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Variables That Affect the Product Quality: A Study in an Electronic Industry of the Manaus Industrial Pole, Brazil

Daniel Nascimento-e-Silva*, Sharla Brunet Costa Valente[1], Chiara da Silva Simões[2], Marison Luiz Soares[3], Dayan Rios Pereira[4]

***CorrespondingAuthor**: Federal InstituteofEducation, Science and Technology of Amazonas, Avenida Danilo de Matos Areosa, 1672, Distrito Industrial, 69075-351 Manaus, Amazonas,Brazil*
[1]Nilton Lins University, Av. Prof. NiltonLins, 3259, Flores, 69058-030, Manaus, Amazonas, Brazil.
[2]Lutheran University Center of Manaus, Av. Carlos Drummond de Andrade, Conjunto tílio Andreazza, 1460, Japiim, 69077-730, Manaus, Amazonas,Brazil,
[3]Federal Universityof Espírito Santo, Avenida Hugo Musso, 2370, Apart. 1404, Praia de Itapoã, 29101-786 Vila Velha, Espírito Santo, Brazil.
[4]Federal Institute of Education, Science and Technology of Pará, Campus Castanhal, BR 316, Km 61, Saudade II, Cristo Redentor, 68740-970Castanhal, Pará, Brazil.

Abstract: *This work identified the main variables that affect product quality in an electro-electronic industry that operates in the industrial center of Manaus. It is an exploratory, quantitative study, whose data were collected with the help of a five-point Likert scale organized questionnaire that used the mean and standard deviation to generate the desired results; The questionnaire was constructed based on three dimensions (production, quality and engineering), each with its analytical dimensions; The population consisted of 11 members of the quality team of this industry. The results showed that quality can be affected by raw material, manager involvement, project quality and validation quality (engineering dimension), adequacy of training, employee awareness, work instructions, welding process replacement, commitment to product quality (quality dimension), working with the right devices, proper tools and proper material handling (production dimension). The conclusion is that these variables may also interfere with the product quality of other organizations in the electro-electronic segment of the Manaus industrial hub.*

Key Words: *Product quality; Electronics industry; Manaus Industrial Pole.*

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I. Introduction

Product quality can be defined by shelf life (Gaieski, 2009), which is established according to the maximum storage time without any external or internal factors affecting the integrity of the product material. Bonato (2004), taking as an example hay, which is the mixture of mown and dried plants usually grass and legume used as fodder for cattle, shows that the quality is directly linked to the cutting season. The product quality is then due to vigorous growth, nutritional value and increased nutritional value provided. Juran (1990) and Montgomery (1996) explain that the quality of the whole is defined by its suitability for use. But consumers are the main influencers for defining the characteristics adopted by companies in their projects.

Gitlow (1993) shows that product or service quality is exceeding customer expectations. Each service or product has its characteristics or definitions established in the project; However, quality is only achieved when customer expectations are exceeded. Reeves and Bednar (1994) define product quality through several characteristics, such as having a high-performance profile, using expensive and better-quality materials, using well-defined design specifications, conformity between the specified and the physical product, uniformity among others. the products or services produced, suitability for use of the products according to the customer's definitions.

Campos (1992) understands differently: the intrinsic quality requirements would be cost, delivery, morale and safety. ISO 8402 of 2002 defines quality as customer satisfaction. This implies that the requirements desired by customers must have in the product or service, as well as the implicit characteristics, being a way to be different in the competitive market. Product quality would also be directly linked to two aspects: design and shaping (Vieira, 1999), which represent the operations performed to obtain a product, according to the specifications or standards established (Pasqua, 1999). , but which may be affected by indirect variables such as the environment (Macdonald andClarck, 1989; Haddad and Castro, 1998).

For Soares and Nascimento (2007), the quality of the product or service is an antecedent of consumer satisfaction. The reason for this is that the quality of a product is related to consumer perception

(Parassuraman,Zeithaml and Berry, 1988), who reason from the customer's perception of the product: whether or not it is within their expectations. This means that if the service is higher than expected by the customer, it is considered of excellent quality; if not within the standard, it is considered to be of inferior quality, even if it is within the profile desired by the service company. The end customer is the primary evaluator of any product or service; Thus, companies aim to conquer them so that they are always competitive in the market.

Pinto (2009) considers the product quality composed of a set of three aspects: interaction, physical environment and result, called second order constructs. These in turn are derived from three relevant aspects: reliability, readiness and empathy, considered first order constructs. The end result of quality can be interpreted from various segments of reality, such as human life, as a product that may or may not have quality (Fleck et al., 1999). This is due to several factors that may influence the physical or psychological health of the individual and that influence their quality of life (Schmidt, 2004). From the analysis of data obtained and exposed above, product quality can be defined as the adequacy of product characteristics, perceptions and specifications by customers meeting their needs.

Chart 1. Examples of variables that affect product quality

AUTHOR	VARIABLES	TIPOLOGY
Soares and Nascimento (2007)	Technological properties Water absorption; Mechanical resistance	Technological Environmental
Marques (2010)	Temperatures	Environmental
Vassalo (2010)	Simulation	Production process
Jesus (2006)	Hydrometeorological conditions Infrastructure Management	Environmental Management
Gaieski (2009)	Drying	Production process
Cordioli, Oldra and Schmitt (2009)	Increased production	Production process
Bonato (2004)	Process; Mechanized system; Operating conditions; Raw material; Workers; Methods; Process and mechanized system Climate; Temperature; Air humidity; Wind speed; Solar radiation; Rains; Soil fertility; Climatic limitations	Production process Environmental
Parasuraman, Zeithaml and Berry (1985)	Design and marketing Service Provision	Management Production process
Gronroos (1995)	Technical aspects inherent to the service rendering process	Production process
Pinto andGouvêa (2009).	Quality of interaction; Quality of the result; Waiting time; Tangible aspects Attitude; Behavior; Expertise; Workers	Production process Social
Azevedo (2003)	Storage	Production process
Corvello (1999)	Low quality seeds	Production process
Kageyama (1992)	Employed packaging	Production process
Carvalho and Nakagawa (2000)	Storage; Physiological quality; Packing Climate conditions; Environment Characteristics	Production process Environmental
Rocha (2006)	Mental and physical health; cognitive function Social role; Social support; Relationship with the partner; Sexual function; Social and educational conditions Financial situation	Health Social Finance
Gotardo (2207)	Culture and customs	Social

Variables that interfere with product quality can be grouped from the literature into various analytical dimensions, predominating environmental, production and social processes, as shown in chart 1. Environmental variables are those related to environmental variables, which includes the external and internal environment of organizations and their production units. Several studies attest to the influence of natural variables on product quality, such as those of Marques et al (2010), concerning temperature; Jesus (2006) on hydrometeorological conditions; climate, temperature, air humidity, wind speed and mainly solar radiation, according to the study by Bonato (2004) and Carvalho and Nakagawa (2000).

The variables cataloged here as arising from the production process are those identified within a given production process. These variables can be derived from several factors, as the process itself is formed by several interconnected activities. When a process is defined, it must meet several criteria for it to be performed as specified. Thus, when any problems that make it difficult to execute a process occur, it cannot be properly executed. These potential issues can range from an incorrect way to assemble a part, a nonconforming part that makes it impossible to assemble a specific product or even conflicts between employees.

Several studies attest to the influence of production process variables on product quality, such as Soares and Nascimento (2007), who confirmed that product quality can be interfered by technological properties, regardless of their compositions or properties; Vassalo (2010) and Marques et al. (2010) found that simulation also interferes with quality, since satisfactory results from a simulation can validate the product with those test specifications; Gaieski (2009) and Jesus (2009) and Corvello et al. (1999) demonstrated that the drying process influences the quality and durability of grains; Cordioli, Oldra and Schmitt (2009) attested that increased production may interfere with the quality of a product.

Parassuraman (1985) lists several variables that interfere with the quality of a product in terms of design, marketing and service delivery. These factors affect quality, as much as the product is within the technical specification or functionality expected by the company, the customer behind the marketing advertising based on its design, in many cases ends up devising a product, which in a way, was disclosed incorrectly, because from the customer's point of view the product is of a lower quality due to non-compliance with the specified by the marketing of the same.

The quality of a product derives from technical aspects and aspects inherent in the service rendering process (Gronroos, 1995). Each and every good or service has technical aspects that must be followed, in order to be directly linked to the means of execution, process. Thus, its quality to be obtained must meet its specifications, otherwise it is non-conforming.

The person or collaborator who performs a certain activity is responsible for the quality of the final product (Pinto, 2009). When a company hires or assigns someone to perform an activity, however trained, the company should train it as needed or to avoid potential nonconformities. If the employee, even if trained, cannot perform that activity as desired, the activity should be directed to another that may feel able to make not only the product, but the quality process.

The study by Kageyama et al. (1992) showed that the packaging employed in the product may interfere with the quality of the final product. Packaging can cause major damage to the physical and functional structures of a material or product. Carvalho and Nakagawa (2000) found that product quality is affected by factors such as storage, which can cause major damage to material quality and the finished product.

Social variables constitute the third analytical dimension and correspond to those related to the people involved with a specific product. These variables can come in many ways, depending on how you are currently feeling. Pinto's research (2009) has shown that product quality can be influenced by the attitude, behavior and expertise of community members. However, the quality of the result is derived by the constructs of time, wait and tangible aspects. Thus, it can be defined that the quality of a product depends on the quality of other aspects that are within the system to which they belong.

Rocha (2006) considers mental and physical health, social, cognitive function, social support, relationship with partner, sexual function and financial situation as interfering with product quality. These are variables that influence the human factor and if any of these are bothering the human factor, will be prone to possible failures, due to lack of concentration influenced by some reason described above.

Rocha (2009) cites social and educational conditions in the same line of reasoning used for social conditions, as well as educational conditions. What is common today is that the education acquired by many is according to their social level, but as most do not have higher conditions ends up acquiring education below or in the social standard. A person who studies and qualifies more quickly understands the importance of producing in the right way and helps to avoid mistakes. Theoretical and practical quality related to the product can be better used and understood according to the social and educational conditions of the individual. Finally, Gotardo (2007) and Rocha (2009) consider the social and psychological factors of the individual as a means of influencing product quality but consider the culture and customs to which the person is involved.

There are numerous dimensions (typologies) and analytical categories (variables) that interfere with product quality. This study focused on just three of them: engineering, quality and productionto know what are the factors that affect the product quality of an industry in the electronics sector that operates in the industrial hub of Manaus, Brazil. The engineering dimension involves all product planning factors, including management team support for the individuals, machines, and equipment available; The quality dimension focuses on the factors arising from the product's compliance with the specified requirements; while the production dimension encompasses all factors related to the materialization of the product.

II. Materials And Methods

The methodology used to achieve the objective of this study is in accordance with the suggestion of Nascimento-e-Silva (2012), which recommends a survey study for these cases, where the population size is small, generally smaller than 40. To facilitate the study, three ancillary research questions were designed: a) what are the engineering variables that interfere with product quality?, b) what are the quality variables that interfere with product quality? and c) which are the production variables that interfere with product quality?

The study was developed within an exploratory research typology, since the purpose of the study is merely to identify the variables that interfere with the product quality from the analytical dimensions created for this purpose, without assessing associations or causal relationships between them. The type of research is quantitative, given that the answers to the questions were generated from the numerical data treatment. The unit of analysis was individual, whose data represent the evaluation of each member of the quality team, taken individually, and the level of analysis was group, since the results only account for the perception of this group of collaborators. The perspective was synchronic (also called transverse), ie it is a portrait of the current situation, rather than a panoramic view over time that configures longitudinal or diachronic perspectives. The population consisted of 11 members of the company's quality team. No sampling was done.

Data were collected through a questionnaire containing three types of questions. Control questions were aimed at sample control to prevent non-quality staff from filling out the questionnaires; Demographic issues dealt with age, gender, education and working time in the company, so that a profile of respondents could be assembled; and the explanatory questions, grouped into three analytical dimensions: engineering, production and quality.

The following were cataloged as engineering dimension variables: team motivation, raw material quality, number of hours worked, manager involvement, project quality and project validations. The production dimension variables were suitability of devices, suitability of tools, suitability of materials and advance of assembly. The quality dimension variables were employee orientation during assembly, monitoring of activities by the leader, adequacy of training, employee awareness, process monitoring by quality personnel, ease of understanding of work instructions, welding process, attention to work process and commitment to quality. These variables made up the questionnaire.

Control and demographic issues were constructed by nominal variables; the explanatory, interval. For intervals, the questionnaire was based on a five-point Likert scale. At the lower limit there was the alternative “completely disagree” and at the upper limit the alternative “completely agree”. The central alternative was “Neither agree nor disagree” to demarcate indifferent assessments. Intermediate positions, both in relation to the lower bound (largely disagree) and the upper bound (largely agree) denoted the gradation of the scale. These guidelines were part of the questionnaire in the item “Instructions for completion”, to avoid construct validity problems.

Data were first organized with the help of spreadsheets; They were then transferred to the Statistics Package for Social Sciences (SPSS), where the tables were generated, and the means and standard deviations of each variable included in each analytical dimension were calculated. Averages are statistical measures representative of the central trends of a data set if that data is normal; if not, the median is used. This means that an average of 2.0 synthesizes the behavior of a data group around the 3.0 value of the scale used; The same happens with the value 4.0, to summarize the fact that most of the values found are close to or tending to 4.0. To generate a low average, most respondents must score low for the question, while high scores represent high ratings.

This logic was applied to this investigation: the average synthesizes the position of the quality group of the investigated company, that is, the closer to 5.0, the greater the tendency to positively evaluate the affirmative of the questionnaire; conversely, the closer to 1.0, the greater the tendency for disagreement (Nascimento-e-Silva et al, 2007a; 2007b). The central point 3 of the scale divided these two possibilities of results, positive or negative. In order to make the results more accurate, both the left and right sides of the scale were subdivided, counting 0.5 points from the center point to the left and right, so that five zones were obtained. averaging results.

The zone of full disagreement framed the averages between 1.0 and 1.5 inclusive; the relative disagreement zone comprised the averages between 1.6 and 2.5 inclusive; the intermediate or indifference zone varied from 2.6 to 3.5 inclusive; the relative agreement zone averaged between 3.6 and 4.5, inclusive; and the zone of full agreement included the averages between 4,6 and 5,0.

Standard deviations marked the differences in valuations between the answers obtained. In non-mathematical terms, this means that standard deviations measure disagreements. Thus, in this research, standard deviations greater than 1.0 were considered as demonstration of lack of consensus among respondents. This happens when one subgroup evaluates the same question negatively and another equivalent subgroup evaluates positively. When all or most respondents evaluate the question in the same way, the difference in these evaluations tends to zero, i.e. the value of the standard deviation will approach or equal to 0.0. Thus, the lower the standard deviation, the greater the degree of consensus among the respondents of an investigation.

As the average informs the group's positioning in relation to each component variable of each of the analytical dimensions of this research and the standard deviation evaluates whether or not this positioning is consensual, the logical scheme used to generate the answer for each question was as follows: according to the mean, the response will be disagreement (full or relative), indifference or agreement (full or relative), and consensual or otherwise, according to standard deviation of up to 1.0 or greater.

The internal validity of the instrument was measured by Cronbach's alpha of 0.89, considered strong enough for the purposes of this investigation. Before, however, the questionnaire was adjusted so that the respondents could adequately understand the questions and could evaluate each component variable of the analytical dimensions. This procedure was necessary to ensure construct validity.

Data analysis and discussion of results were organized in two parts. First, the characteristics of the respondents are shown, to configure the group profile, and then the results achieved are presented and simultaneously discussed. Information regarding the respondent's age, gender and length of company were obtained, which configures the characterization of the respondents. This procedure was necessary in order to have the profile of the respondents and thus be better understood the results presented for the explanatory questions of this research.

III. Results And Discussion

The results allowed us to frame the company's quality team components as young adults. The sample size was 38 years, with 9 respondents up to 40 years old. Regarding gender, women correspond to 81.8% of respondents, nine participating women, which gives them the majority among those responsible for product quality in the company. These data seem to confirm the assumption that females are more apt to handle minutiae, details. This explains, therefore, the predominance of women in activities of this nature, typical of quality teams.

Regarding the level of education, the complete high school category has the highest percentage value in relation to attendance, 63.6%; However, in relation to incomplete high school and complete higher education, the frequency was the same, 18.2%, totaling 100%. These results indicate contestable intellectual training to deal with product quality issues, which would require at least the complete high school of all members. Regarding working time, most correspondents have less than 1 year in the company, equivalent to 54.5% of the frequency and accumulated frequency. From 4 to 6 years old, the frequency was 45.5%, the difference between the frequency of respondents is small, but their values are different. It is therefore a team of short time working in the researched company.

The results related to the engineering dimension variables presented results consistent with the questions asked. This means that product quality can be fully affected by raw material quality, manager involvement, project quality and project validations. Although there is no consensus, the motivation and overtime variables also impact product quality, as shown in Table 1.

Table1.Results of Engineering Dimension

Questions	Average	SD	Result
Product quality increases when I'm motivated	3,6	1,2	Non-consensual relative agreement
Product quality increases when raw material quality is adequate	5,0	0,0	consensual full agreement
Product quality decreases with excess hours worked	3,4	1,1	Non-consensual relative agreement
Manager involvement increases product quality	4,4	0,5	Consensual relative agreement
When projects are poorly designed, product quality decreases.	5,0	0,0	consensual full agreement
When validations are poorly performed, product quality decreases.	4,6	0,7	consensual full agreement

These results seem to indicate that the technical aspects, which characterize engineering as an analytical dimension, predominate in importance over non-technical aspects, such as human and labor aspects. This does not mean, however, that the latter are not important, so much so that motivation (human aspect) and excessive working hours (labor aspect) were considered by respondents as variables that affect product quality. However, if we compare both the averages and standard deviations of these variables with the typical engineering ones, we will see a huge difference.

Regarding the questions defined for the quality dimension, it can be seen from table 2 that the respondents agree that, except for the leader and his follow-up in activities, all variables interfere with product quality. This means that training, work awareness and commitment are consensual variables among respondents that decisively influence product quality. Guidance on assembly, process follow-up by quality department personnel, ease of understanding of instructions, replacement of welding by connection and attention are variables that interfere with product quality, but no consensus was detected. Finally, the leader remains an important figure in ensuring product quality.

Table 2. Results of Quality Dimension

Question	Average	SD	Result
When I am not oriented during assembly, product quality decreases	4,5	0,7	Consensual relative agreement
When my leader does not follow my activities, product quality decreases	2,6	1,3	Non-consensual relative disagreement
When I have the right training, product quality increases	4,7	0,5	Consensual full agreement
If each employee were made aware of the importance of their activity, product quality would increase	4,9	0,3	Consensual full agreement
When quality people follow the process, product quality increases	4,4	0,8	Consensual relative agreement

When I receive easy-to-understand work instructions, product quality increases	4,5	0,5	Consensual relative agreement
If the welding process is replaced by connection, the product quality increases	4,2	0,9	Consensual relative agreement
When I'm inattentive, product quality decreases	4,2	1,2	Non-consensual relative agreement
When I am committed the product, quality increases	4,8	0,4	Consensual full agreement

These results indicate that quality itself is affected by relational and individual variables. So much so that training, guidance and follow-up appear as relational aspects that ensure product quality. Individual variables (such as attention and commitment) also gained importance, according to the study respondents. The logical scheme that connects these two blocks of variables is that through the individual's relationship with group members, whether to receive guidance or training, and with their hierarchical superior to have the necessary follow-up, they seem to impact commitment as well as the attention given to them. to your activities. The non-relational technical variable related to welding also obtained consensual but not absolute agreement, as shown by the results in table 3.

In the variables pertinent to the production, the averages obtained were higher than 4.0, indicating agreement with the formulated questions. In addition to the agreement, the average values were high, indicating full agreement that suitable devices, tools and materials are fundamental to guarantee the quality of products from the production point of view. On the other hand, advancing the assembly, despite being considered a variable that interferes with the quality, presented a high standard deviation, denoting a lack of agreement on this.

Table 3. Results of Production Dimension

Question	Average	SD	Result
When I work with the right devices, product quality increases	4,8	0,4	Consensual full agreement
When I work with the right tools, product quality increases	4,7	0,5	Consensual full agreement
When handling materials properly, product quality increases	4,8	0,4	Consensual full agreement
When advancing subassembly, product quality increases	4,4	1,2	Non-consensual relative agreement

These finds show that product quality is due to the proper handling of materials (components) from the proper application of appropriate devices and tools. This scheme, according to respondents, needs to be carried out over a certain period, with minimum and maximum limits, so that if this specified time is not obeyed, the quality of the product is compromised. There must therefore be a synchronization between each step of the production process, each with the correct handling of materials, devices and tools.

IV. Conclusion

This study identified the main variables that affect the product quality of an organization active in the electro-electronic sector of the industrial hub of Manaus, Brazil. The results pointed out that the adequacy of the raw material, the involvement of the managers, the adequate elaboration of the projects and the adequacy of the evaluations are variables that interfere in the product quality from the engineering point of view; orientation during assembly, proper training, employee awareness, process monitoring by quality personnel, ease of understanding of instructions received, welding process replacement and quality commitment are quality variables that interfere with product quality; and suitability of devices, tools and material handling are the variables that interfere with product quality from the production perspective.

Thus, product quality is influenced by these three aspects (engineering, production and quality), directly or indirectly. These results allow us to empirically suspect that product quality is also a multidimensional phenomenon influenced by its various internal dimensions, as well as, of course, being influenced by other external phenomena and variables. The relation of influence of product quality with these other phenomena can be object of studies from the structural equation models (if studied from the perspective of quantitative phenomena) or multiple correspondence analysis (if studied from the qualitative point of view) or other multivariate techniques.

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