
4. Improve Work Productivity 3.658(μ_4)
[a] For each objective, respondents rated its importance on a scale of "1" to "4", where represented "the most important objective"
[b] Using Fisher's Least Square Difference Procedure indicated the correct relative ordering of the mean scores at $a = 0.05$ to be: $\mu_1 = \mu_2 > \mu_3 > \mu_4$.

Table 5. Relative Importance of Causes of Quality Problems
(N = 73)
Rank of causes Mean [ab] Score
1. Material/Parts Purchased 2.836(μ_1)
2. Maintenance/Adjustment of 2.836(μ_2) Process/Equipment
3. Workshop/Workforce Problems 3.137(μ_3)
4. Poor Product Design 3.438(μ_4)
5. Poor Design of Process 4.110(μ_5) /Equipment
6. Inadequate Systems of Control 5.521(μ_6)
7. Management Errors 6.041(μ_7)
[a] For each cause, respondents rate its importance on a scale of "1" to "7", where "1" represented "the most important cause"
[b] Using Fisher's Least Square Difference Procedure indicated the correct relative ordering of the mean scores at $a = 0.05$ to be: $\mu_1 = \mu_2 > \mu_3 > \mu_4 > \mu_5 > \mu_6 > \mu_7$

Table 6: Pearson's Coefficient of Correlation for Assembly-line Rejects

Critical factor	*R*	*P*-value
Top management	0.1062	0.186
Quality policies	-0.4344	0.001*
Role of the quality department	-0.3842	0.001*
Training	-0.7233	0.000*
Product design	0.1246	0.147
Vendor quality management	-0.6753	0.000*
Process design	-0.7212	0.000*
Quality data	-0.2821	0.008*
Feedback and employee relations	0.2820	0.242
*P<0.01		

Table 7: Pearson's Coefficient of Correlation for After-delivery Rejects

Critical factor	*R*	*P*-value
Top management	0.0851	0.237
Quality policies	-0.3050	0.004*
Role of the quality department	-0.2586	0.014**
Training	-0.6045	0.000*
Product design	0.0094	0.468
Vendor quality management	-0.5786	0.000*
Process design	-0.6317	0.000*
Quality data	-0.2948	0.006*
Feedback and employee relations	0.0942	0.214
*P<0.01		
**P<0.05		

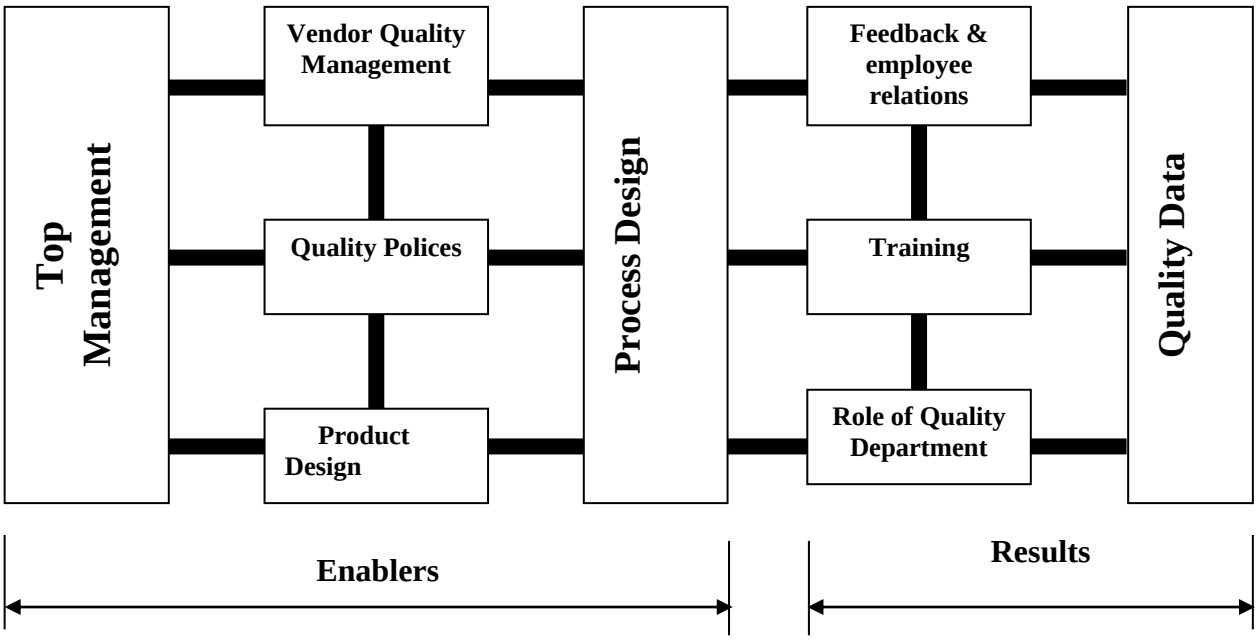

Fig. 1.: Model of Study