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LIFECYCLE QUALITY

Abstract: *Effectiveness of quality management in the effort to satisfy customers' expectations has been questioned both by academicians and practitioners. In the course of the evolution of quality, very important theories have been developed in the field but failed to satisfy customers' expectation. The aim of this paper is to examine the challenge and develop a new method to address it. Following a literature review on the evolution of the concept of quality, confusions and limitations in the present paradigm are clarified. Then the future quality paradigm is proposed, and two practical cases are presented to substantiate the new approach. Quality management evolved from product inspection at the final stages of the production process. Basically, manufacturers take care of quality up to the point where a product is delivered to a customer. Product failure occurs due to various reasons after purchase. However, this happened or discovered during operational phase of the product which subsequently result in dissatisfaction for the users after purchase. To address this misalignment, all inclusive approach called Lifecycle Quality came into being as the future generation's paradigm. Misalignment between the manufacturer and the customer's desire in the operational phases of a product life-time leads to market loss to the former and dissatisfaction to the latter. Considering lifecycle quality of the product will definitely resolve the occurrence of such undesired outcomes affecting the two parties.*

Keywords: *quality, lifecycle quality, operation quality*

1. Introduction

Both quality and quantity are very important issues in the day-to-day activities of our lives. The decision of right quantity may vary, but the need for quality is always found to be high. Quality of a product is one of customers' ever-changing criteria for purchasing decision making. Due to this reason, nowadays where competition is fierce, quality has become one of the means for the survival of an organization.

The term quality comes from a Latin word *qualitas* which means an attribute or a property. In popular use, the word quality suggests a degree of excellence that is expensive and conforming to a high, perhaps, luxurious specification. Others used it to mean superior in all aspects to others in its class. However, scholarly definitions remain controversial.

According to Deming (2005), quality is all

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about reducing variation and attaining precision and accuracy of production. He argues that shop floor day-to-day fight against variation brings continuous improvement in the processes of key performance parameters. In principle, however, reducing variation mainly depends on the nominal or the average value. A product manufactured with minimum variation may not be a guarantee. For example, a black-and-white television manufactured with minimum variation does not have a market or customers as a color television produced with the same minimum variation.

Juran (1999) defines quality as "fitness for use". This definition has a utility value concept, which varies from one customer to another. On the contrary, customers may purchase products/services to differentiate social status without considering the functional use. In airlines transport, the business class basically determines the social status of the users. Otherwise, the business and economic classes do not have much difference in their functional use of the services.

Scholars of recent years, however, associate the essence of quality with customers' actual experience with the product/service (Kumar, 2014). As a result, quality is measured against requirements which are stated or implied, conscious or merely sensed, technically operational or entirely subjective. It becomes appealing to define quality, briefly; never-ending journey to exceed customers' expectations.

However, there are strong critics of measuring customers' expectation and also on the methodologies to be followed to fulfill those expectations. Expectations are actually a combination of subjective – emotional and objective – functional attributes. They are naturally dynamic that change with time. In Lilja (2006) Kano tries to level functional fulfillment and emotional satisfaction targeted in an attribute. The theory also points out the existence of a category of quality-elements that are of particular interest. The attributes have been given considerable words of praise but have principally failed to be reflected in the current quality practice. For example, Digital Versatile/Video Disk (DVD) was devised many years before it became popular and widespread, because its potential was not perceived by customers in the early stage (Franceschini, 2002).

The quality improvement approach was started by product inspection and progressively developed in depth and breadth. In general, the past Century has been entirely emphasized on 'product quality' during manufacturing only. After the middle 20th Century, the idea of 'product quality' flourished, especially, in the designing stages of products and their processes. However, so far, limited effort has been visible about lifecycle quality that includes the life-time of a product from purchase to disposal.

The critical question left unanswered at present is the methods and techniques to create a satisfied or delighted customer whatever the expectations are. Therefore, the remaining task of this paper is to summarize the past and present approaches of quality paradigms that were/are adopted to enhance customers' satisfaction. It addresses their limitations and produce examples to show what directions the theory and practice of quality will take.

2. Quality Improvement Approaches

Improving ways of doing things dated back to the human civilization time. Scientific quality improvement methodologies emerged as a discipline during the industrial revolution. Since then, manufacturers' concern are also stretched backward to keep quality at the source from the suppliers' side and forward by their after-sales service to support users on the customers' side. Thus quality improvement methodologies have

passed through different phases, namely, quality inspection, quality control, quality management and quality engineering. Each of these phase are explained in brief below (Gidey *et al.,* 2014).

In a quality-by-inspection phase, one or more characteristics of a product are examined, measured or tested, and compared with a pre-specified requirement to assess its conformity. Products which do not conform to specification may be scrapped, reworked, or sold at a discount as lower quality items. This method is an after-the-fact screening process with no prevention content.

In the quality control phase, important characteristics of a product are continuously tested and documented to ensure greater process control and reduce non-conformance. Typical characteristics of this method are performance data collection, feedback to earlier stages in the process, and self-inspection. This led to greater process control and a lower incidence of non-conformance.

Whereas, in Quality Management (QM) phase, quality concepts and principles are applied to all facets of an organization including: sales, finance, personnel, planning, purchasing and other non-manufacturing functions. Total Quality Management (TQM), Six-Sigma and Lean Six-Sigma are recent advancements of this discipline. At company level, QM is the highest form of quality improvement. As a management theory, QM gained a sudden popularity but, according to Larsen (2001), it was soon forgotten or appeared old-fashioned.

In the case quality engineering phase, since it inbuilt qualities in the product and process design, prevention of defects and quality costs are actually begin with the engineering design. The design determines the materials and often the machines, processes and skills required to manufacture a product for the marketplace (Huggins, 1998). This method of quality improvement relied on the product and process design.

As mentioned above, manufacturers are also stretched backward to keep quality at the source from the suppliers' side and forwarded by their after-sales service to support users on the customers' side. As the quality of a product is not only determined by the internal process of a company, organizations tried to stretch their effort back to the suppliers. Perhaps improving the quality of the raw materials, in some organizations/processes, is one of the options to improve quality for the final product. In this direction, a new era is emerging. Organizations are shifting their focus from building their unique competency to efficiently managing their supplies. Such organizations are mushrooming around the globe. It is also estimated that the future competition will be among supply chains other than products or individual organization.

In the forward direction, manufacturers also considered effective after-sales service as a methodology to satisfy customers need. Manufacturers support becomes indispensable for the users. For example, the auto-makers give more emphasis to the after-sales service. According to Ehinlanwo (1996), major players in the automotive industries are dealers or point of sales, and buyers in addition to component suppliers and producers.

The present trend in the car industry is to push for improvements at the dealers' or at the point of sales level. Moreover, realization of the after-sales policies and processes of the producer are also basic to achieve these improvements. Automobile producers realize that "achieving dealer satisfaction is a basis and a requirement for true end-customer satisfaction". Dealer satisfaction can only be achieved when the after-sales policies of the automobile producer take into account factors that are critical for continued dealer success. The critical policies, as far as the dealers are concerned represent the marketing policies of the producers (Ehinlanwo, 1996). In this regard, Lele (1997) proposed three after-

sales services strategies. These strategies are – product design, support system and reducing or minimizing customer risk strategies. Furthermore, products would be categorized as disposable, repairable, rapid response and never fail. For each type of product, different type of after-sales service strategies could be matched. This is partly because the implicit transaction-oriented business philosophy of the manufacturer does not support service offerings. Due to this, a more radical approach is necessary to question the implicit view of the world in which companies operate (Brax, 2005; Gebauer, 2005).

3. Limitations of quality improvement approaches

All the approaches summarized above were important methodologies but fail to achieve the objectives of satisfying customers' expectations. The possible causes are the complexity of defining customers' expectations and limitations of the methods. It is to the latter issue that much attention has been paid in this paper.

About 75% of product features are determined in the early product development that is in the design phase (Nicholas, 2004). Failures, however, occur during manufacturing and operational phases. That means a well-designed product may be defective because of poor manufacturing practices/processes. In addition, even a product manufactured based on the design may fail due to inappropriate use in its operation phase.

Moreover, the real challenges to the product's performance would be realized when it began operation. Failures would be either expected or unexpected. The expected failures could be addressed and preconditions could be fulfilled based on users' feedback. The unexpected failures are most of the time associated with inappropriate use of the product, often left unsolved. In this case, so far, there is no means of questioning the manufacturers except claims on warranty and guarantee. During claims manufacturers may give a warranty or guaranty service to customers. But they do not prevent product failures during operation with warranty and guarantee. Hence, the end outcomes neither extend the life of the product nor ensure customers' satisfaction.

Basically, lifecycle of a product can be divided into two parts that is the suppliers' side and the users' side. However, quality improvement paradigms were entirely focused on the suppliers' side. As discussed in detail above, the aim of quality improvement is, first of all, to prevent the supply of defective products to the users. The second stage of development is focused on minimizing defects level by inspecting at each stage of the manufacturing process. The third phase is an attempt to align internal customer-supplier relationship with that of the external customers' requirements. The entire emphasis of the quality improvement approaches is on the quality of the supplies particularly in the manufacturing phase.

Customers may decide to purchase a product based on a sort of evaluation criteria which might be subjective or objective. Fulfilling these criteria is crucial and is an important quality indicator but, the actors of the supply chain, from manufacturers down to wholesalers and retailers, only consider their business role as ending with the transactional undertaking of product sale. Supplying quality product is not a sufficient condition as long as the operational quality is not ensured. Primary benefit of supplying quality product is to influence the customers' decision. Of course, creating convinced customers who buy the supplied products is the most important and immediate outcome of the manufacturer. Certainly, manufactures must also channel their efforts in ensuring a long-lasting and stable relationship with the final customer through the overall product lifecycle by providing a customised and value-added portfolio of connected services (Cavalieri, 2007).

For example, assume that there are two competent manufacturers who produce the same type of product for the same market. The first one produces by considering the customers' limited knowledge to differentiate important quality parameters of a product and the second produces according to the functional value and specifications of the product design. Which one is bound to win the market? Obviously, the former manufacturer, because it considered customers' knowledge of quality at the moment of the exchange in spite of the latter's position.

As a general rule, customers are influenced by price. Moreover, more knowledgeable customers are also influenced by specifications and standards. There are some customers who do not give due consideration to price because of their deep knowledge about a product specification and standards. This is a rational choice. Some others who do not have accurate knowledge of specifications and standards always prefer cheaper prices. Hence, customers' knowledge about product characteristics, definitely, determines decision at the moment of the exchange. Those who took a wrong decision, 'realize their failure after a while'. In the one hand, the customers themselves are dissatisfied and on the other hand, the manufacturers are also misled by least cost consideration and finally lose their customers. The overall outcome is a loss-loss situation. This phenomenon is common in the developing countries. Since least cost is considered as crucial criteria, manufacturers strive to meet this requirement.

In fact, a correct purchasing decision does not guarantee products' operational quality because it is dependant on factors such as operators, working hours, maintenance, working condition, etc. Design and manufacturing failures are also revealed when the product starts operation. Naturally, the Bathtub Curve clearly presents the probability of failures in the life time of a product in the early intrinsic and wear-out period (Fig.1). Practically, customers' dissatisfaction basically begins during operation when the product malfunctions. At this point, the customers are the losers and the manufacturers are also losing their loyal customers, because the current quality management theories fail to fully address customers' expectations.

In the previous quality trend, employees of an organization had nothing to do with creating a high quality product, supplying at a fair price, and providing excellent service. Rather most of the tasks were done simply to satisfy the internal demands of the company's own organization (Hammer, 1993).

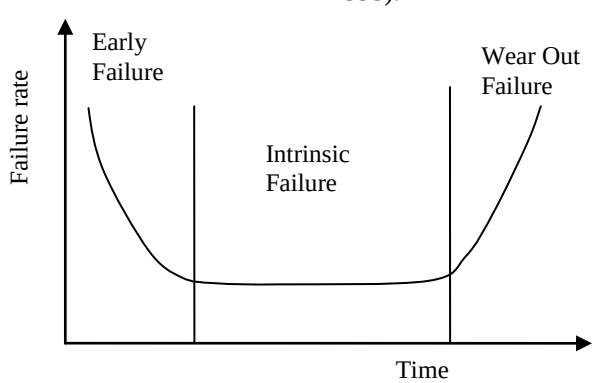

Figure 1. Typical life history of a complex product

Based on scientific advancement theory (Kuhn, 1962), the future of quality could be predicted in two ways. The first prediction is that, the models and theories associated with quality management will become more context-specific. This means more and more emphasis will be given on contingency and configuration theories. The second way is that quality management will have the potential to dissipate away from existing disciplinary structures. In many organizations, today, the quality department and quality-related jobs have been eliminated. The justification given behind this is that, if quality is everyone's job why do we need a separate department to carry out this activity?

Currently, theories in the quality improvement approach seem to follow the first premise which still expanded the concept of quality on the side of the producers. However, the researchers strongly argued and believed that the future direction in the progress of quality should be along the lifecycle of a product. The concept behind lifecycle quality as a new paradigm for quality improvement has not been given attention in the literature so far.

In fact, there are very few researches which try to integrate the concept of product lifecycle with quality practice. Parzinger (1997) proposed a stage-wise application of total quality management through the product life cycle. This research tries to integrate the implementation of quality management at each phase of the product lifecycle. However, the previous studies considered introduction, growth, maturity and decline as distinct stages which are developed based on the sales history of a product as a product lifecycle. Hence, they do not address the objective raised under this study. Dudek-Burlikowska and Szewieczek (2007) integrate quality management and quality control with product lifecycle. Jun (2005) also developed a product lifecycle total quality management system. The study considered product development/ manufacturing lifecycle which does not consider the operation stages of the product. In addition, Tang (2008) developed a data model for quality in the product lifecycle. Still its focus is in the internal matters. The literature under review dealing with Lifecycle costing, Lifecycle management, and lifecycle assessment/analysis are widely available but do not address lifecycle quality.

For instance, Lifecycle costing is an economic method of project evaluation in which all costs arising from owning, operating, maintaining, and ultimately disposing of the project. This approach is considered to be potentially important prior to that decision. It provides significantly a better assessment of the long-term cost effectiveness of a project than alternative economic methods. It focuses only on first costs or on operating-related costs in the short-run. Its objective is limited to the economic analysis of project alternatives and prioritization of independent projects. It is used to allocate a limited budget among such projects within a facility or agency (Fuller, 1996).

Product lifecycle management has evolved from the product data management which emphasize on recording products information across the lifecycle basically to enhance future product and process design. And when quality issues do occur, feedback is gathered centrally to close the loop on quality issues, identify corrective/preventive actions, and reuse these lessons to improve current and future products and processes (Karniel, 2011).

Lifecycle assessment aims at comparing different products (goods and services) regarding their environmental impact. The increased awareness on the importance of environmental protection and its possible impact associated with products (both manufactured and consumed) have increased interest in the development methods to better understand and address these impacts. One of the techniques being developed for this purpose is lifecycle assessment (ISO, 2006). Arsić *et al.* (2009) also studied about the

Role of Eco-Innovation in the Energy sector.

Although, the lifecycle approaches discussed above addressed critical points, they did not consider Lifecycle Quality with the perspective of this paper. Therefore, lifecycle quality proposed from this study is an original contribution in the field quality.

4. Lifecycle Quality – a Future Direction

The limitation of previous studies on quality improvement approaches is associated with the difficulty to satisfy customers' expectations either due to the manufacturers' or the users' related problems. The theories developed, so far, as a quality improvement approaches are started failing even to achieve predetermined targets. The shortcoming of a theory signifies the up-coming of a new one. It is therefore, the time to germinate a new approach at the expense of the crumpled theory to meet or excel customers' expectations.

As pointed out above, the main failures of the current theory are; (1) focusing on the entire manufacturing stages, (2) limited attention given to the product and process design and (3) limited or no effort made at all in the operation stages. In principle, however, the customers' expectations should be addressed in all the phases of a product lifecycle. Product is born and also passes away like any creature. Quality efforts should also give equal emphasis to all these phases.

Quality improvement efforts should have been equally applied on the design, manufacturing and operation phases of a product lifecycle. However, previous studies ignored the last phase of the product lifecycle. Hence, lifecycle quality would be the future paradigm for manufacturers and users. In this study, lifecycle quality can be specifically defined as a continuous improvement effort across all the stages of a product life cycle. Which means, as opposed to the traditional method which entirely focuses on the product design and manufacturing, the lifecycle quality includes the operation phase. This gives equal attention on the product quality as do the design and manufacturing phases. In principle, focusing on the design and manufacturing phases is acceptable/ appropriate because the most important quality indicators are determined in these stages. Practically, however, 60-70% of a product lifecycle cost is associated with the operation stage where the devils reside. Hence, the lifecycle quality approach that will be considered as the future paradigm is an all-inclusive package that addresses all the phase of the product lifecycle.

Based on this premise, the gap between manufacturers and customers in the product lifecycle will be bridged and the aim of quality improvement will also encompass the entire spectrum of the product lifecycle. Very fast development on information and communication technology will have a paramount importance in the control and management of products while they are operated by customers. Feedback about the product performance would be tracked online which will enable manufacturers to trace the product throughout its lifecycle.

After all, lifecycle quality is neither about effective after-sales service nor offering satisfaction to customers for a short fade. It is not also about the environmental impact of a product. Rather it is a new approach in which manufacturers view their product quality all along the design, production, exchange and consumption. In lifecycle quality, elements such as cheap product price, high specifications, very fast delivery and so on cease to matter. What matters most would be how the manufacturers support the users while their product is in use.

How do we develop a methodology to implement lifecycle quality in an organization? The central theme in lifecycle quality is to redefine the relationship between the manufacturer and the end-users who are working in isolation due to

intermediaries such as wholesalers and retailers. The type of relationship may vary depending on the type of the sector or product. For example, capital equipment manufacturers such as heavy-duty machineries, industrial equipment, aeroplanes, ships, etc. will have their own specific type of relationship. On the other hand, electronic products such as mobile phones, computers, TV, Radios, etc. will have a different modality. In the former, strong collaboration will be very critical than the latter since the life time of the products are longer and the consequence creates immense problems. Moreover, service providers such as communication, transportation, hotels, and energy supplies may demand a different relationship. Even consumable goods such as clothes, footwear, foods, etc. demand their own lifecycle quality approaches.

Lifecycle quality, the new paradigm, enables manufacturers and customers to establish long-term relationship which will be a win-win situation. The manufacturers can earn additional profit in return for the service they deliver. Above all, the relationship reduces the uncertainty of customers' satisfaction. On the other hand, customers considerably minimize losses and maximize availability of products with limited risk. More specifically, lifecycle quality will have the following benefits:

- Maximizing customers' satisfaction at the time of use
- Easing feedback collection and inclusion by manufacturers especially in design and production processes
- Ensuring loyalty and long-term relationship between customers and manufacturers
- Enhancing manufacturer's opportunity for business expansion and profitability
- Minimizing unexpected and undesirable failures during operation that could affect customers
- Reducing lifecycle cost of a product
- Minimizing risks of both manufacturers and users
- Increasing customers' confidence to decide and purchase a product

To achieve the above benefits through effective implementation of lifecycle quality, organizational transformation is mandatory. Organizational structure should include the product lifecycle quality management people, teams, or departments which can record, follow up, monitor, improve, support and control the product at every level including the operation stage. However, the type of action may significantly vary depending on the organization.

How did the concept of lifecycle quality evolve? Some organizations are extending their activity beyond selling their product by attempting to support their customers while operating their product. Two case studies such as Rolls-Royce and Ethiopian Electric Power Corporation are cited as examples to show applicability of lifecycle quality in the manufacturing and service organizations.

4.1. Case 1: Rolls-Royce service

Rolls-Royce has been producing aero engines for a period of 90 years. During this period, in addition to others it has been providing after-sales service. Its after-sales service was further improved in the last decades with the company's new program called Corporate-Care. The corporate-Care is a simple, flexible and comprehensive cost-per-flight-hour service designed to deliver a highly competitive engine-maintenance programme to corporate customers ranging from the traditional operator to fractional ownership programmes.

Corporate-Care is the only credible engine maintenance cost programme available in the market for Rolls-Royce engines because it encompasses the experience and technical excellence of the engine manufacturer, the repair and overhaul expertise of Rolls-Royce, and the dedicated support of an

established worldwide customer support organisation. According to the company report Corporate-Care has the following benefits (http://www.rolls-royce.com/):

- Low risk, fixed cost engine maintenance
- Reduced management burden
- Enhanced aircraft resale value
- Increased aircraft availability
- Reduced capital investment

Corporate-Care covers the cost of all parts and labours when the engine is sent to the appropriate Rolls-Royce authorised overhaul facility. These covered the cost of mandatory and recommended service bulletins as well as unscheduled maintenance expenditures. There is also an optional service that covers the replacement of Life Limited Parts.

This comprehensive coverage permits accurate budgeting based on each operator's forecast utilisation. The Rolls-Royce global network of repair and overhaul operations ensure convenient access to the required facilities. Quality is assured since only authorised Rolls-Royce facilities are used for Corporate-Care.

Corporate-Care, as the name itself implies, has overall aim of minimizing the inconvenience that will be created on the Rolls-Royce engine customers while using the engine. This program is benefiting both the customers and the manufacturer. Hence, the Rolls-Royce Corporate-Care program could be considered as a pioneer in the lifecycle quality approach.

4.2. Case 2: Ethiopian Electric Power Corporation (EEPCO)

The Electric Power was first introduced to Ethiopia in the late 19th Century, during the reign of Emperor Menelik II. He was also the one who got the first Hydro Power Plant to be constructed on Akaki River in 1912. However, the effort of the government to extend the power supply to the public was hindered by the Italian invasion in 1936. The Ethiopian Electric Light and Power Authority (EELPA) were established in 1956. After having undergone restructuring, EELPA, has been reorganized as the Ethiopian Electric Power Corporation (EEPCo) in 1997. EEPCO is a monopoly corporation owned by the government to generate, transmit, distribute and sell electric power in the country. However, due to the escalating increase of electric power in the country, EEPC has undergone a critical situation since 2009. Due to these reasons, it forced to provide the service by shift and most of the times, unprecedented power blackout. This makes Ethiopia one of the countries among the nations where power interruptions and sporadic blackouts as well as brown outs (reductions in voltage) are all but common, and in fact part of everyday life. In most cases power blackout happened even without advanced notice.

Quite recently its power coverage reached about 50% of population. EEPCO further strives to increase its coverage and improve its service in two ways: one, by increasing the power generated and second, by improving energy conservation and efficiency. Notwithstanding its plan to expand its power generation, the paper would like to consider the second approach as a case to illustrate the new paradigm of lifecycle quality. The project that improve energy conservation and efficiency was initiated by EEPCo to improve energy utilization efficiency by replacing the old incandescent lamp by a new compact florescent lamps (CFL) that are efficient on energy conservation (http://www.eepco.gov.et/) for each household. According to EEPCo in its first phase compact florescent lamps (CFL) distribution has covered about 350,000. But it targets four million bulbs to be distributed among households. The power saving lamps' are hoped to cut 70 MW from the total electric power consumption at peak hours when the planned total amount is distributed to customers. A CFL consumes only 8-20 watts to give the same light the commonly used incandescent lamps put out consuming

40 to 1000 watts.

By so doing, EEPCO has reduced the energy consumption and costs of households. The mandate of EEPCO is distribution and selling of electric power. Selecting and using energy efficient lamps is the responsibility of the users. But, the users' energy cost is partly determined on the type of the lamps they install. From the old quality perspective, EEPCO supplies energy to users at their required capacity but still their expense is very high because of the equipment they used which subsequently affects the power demand of the nation. Due to this, EEPCo failed to provide efficient and quality service and as the same time crated dissatisfaction to its customers, which is lose-lose situation. It is up the customer to choose what type of lamp as they considered is best for them. The customers are responsible to choose what they considered is the best. And as the same time, EEPCo has to provide the service based on their preference and charge more for its service. As a result, in the case of EEPCO and its clients customer-supplier relationships can be described as a loss – loss type.

Although the costumers do not have alternatives to choose from, since there is shortage of power in the country, for EEPCo, efficient utilization of the available resources is considered as a strategy to maximize its service coverage. Realising this, EEPCO after securing fund form the World Bank, installed energy efficient lamps in every household for free of charge. Customers often used 40W or 100W Lamps but the florescent lamp installed by EEPCO is 8 to 20W. Due to the new technology, energy cost of the users decreased by three to five folds. This implies that if the manufacturers or suppliers of product/services strive to support customers while operating/using, it will ensure significant improvement in the effort to satisfy customers. Because, most of customers dissatisfaction emanates after same time because the product is operating and the service is used. Hence, managing the overall lifecycle of a product including the operation and disposal will ensure customer satisfaction.

EEPCO's intuitive support, although, a project financed by the World Bank, could be considered as a good example showing the benefits of lifecycle quality even in the service-giving industries and the public sector as well.

5. Conclusions

The dilemma on quality definition seems to hinge on satisfying customers' expectations. More confusing arguments are forwarded in connection with the approaches and/or methodologies to fulfil customers' stated or implied needs. To achieve the core objective of quality different approaches have been used in the literatures. In the early stage, the practice was inspecting a product before delivering it to the customers. Quality control, management, and engineering have also been practiced at different periods. Moreover, suppliers of raw materials in the backward value chain and after-sales services in the forward chain were considered as important points to satisfy customers. Despite these methodologies, frequently used by manufacturers, there is still an unanswered question toward a complete satisfaction of customers. In this research, a new approach in quality called lifecycle quality is proposed to be the future quality philosophy and recommended to prevent possible failures a product after sell and during operations. In this regard, lifecycle quality will ensure customer satisfaction and result in a win-win relationship between manufacturers and users.

Further empirical evidence on lifecycle quality, implementation methodology, relationship between manufacturers and customers for different types of the products and sectors will be the areas where future research should concentrate to enhance the development of the concept. Moreover, practical application of this principle may

also be a future research direction to be considered.

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