



**Malek Souilem**

**Total Quality Management and Lean in the logistic process of a company that commercializes LED lighting products**

**Gestão da Qualidade Total e Lean no processo de logística de uma empresa que comercializa produtos LED de iluminação**

Relatório de Projeto apresentado à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Engenharia e Gestão Industrial, realizado sob a orientação científica da Professora Doutora Helena Maria Pereira Pinto Dourado e Alvelos, Professora Auxiliar do Departamento de Economia, Gestão e Engenharia Industrial da Universidade de Aveiro.



I would like to dedicate this work to my family, especially to my parents and my husband.



## **o júri**

Presidente

Professora Doutora Marlene Paula Castro Amorim,  
Professora Auxiliar, Universidade de Aveiro

Professor Doutor Nuno Filipe Rosa Melão,  
Professor Adjunto Convidado, Instituto Politécnico de Viseu - Escola Superior de  
Tecnologia e Gestão

Professora Doutora Helena Maria Pereira Pinto Dourado e Alvelos,  
Professora Auxiliar, Universidade de Aveiro



## **Acknowledgement**

I would like to express my sincere gratitude to my supervisors, Professor Helena Maria Alvelos and Ana Claudia Soares Ferreira for their guidance and support during my graduate studies. I will always be grateful for their generous supports, insightful academic and professional suggestions and encouragement during the Master course and the training work.

I am grateful also to the rest of the members of the Primelux company that helped me by providing valuable feedback within their areas of expertise.

My thanks to my parents, for installing the correct values on my personality and their supports. Finally, I am grateful to my husband, Wael Dghais, for his support, discussion and sacrifice.





## Palavras-chave

Gestão de Qualidade Total , 5S, Melhoria Contínua, Gestão da Cadeia de Abastecimento

## Resumo

No mercado contemporâneo as empresas competem pela angariação e manutenção do seu mercado suportadas na manutenção dum elevado grau de satisfação dos clientes e na adequação da sua oferta às necessidades evolutivas do mercado, contudo tal por si só não é suficiente para manter uma posição de mercado confortável ao longo do tempo, sendo necessário também um investimento contínuo nos processos de negócio e de organização internos a cada empresa.

Por estas razões as empresas precisam de gerir bem os seus processos de negócio tendo presente a redução dos custos, mantendo simultaneamente produtos e serviços de alta qualidade para manter e atrair clientes. A forma de equilibrar estes compromissos dispares é encontrada através da implementação das metodologias de melhoria contínua da qualidade, minimização do desperdício em resíduos e redução de custos globais tudo simultaneamente, através de uma boa gestão de aproximação da cadeia de abastecimento, do stock e do processo de controlo de qualidade.

O objetivo deste projeto específico de mestrado é integrar os princípios da qualidade total e da gestão da cadeia de abastecimento num quadro de pensamento Lean, afim de implantar processos de melhoria contínua sustentável (Kaizen) numa empresa específica de produtos LED.

Este objetivo será perseguido através de, em primeiro lugar, melhorar os processos de qualidade, minimizando as falhas na preparação de ordens de entrega e nos processos de pós-venda. Em segundo lugar, implementar-se-á a redução de custos, minimizando o desperdício, com recurso a ferramentas lean 5S aplicadas aos produtos LED e à logística na Primelux.

O trabalho desenvolvido será iniciado através do desenvolvimento de representação qualitativa e visual dos processos logísticos e completado com uma análise quantitativa que permite avaliar o desempenho da cadeia de abastecimento através de métricas adequadas após a aplicação de um plano de ação comunicado aos trabalhadores por meio de uma formação fácil e ilustrativa.

**A melhoria conseguida através destas abordagens propostas que combinam as ferramentas de 5S-Kaizen-TQM são relatados neste relatório e exibem como resultados uma redução na taxa de falhas e uma economia de tempo na execução do processo de logística que terá certamente um impacto direto positivo sobre a satisfação do cliente.**





## **Keywords**

Total Quality Management, 5S's, Continuous Improvement, Supply Chain Management.

## **Abstract**

Nowadays, the globalized economy leads the emergence of highly competitive companies. Many companies are competing not only to keep track and boost their customer's satisfaction but also to look for other potential resources, to increase their market share regarding other competitors. The companies have to organize their business and internal processes in order to maximize efficiency and therefore achieve their objectives and maintain their growth and expansion in a very struggling economy constrained by austerity.

For these reasons, the companies need to manage their industrial production/business process towards reducing the cost while maintaining high quality products or services to maintain and attract more customers. This seems clearly a conflicting situation, however, it is possible for the companies to balance these tradeoffs by implementing the methodologies of continuous quality improvement, waste minimization, and cost reduction simultaneously for their goods or services, through good management approaches of their supply chain, inventory, and quality control process.

The objective of this master project is to integrate the total quality and supply chain management methodologies within a Lean thinking framework in order to install a sustainable continuous improvement(Kaizen) process in a company near Aveiro city, the Primelux company. This will be achieved through, firstly identifying the company current working processes and then trying to improve the quality in the overall processes by minimizing the failures in preparing orders and on the after-sales processes as well as through reducing the cost by minimizing the waste using 5S lean tools applied to the LED products logistics in the Company.

The work will start by developing qualitative and visual representation of the above-mentioned logistics processes and completed with a quantitative analysis that evaluate the supply chain performance through adequate metrics after applying a set of action plans that were efficiently communicated to the employees by means of an easy and illustrative training. The achieved improvements through this proposed approach that combine the 5S-Kaizen-TQM tools are reported in this report, namely a reduction in failure rate and the time saving in the execution of the logistics process that will have surely a direct impact on the company customer satisfaction



## Table of Contents

Chapter 1: Introduction.....	1
I.1. Objective.....	1
I.2. Report structure .....	1
Chapter 2: Theoretical Framework.....	3
II.1. Total Quality Management Principles and Concepts .....	3
II.1.1. From Quality to Total Quality Management .....	3
II.1.2. Management’s commitment (leadership) .....	7
II.1.3. Focus on the customer and the employees .....	7
II.1.4. Focus on facts .....	8
II.1.5. Continuous improvements (Kaizen).....	9
II.1.6. Everybody’s participation.....	10
II.2. Lean Principles and Concepts.....	11
II.2.1. Lean Manufacturing .....	11
II.2.2. The Seven Wastes.....	13
II.3. Total Quality Management vs Lean .....	14
II.4. Continuous Improvement/Kaizen Tools.....	17
II.4.1. Process Flowcharting.....	18
II.4.2. Fishbone Analysis: Cause and Effect Diagram .....	19
II.4.3. Pareto Analysis .....	21
II.4.4. Histogram .....	21
II.4.5. Check Sheets and Lists .....	22
II.4.6. 5S’s Tool .....	22
II.5. Total Quality Management and Lean in Supply Chain .....	24
II.5.1. Supply Chain Management .....	24
II.5.2. Integrated Total Quality and Supply Chain Management .....	25
II.5.3. Lean Supply Chain .....	28
II.6. Summary.....	29
Chapter 3: Case Study: Lean and Total Quality Management in Logistics Processes...	31
III.1. Company Presentation.....	31

III.1.1. Human Resources and Market.....	33
III.1.2. Primelux LED Product .....	34
III.1.3. Organization Chart .....	36
III.2. Case Study Analysis .....	38
III.2.1. TQM Analysis: Cause-Effect Diagram .....	39
III.2.2. TQM Analysis: Pareto Diagram.....	41
III.3. Action Plan .....	42
III.3.1. Process Flowcharting.....	43
III.3.2. Preparing Order process .....	44
III.3.3. After Sales Process .....	45
III.3.4. 5S application: .....	49
III.3.4.1 1st phase: Sort - Set in - Shine .....	51
III.3.4.2 5S 2nd phase application: training and presentation.....	56
III.3.4.3 5S 3rd phase application: Standardize – Sustain.....	57
III.4. Additional Improvement Actions .....	59
III.5. Results and Discussion .....	61
III.6. Summary.....	63
Chapter 4: Conclusions and Future Work .....	65
IV.1. Conclusions .....	65
IV.2. Future Work.....	65
References .....	67
Appendix I.1 First Training Activity.....	71
Appendix I.2 Second Training Activity .....	72
Appendix II.1 First Training Activity .....	72
Appendix II.2 Second Training Activity .....	73
Appendix III. Cleaning list for 5S standardization and sustain.....	74
Appendix VI.1 Lean Audit Checklist.....	75
Appendix VI.2 5S-Lean Audit Checklist—Guidelines.....	76

## List of Figures

Figure 2.1. Classification of the different stages of the quality development (adapted from [6]).	4
Figure 2.2 - Illustration of the total quality pillars focusing on customer satisfactions (adapted from [4]).	6
Figure 2.3 - The interdependent principles of the TQM [10].	7
Figure 2.4. - Continuous improvement (Kaizen) and their consequences (adapted from [8]).	10
Figure 2.5. - Seven types of waste to be eliminated (adapted from [19]).	13
Figure 2.6 - Integrated tools combined with Lean thinking for efficient total management. [34].	15
Figure 2.7 - PDCA model for continuous quality improvement (adapted from [37]).	18
Figure 2.8 - Seven quality continuous tools in process identification and analysis (adapted from [13]).	18
Figure 2.9 - General structure of fishbone or the cause-effect diagram [4].	20
Figure 2. 10 - Pareto chart, continuous process improvement [4].	21
Figure 2.11. - Histogram graph for detecting the defect occurrence (adapted from [4]).	22
Figure 2.12. - Kaizen/Lean 5S framework for clean and healthy working environment (adapted from [18]).	23
Figure 2.13 - Supply chain process [21].	24
Figure 2.14 - Conceptual model of the integrated SCM and TQM methodologies (adapted from [24]).	25
Figure 3.1 - Primelux locals and warehouse.	31
Figure 3.2 - General flowchart describing the Primelux's main functions.	33
Figure 3.3 - Primelux Customer's distribution in Portugal to date.	34
Figure 3.4. - Example of lamp, LED spotlight, and codification.	36
Figure 3.5 - Primelux organigram.	37
Figure 3.6 - Cause effect diagram applied in SCM of Primelux developed during the project.	40
Figure 3.7 - Pareto Diagram of the nonconformity of the orders.	42
Figure 3.8 - The main activities of the warehouse and their relationship.	44
Figure 3.9 - Flowchart of the after sale process.	47
Figure 3.10. - Flowchart of the technical assistance.	49
Figure 3. 11. Illustration of the status of the two workplaces before applying the 5S tool.	51
Figure 3.12 - Illustration of the status of the 1st workplace after applying the 5S tool.	53



Figure 3.13. - Illustration of the status of the 2 <sup>nd</sup> workplace after applying the 5S tool. ....	56
Figure 3.14. - Illustration of the Standardize – Sustain 5S application.....	57
Figure 3.15. - 5S’s Evaluation by means of radar chart. ....	58
Figure 3. 16. -: 5S assessment through histogram. ....	58
Figure 3.17. - Illustration of the number of defects variation for three different periods of observation. ....	62
Figure 4.1. - Lumen depreciation to 70% of initial lumen output (L <sub>70</sub> ). ....	66

### **List of Tables**

Table 2. 1 The expanded concept of Quality measurements [8]. ....	8
Table 2. 2. Comparison overview between TQM and Lean principles[33] .....	15
Table 2. 3 Eight modern TQM principles of ISO9000 in SCQM [24].....	26
Table 3. 1 An Example of different types of LED products commercialized by Primelux	35
Table 3. 2 Primelux LED products’ codification .....	35
Table 3. 3 Different types of the errors and fails that impact the customer satisfaction and company organization, which are identified after an observation period (i.e. 45 days).....	38
Table 3. 4 Identification of the root cause of each problem and their respective score. ....	41
Table 3. 5 Data sorted data with the cumulative score and their percentage .....	42
Table 3. 6. Preparing order flowchart and their respective actions. ....	45
Table 3. 7 Lista de Responsáveis de auditoria.....	59
Table 3. 8 Nnumber of defect variation.....	61
Table 3. 9 Preparing order measurements .....	62

## List of Acronyms

ASQ	American Society for Quality
CI	Continuous Improvement
ISO	International Organization for Standardization.
LED	Light Emitting Diode
TQM	Total Quality Management
LM	Lean Manufacturing
LP	Lean Production
TPS	Toyota Production System
MRP	Material Resource Planning
SC	Supply Chain
SCM	Supply Chain Management
LSC	Lean Supply Chain
SCQM	Supply Chain Quality Management



## **Chapter 1: Introduction**

### **I.1. Objective**

Primelux is a small company which has been established a few years ago near Aveiro city in Portugal. It is a commercial company of light-emitting diode (LED) lighting products and systems. Primelux is in a development phase since, consequently in a growing state. Therefore, improving and maintaining their good quality products and services is a major concern in order to keep the growth of the company, so that Primelux can preserve its clients and attract new ones. Since Primelux is in a progressing situation where there is a significant increase in both information and physical flux (orders number, clients number, quantity of materials, stock level, different transport service suppliers...), it is fundamental to make an analysis of all organizational activities and identify the processes associated with them in order to detect the dysfunctions and to achieve the concept of continuous improvement (CI). The activities/functions of Primelux, were not organized/structured by processes.

The study of the activities and the identification of the business processes is an improvement in the organization and control of the company. The definition and characterization of the processes help in the identification of responsibilities and defining the working methodologies and the adequate tools in order to improve the quality and reduce wastes/cost. Effective implementations of the management tools within the supply chain not only enables to coordinate the efficient flow of new products across the supply chain but also assists the company and its supply chain members with a ramp-up of logistics, marketing and other related activities to support commercialization of the LED products that the company offers to the market.

This master project work aims at addressing these problems in order to achieve an efficient supply chain management aligned with satisfying customer requirements. Therefore, the supply chain's performance can be improved in order to gain competitive advantage. The main goal is to improve the performance of LED supply chain management by addressing the improvement of the quality and reducing the costs/wastes based on continual improvement strategy and lean thinking. In order to achieve this objective, a deep study and analysis of the current situation will be carried out based on qualitative and quantitative tools in order to identify the remarkably dysfunctional processes and propose corrective and preventive actions in place to improve these processes.

Moreover, the required actions will be implemented to achieve the CI of the supply chain in Primelux by means of total quality management methodology and reducing the identified wastes/costs in the commercialization process through lean approaches.

### **I.2. Report structure**

This report describes the work carried out during the internship in the company and is divided into four chapters. The remainder of the Master report is organized as follows.

Chapter 2 provides the theoretical and technical descriptions of the followed approach based on Total Quality Management (TQM) tools in conjunction with Lean thinking methodology and 5S' application that will be adapted in ensuring CI (Kaizen) of the quality

and reducing the costs/wastes of supply chain management (SCM) at Primelux. A conceptual model of the integration of the TQM-SCM and Lean Supply Chain (LSC) approach will be introduced in order to apply it to the case study of the company's supply chain management.

Chapter 3 is dedicated to the application of the 5S-Kaizen-TQM tools for analyzing the initial situation, identifying the problems to be addressed and proposing the action plan in order to install autonomous and stepwise CI (Kaizen) for the preparing orders, after sales process, warehouse organization, and elimination of wastes. The challenges arising from applying these tools and techniques within the 5S-Kaizen-TQM approach in the company organization will be discussed. The qualitative and quantitative results of the CI that targets the process standardization and quality excellence in order to satisfy customer's needs and their expectations are reported at the end of this chapter.

Finally, Chapter 4 provides the main conclusions that can be drawn from the achieved results of the master report and presents the possible future work.

## **Chapter 2: Theoretical Framework**

This chapter provides the theoretical and technical descriptions of the followed approach based on TQM tools in conjunction with Lean thinking methodology that will be adapted in ensuring CI (Kaizen) of the quality and reduce the costs/wastes of SCM at the Primelux Company. A conceptual model of the integration of the 5S-Kaizen-TQM approach will be introduced in order to apply it to the case study of the Primelux SCM.

### **II.1. Total Quality Management Principles and Concepts**

#### **II.1.1. From Quality to Total Quality Management**

Since the 1970s, the importance of the competition based on quality has grown and generated tremendous interest in order to increase the business performance. Nowadays, successful companies understand that quality provides a competitive advantage. They put the customer first and define quality as meeting or exceeding customer expectation. Toward this end, the organizations strive to increase their performance in this highly competitive market while disregarding to integrate planning activities, strategic and quality planning [1].

The TQM terminology can be briefly described as follows. First, the quality is the continuous satisfaction of customer's expectation. Additionally, the total term aims at minimizing the cost of all functions required to achieve good quality. Finally, the management term targets the involvement of all the human resources at all the hierarchy level to be implicated in the total quality participation.

##### **✓ Quality Terminology**

There are plenty of quality definitions in the literature. For instance, quality is the degree to which an object (e.g. process, product, or service) satisfies a specified set of attributes or requirement [2]. Quality is defined as: "The totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs" ISO definition [3]. Furthermore, quality may be understood differently from different perspectives. The quality can be perceived as the standardization metric or the degree of excellence of a product when compared to their similar ones. The quality is usually qualitatively evaluated by customer based on visual inspections. However, the quality can be quantified and measured so the customer can differentiate which product satisfies their specifications [4]. According to the American Society for Quality, "Quality denotes an excellence in goods and services, especially to the degree they conform to requirement and satisfy customers" [5]. Moreover, "Quality, as macro function of institutions, must be present in the day-to-day running of an institution, in aspects like the establishment of policies, the decision process, the selection of personnel, the allocation of resources, the definition of priorities and service delivery to satisfy customer requirements"[5].

Consequently, quality is an ongoing process that has to be pervasive throughout the all company's departments so that it becomes the philosophy and culture of the whole company in order to serve customers with better-quality, lower cost, quicker response and greater flexibility.

## ✓ Quality Evolution

The historical evolution of TQM has taken place in four stages. They can be classified as illustrated in figure 2.1 from Quality inspection till TQM along with their respective characteristics [6]-[8]:

- 1- Quality inspection (1910)
- 2- Quality control (1924)
- 3- Quality assurance (1950)
- 4- Total Quality Management (1980)



Figure 2.1. Classification of the different stages of the quality development (adapted from [6]).

In the 1910s, the Ford Motor company started to employ teams of inspectors to compare or test the product with the project standard. This was applied at all stages covering the production process and delivery, etc.[8] The purpose of the inspection was that the poor quality product found by the inspectors would be separated from the acceptable quality product and then would be scrapped, reworked or sold as lower quality. With further industrial advancement came the second stage of TQM development and quality was controlled through supervised skills, written specification, measurement and standardization.

During the Second World War, manufacturing systems became complex and the quality began to be verified by inspections rather than the workers themselves. Statistical quality control by inspection the post production effort to separate the good product from the bad product- was then developed. The development of control charts and accepting sampling methods by Shewhart and Dodge-Roming during the period 1924-1931 helped this era to prosper further from the previous inspection era. At this stage Shewhart introduced the idea that quality control can help to distinguish and separate two types of process variation; firstly the variation resulting from random causes and secondly from assignable or special causes that can

be identified, characterized and separated. Further, the control chart for monitoring such process control and lower evidence of non-conformance was designed and proposed [8].

Thirdly, the quality assurance has provided the sufficient confidence that a product or service will satisfy customers' needs. Other activities such as comprehensive quality manuals, use of cost of quality, development of process control and auditing of quality systems are also developed in order to progress from quality control to the quality assurance era of TQM. At this stage there was also an emphasis of change from detection activities towards prevention of bad quality.

The fourth level, (i.e. TQM) involves the understanding and implementation of quality management principles and concepts in every aspect of business activities. TQM demands that the principles of quality management must be applied to every level, every stage and in every department of the organization. The idea of TQM principles must also be enriched by the application of sophisticated quality management techniques. The process of quality management would also be beyond the inner organization in order to develop close collaboration with suppliers.

To be successful in business, the implemented quality process in the company should not be able only to satisfy the present/actual customers' needs, but has to be able to predict their needs evolution and expectations in the future and adapt their process according to this change [2], [3]. The quality cannot be achieved by good or high technological equipment only. It requires also the implications of the whole managerial board and the high skillful technical workers in order to achieve quality improvements that continuously satisfy the customer's expectations, thus, ensuring the success of the company business. Therefore, the quality is the most important force leading to organizational success and company growth in national and international markets [4].

For instance, the production worker can only produce high quality if he is pride of his work and aware of his implication in the quality process. A minor or small error in his task can propagate though the production or the service which leads to a poor quality product/service. This could mean loss of business and perhaps of his job in the future. Nevertheless, good quality will keep the company in business. Quality manager should motivate the working technical teams to meet their specifications by leading the company to implement a continual improvement strategy. Therefore, we can conclude that quality is not related to one product, but it involves also the service, the people, the process and the environment.

In summary, TQM should be perceived as the total of activities in the different levels of the organization dealing with the methods (e.g. learning procedures and innovative ideas) and the resources (human, infrastructure, techniques) used by the company in order to fulfill the client/customer's needs and expectations with the lowest cost.

### ✓ **Total Quality Management**

Total quality management is a set of management practices applicable throughout the organization and geared to ensure the organization consistently meets or exceeds and predict the future customer requirements. Introducing TQM practices in an organization is a long-term commitment. The successful implementation and adoption of TQM practices requires planning,



time and effort. A number of studies have been carried out to investigate practices of TQM and to examine its implementation process. The common conclusion of these studies is that the implementation process is central to the long-term success of TQM within an organization and implementation is firm-specific [7]. TQM attempts to satisfy customers' actual and future needs and expectations. It is a total approach of considering the technical aspects of quality as well as the involvement of people in quality, such as customers, company employees, and suppliers to solve and predict the problems and eliminate wastes and reduce cost as well. Therefore, "it is a management philosophy that builds a customer driven, learning organization dedicated to total customer satisfaction through CI/Kaizen in the effectiveness and efficiency of the organization and its processes." [9].

The most important practices for TQM implementation are considered as a three-leg stool as illustrated in the figure 2.2.

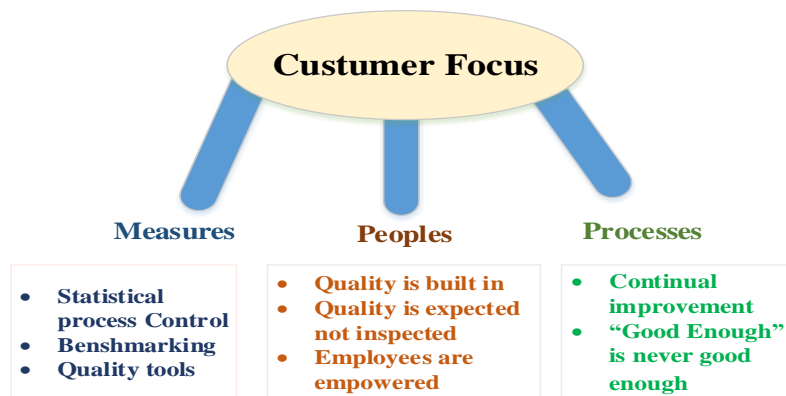


Figure 2.2 - Illustration of the total quality pillars focusing on customer satisfaction (adapted from [4]).

The seat of the stool is customer focus. This means with total quality approach the customer is in the "driver's seat" as the primary arbiter that evaluates the quality acceptance. Each of the three legs or pillars represents the crucial elements of the total quality philosophy (i.e., measures, people, and processes). The "measures" leg of the stool makes the point that quality can and must be measured and quantified. The "people" leg of the stool makes the point that quality cannot be inspected into a product or service. Rather, it must be built in by people who are empowered to do their jobs the right way. The "processes" leg of the stool makes the point that processes must be improved, continually and forever. Indeed, what is considered excellent today may be just mediocre tomorrow. Consequently, "good enough" is never good enough.

Moreover, total quality enables the business company to continuously improve its product, services, peoples, and environment competitiveness. This can be achieved only if the management board and leader take it seriously as a strategic approach with long term commitment for customer satisfaction. The leader should promote scientific approach to decision making and problem solving and encourage team work by providing adequate education and training for his employees in continual process improvement in order to keep them united and involved in this framework.

TQM helps to reduce process variance, which has a direct impact on supply chain performance measures, such as cycle time and delivery dependability. TQM practices result in set-up time reduction, allowing improved schedule attainment and faster response to market demands [8]. This helps in synchronizing the whole functions in supply chain [10]. The TQM is characterized by five interdependent principles as illustrated in figure 2.3. These five principles will be discussed in detail below.



Figure 2.3 - The interdependent principles of the TQM [10].

### **II.1.2. Management’s commitment (leadership)**

TQM requires the implication and the active participation of the management boards at all levels and in all departments. A vital task for any top management (the board of directors) is to outline and review the quality goals, quality policies, and quality plans and if necessary reformulate them so that they conform to all the TQM principles. The quality goals have to be communicated to the employees about what is going to be achieved concerning quality. Moreover, the quality policies describe in more detail how employees are to achieve the goal. These goals and quality policies must be followed by meaningful action plans.

A good TQM vision requires that the management board should concentrate on short-term plans (one-year plans) and long-term plans (three-year plans) which are revised annually in connection with an annual quality audit. Moreover, the annual quality audit is an essential part of the TQM vision. Only through active participation in the quality audit, the top management can acquire the necessary insight into the problems in order to implement the quality plan. The annual quality audit gives top management the opportunity to check whether employees are in fact seriously trying to fulfill the company’s quality goals. By actively participating in the annual quality audit, top management shows that they have understood the TQM message and made their commitment highly visible which are essential conditions for making and achieving new, meaningful quality plans.

### **II.1.3. Focus on the customer and the employees**

Focusing on the customer’s requirements and expectations is neither new nor revolutionary. This is precisely what the service management movement of the 1980s was about. The first new message in TQM is to additionally focus on external customers and their expectations and demands, it is necessary to focus on so-called internal customer and supplier

relations. Since employees are part of the company’s processes, therefore, improving quality at lower costs can only be achieved if a company has good, committed and satisfied employees. Before you can satisfy external customers, the manager’s board must first eliminate some of the obstacles to the internal customers (i.e. the employees) and create the conditions necessary for them to produce and deliver quality. Among the obstacles that must be eliminated in an organization is fear, while time and money should be invested in education and training [8].

The second new message of the TQM is to create and keep improving the internal and customer satisfaction because it is not enough just to live up to the customer’s expectations. In order to deliver the expected quality, firms have to know what the customers expect and then they must try to live up with these expectations. Nevertheless, for many customers it is not enough, coping with expectation satisfaction does not create satisfaction, it ‘only’ removes dissatisfactions. Creating satisfaction demands mores, this ‘more’ is what Kano calls ‘exciting quality’ [8].

Concluding, the management board must care and need to know what both internal and external customers want/expect from the company in order to produce and deliver high quality with low cost. This information enable the starting of the CI processes which is a first step towards becoming a ‘TQM firm’ for continuous monitoring of customer and employees satisfaction.

**II.1.4. Focus on facts**

Collecting the measurements that carry the information and knowledge about the customers’ experiences regarding the products and/or the services is essential before addressing the improvement of their satisfaction. The companies are increasingly realizing that they must first set up a system for the continuous measurement/identification, collection and reporting of quality facts in order to install and implement the TQM vision. Therefore, it is important to understand that *“The quality process starts with measurements”* [8]. In fact, the first step in improvement processes is to determine our current performance and identify the cause of the problems by measuring the customer and employee satisfactions.

The new quality measurement can be classified according to process or the final results in to three main groups as illustrated in table 2.1. This is due to the fact that, on one hand, TQM is basically process-oriented while, on the other hand, the processes and results depend on the party concerned. This proposal is a logical outcome of the expanded concept of quality implicit in TQM and is also an element of the European Quality Award.

Table 2.1 - The expanded concept of Quality measurements (adapted from [8]).

	<b>Firm</b>	<b>Customer</b>	<b>Society</b>
<b>Process</b>	Employee satisfaction	Control and Checkpoints	External Checkpoints (environnements, Political, social)
<b>Results</b>	Business result	Customer satisfaction	Ethical/social accounting

Traditionally, managing board mainly measures the company's business result. The problem with this, however, is that it is retrospective, since the business result only gives a picture of past events. What is needed is a number of forward-looking measurements connected with the business results.

Focus on the customer and the employee is the cornerstone of TQM that has to be both included as the primary quality goals. Achieving these objectives will lead to a good quality products and services and therefore business results. There is therefore a need for control and checkpoints of all the company's processes. Finally, the company results will be a function of its general reputation in society. This is reported in both the ethical/social accounting and in relevant external checkpoints in, e.g. the environmental and social areas [9].

### **II.1.5. Continuous improvements (Kaizen)**

The Kaizen management originates from the best Japanese management practices and is dedicated to the improvement of productivity, efficiency, quality and, in general, of business excellence. The Kaizen methods are internationally known as methods of CI, through small steps, of the economical results of companies. The small improvements applied to key processes will generate the major multiplication of the company's profit while constituting a secure way to obtain the clients' loyalty/fidelity [11]. The companies that want to sustain their good performance must keep their leading position on the market by increasing the quality level of the services provided, reducing costs and last, but not least, motivating the whole staff in order to implement the concept of performance-oriented organization. Within the present economical context, cost reduction is one of the major objectives.

Higher quality should and can only be achieved through balancing the improvement of both internal and external quality. The main goal of internal quality improvements is to make an internal continuous learning process in order to prevent defects and problems which will lead to lower costs. However, the external quality improvement targets the external customer in order to increase their satisfaction and thereby achieve a bigger market share and higher earnings/revenues.

Both types of improvements are closely connected with the questions top management board objectives released and communicated at the annual quality audit. It is worth to note that the internal and external improvements strategies should be gradually developed to become an integral part of the company's quality culture, with the active employee participation while considering the raised issues/questions in all departments and solving these quality issues by providing a corrective and preventive actions in order to assure continuous quality improvements. The two types of quality improvements are shown in figure 2.4, which illustrates these both types of quality improvements – which should not be seen independently of each other- result in higher profits. This fact leads to Phil Crosby's (1982) famous observation that 'quality is free'. Only poor quality is expensive [8].

Consequently, CI/Kaizen principles describe the "Improvement initiatives that increase successes and reduce failures" [13]. CI is defined as a culture of sustained improvement targeting the elimination of waste in all systems and processes of an organization. It involves

everyone working together to make improvements without necessarily making huge capital investments. CI can occur through evolutionary improvement, in which case improvements are incremental, or through radical changes that take place as a result of an innovative idea or new technology [14].

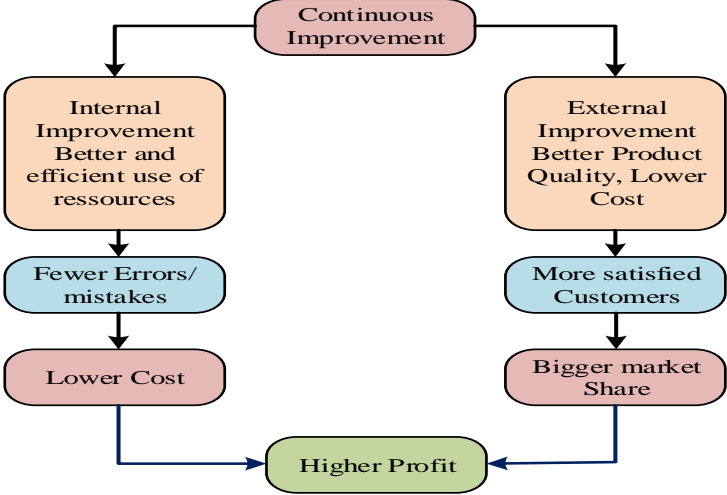


Figure 2.4. - Continuous improvement (Kaizen) and their consequences (adapted from [8]).

**II.1.6. Everybody’s participation**

As previously mentioned, TQM is process-oriented. The internal (employees) and external customers are the active part of the company’s processes. These customers, together with their requirements and expectations, must be identified in all the process. The next step is to plan how these requirements and expectations can be fulfilled. This requires the customer’s feedback, so that their experiences and problems become identified and known in all processes. This feedback information will enable the control and the auto regulation of the CI of both products and processes. For this to be effective, it seems only common sense that everybody should participate.

To get everybody involved from both management and employees to participate, educate and motivation. The company’s management must get involved in as many education and training activities as possible. The active participation of total management in the annual quality audit is an important part of these activities, the effect of which will quickly filter down throughout the organization. Department managers will make demands on middle managers, who will make demands on their subordinates and so on down the hierarchy. Deming’s seventh point of his plan to implement TQM will be a natural consequence of the diffusion of the quality message: ‘Management must endure that every employee in the company participates actively in a team work team, quality circle [8].

Therefore, both work/technical and management teams are important and crucial parts of the company’s quality organization to ensure that technical work teams start making improvements as quickly as possible and the management team collaborate with them to lead and build up an organization to advice on the carrying out of CIs. Management team must be actively committed through a good leadership to the participation in the quality audit and make

the necessary organizational changes and corrections. Consequently, good leadership skills have to be present in the management team and decision making board of the company by applying a wise guidance by powerful education and training. This implication of the management board will make easier the implementation and the realization of the TQM vision. It is worth to note that the management board must believe ‘that it will help’ to involve all employees and also to invest in the education and training of all employees at all levels in:

1. Identifying defects and problems;
2. Finding the causes of defects and problems;
3. Preventing the causes of defects and problems.

A condition for effective prevention is that employees have completed points 1 and 2 and that, on the basis of a causal analysis, they make suggestions for, and implement, quality improvements.

## **II.2. Lean Principles and Concepts**

### **II.2.1. Lean Manufacturing**

The concept of lean production (LP) appeared and was recognized in the Toyota Production System (TPS) in Japan in the 1940s and is considered to improve the firm performance through eliminating the waste. LP is a prominent manufacturing philosophy that is based on customer-focused process improvements. The key idea is to increase value to customers while reducing the number of resources consumed and the cycle times via waste elimination. [19]

Lean is a philosophy of manufacturing that incorporates a collection of principles, tools and techniques into the business processes to optimize time, human resources, assets, and productivity, while improving the quality level of products and services to their customers. It is one of the most important concepts that help companies gain competitive advantage in the world market. Lean Manufacturing (LM) or LP is a production practice, which regards the use of resources for any work other than the creation of value for the end customer, as waste. LM is a multi-dimensional management practice including just in time, quality systems, work teams, cellular manufacturing, supplier management, etc. in an integrated system [19].

These extensions are obvious in the definition of national institute of standards and technology (NIST) [32]: “as a systematic approach to identifying and eliminating waste through continuous improvement, following the product at the pull of the customer in pursuit of perfection”. Therefore, Lean is defined as an integrated socio-technical approach that balances and compromises the entire crucial factors in order to reduce the waste, minimize supplier cost fluctuation, and internal variability that will directly improve the SC performance and customer satisfaction [31].

The TPS is based on the desire of producing a continuous flow which does not rely on long production runs to be efficient; it is based on the recognition that only a small fraction of the total time and effort to process a product add value to the end customer. Lean continued its development into the late 1980s driven by the advancements in computers which had allowed

mass production to be further ‘enhanced’ by material resource planning (MRP) Systems. The key tools and techniques within the ‘lean’ system, included [29]:

- Kanban: a visual signal to support flow by ‘pulling’ product through the manufacturing process as required by the customer.
- 5 S’s: a visual housekeeping technique which devolved control to the shopfloor.
- Visual control: a method of measuring performance at the ‘shop floor’ which was visual and owned by the operator team.
- Poke yoke: an ‘error-proofing’ technique.
- SMED (single minute exchange of dies): a changeover reduction technique.

Moreover, Lean thinking [30] enables to extend the principles of lean to:

- The identification of value.
- The elimination of waste.
- The generation of flow (of value to the customer).

The concept of Lean can be described at different levels of abstraction: it can be defined as a philosophy, as a set of principles and as bundles of practices [19].

- **Lean philosophy:** LP is defined as a business and production philosophy that shortens the time between order placement and product delivery by eliminating waste from a product’s value-stream.

- **Lean set of principles:** The dominant view in describing and measuring LP and is based on a set of practices and tools used in eliminating waste.

- **Lean bundles of practices:** Four main aspects of LP and frequently group related practices together into bundles. These are practices associated with quality management, pull production, preventive maintenance, and human resource management.

Lean thinking has fundamentally two basic concepts that are eliminating waste and create value. Furthermore, LM is underpinned by the 5 principles briefly described below [19] [31]:

- 1. Identify Customers and specify value:** By clearly defining value for a specific product or service from the end customer’s perspective, all the non-value-added activities - or waste - can be targeted for removal. Value defines the use that a product offers a customer, and works backward to build the production process. Only what the customers’ remark as value is important.

- 2. Value stream analysis:** Having understood the value for the customers. The Value Stream is the collection of processes and activities across all parts of the organization involved in jointly delivering the product or service. This represents the end-to-end process that delivers the value to the customer. Once you understand what your customers want the next step is to identify how you are delivering (or not) that to them.

- 3. Creating flow by eliminating waste:** Focus on organizing a continuous flow through the production. Flow reorganizes processes so products move smoothly through the value-creating steps. It is necessary to eliminate the waste through the steps and increase the percentage of adding value activities. Reducing inventory and eliminating the waste ensure that the product or service “flows” to the customer without any interruption, deviation or waiting.

**4. Pull:** Demand chain management prevents producing commodities to stock. This is about understanding the customer demand on the service and then creating the process to answer to this. Such that produce only what the customer wants when the customer wants it. Companies should not push their products to customers, and rather let them pull “value” (products or services) and link all the production chain (even with suppliers) in such a way that materials are not released and activities are not done until they are needed.

**5. Perfection:** Perfection requires constant striving to meet customer needs and improving one’s process with zero defects through the continuous improvement process in order to eliminate the non-value-adding elements.

As a result, Lean is a way of thinking: to adopt, to change, to eliminate waste and to establish a continuous improvement environment [33].

## II.2.2. The Seven Wastes

Moreover, Lean is a solid strategic instrument which is used to achieve and look beyond company’s objectives. By improving standardized activities and processes, the typical problem addressed in the Lean school is all the form of waste such as poor and messy arrangement of the workplace and doing a job inefficiently. A good definition of waste has been provided in [16] as ‘everything that increases cost without adding any value in the eyes of the customer’. The same authors have also highlighted that the problem with waste is that you will not have an overview of its size because it is never measured as a whole in the company’s management accounting system. Therefore, the waste can be reduced to a desirable level by means of Lean tools but their application need to be related to the overall strategy and to the principles of lean in order to be successful [17]. There are at least seven areas that can be looked at towards reducing waste or excess of a product, as can be seen in figure 2.5 [19].

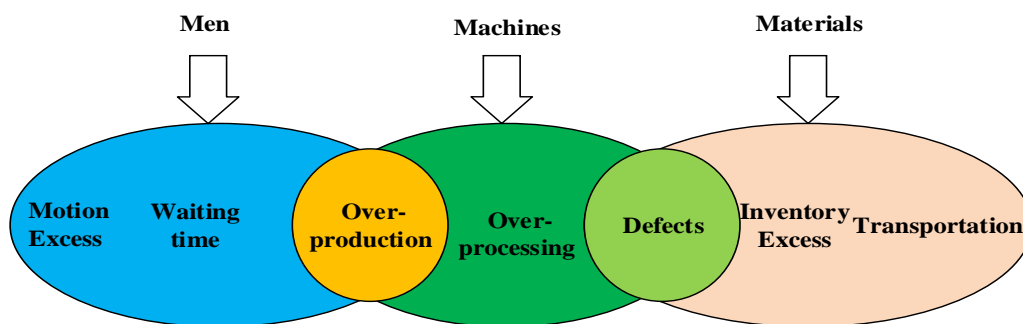


Figure 2.5. - Seven types of waste to be eliminated (adapted from [19]).

The types of waste just mentioned above, and that should be minimized or eliminated are briefly described below [19]:

✓ **Overproduction:** is the non-value-adding use of available capacity as opposed to that capacity being used to satisfy the needs of a customer. It is symptomatic of the ‘busy fool’ syndrome, with true process performance being distorted as a result.

✓ **Waiting Time, Delays and Transportation:** are clearly unwanted non-value adding activities which should be minimized and avoided wherever possible.



✓ **Over-Processing:** whether additional unnecessary stages within the process, such as an intermediate packing activities that could be improved through facility re-layout, or over-processing product beyond design specification. Similarly such waste should be minimized.

✓ **Inventory Excess:** often either through poorly synchronized purchasing practice or over production. This drives inventory up and inevitably results in process performance ambiguity and a loss in agility.

✓ **Excessive Motion:** within the process should be avoided. The point of output from one process stage should ideally be the point of use for the next stage.

✓ **Defects and Rework:** whether this is a lean, Just-in-Time (JIT), or TQM approach, all share similar objectives of minimizing or eliminating all defects. The ‘zero-defect’ philosophy of TQM is therefore very much embodied within any lean-thinking organization.

It is not enough to simply conduct a review of potential wasteful areas from an individual functional perspective. A proper end-to-end analysis should be conducted, with internal customer-supplier links well understood and considered when defining waste in order to ensure that the whole is indeed greater than the sum of the parts. Ideally waste and non-value adding activity should be defined by careful customer consultation, rather than by the process team working for the customer themselves.

Figure 2.5 also shows that Lean focuses on the speed with which a process can perform its function, A Lean strategy often addresses problems that are very visible (e.g. excessive inventory, excessive motion, etc.) and data are less important. The Lean methodology is very useful for improving floor space usage and cleanliness, reducing cycle time of processes, creating a healthy work environment, etc. Nevertheless, the Lean thinking is also a total approach that involves more general operating principles (e.g. experiments, coaching/training, and teamwork) that have greater influences on the success behind Lean tools and techniques such as Just-in-Time (JIT)/Kanban, pull system, cellular manufacturing, etc. [20]. Furthermore, these operating principles have been recently expanded to include more factors, such as: learning; leadership employee relationship practice; top management commitment; communication; employee involvement; cross functionality; multiple and cumulative capabilities partnership within a supply chain [19].

### II.3. Total Quality Management vs Lean

Lean thinking had different evolutions over the time: its focus is on quality during the literature of the early 1990, through quality, cost and delivery, to customer value from 200 onwards [33]. However, it is possible to integrate other approaches (particularly the tools they offer) without contradicting the core objective of lean – to provide customer value. In other words, any concept that provides customer value can be in line with a lean strategy, even if LP tools on the shop-floor, such as kanban, level scheduling, or take time, are not used. And in fact, there are a range of complementary approaches that can, and have been, used in conjunction with lean as shown in figure 2.6 [34].

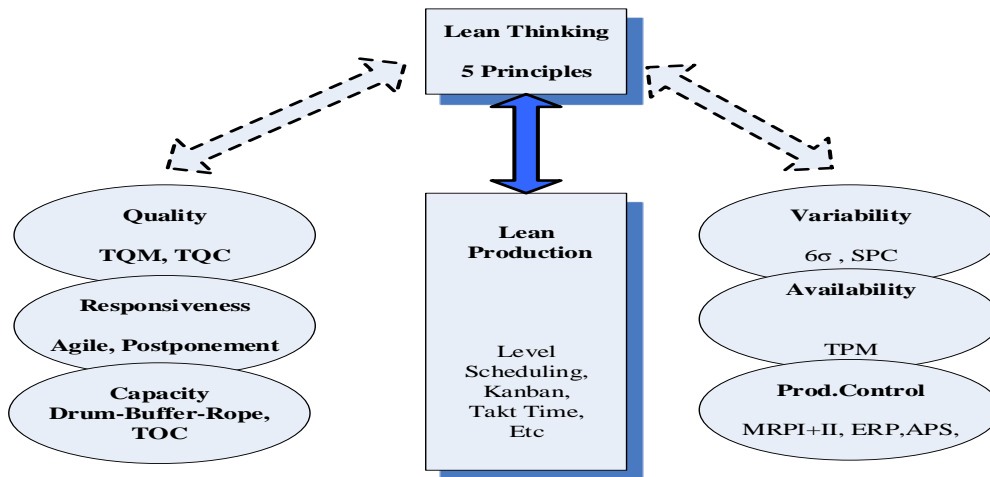


Figure 2.6 - Integrated tools combined with Lean thinking for efficient total management. [34].

The similarities and the differences between the LM and the TQM approaches will be cited in the following table 2.2 [33]

Table 2. 2. - Comparison overview between TQM and Lean principles (adapted from [33])

Aspects	TQM	Lean
Origin	Japan	Japan
Approach	Quality, Focus on customer	Understand customer value, eliminate waste
Process view	Improve and uniform processes	Improve flow in processes
Time phase	Continuous improvement	Continuous improvement
Fundamental concepts	Data-based, employee driven, orientation towards customers and suppliers	Continuous improving the value created for the customers by letting them pull value through a streamlined value stream
Participation	Normally everyone and suppliers; Let everybody be committed	Everyone participates
Methodologies	Plan, do, study, act	Customer value, value stream, analysis, flow, pull, perfection
Tools	Analytical and statistical tools	Analytical tools
Primary effects	Increase customer satisfaction	Reduce lead time
Secondary effects	Achieves customer loyalty and improves performance	Reduces inventory, increases productivity and customer satisfaction
Change introduced	Slow, incremental	Could be dramatic as well as incremental

Implementation time	Long term, 5-10 years	Long, many new things are to be incremental
Criticism	No tangible improvements, resource-demanding, unclear notion	Causes congestion in the Supply Chain

The following analysis, of the similarities and the differences between Lean and TQM, is done through three different aspects: basic assumptions, change principles and the intervention, briefly discussed below [31].

#### ❖ **Basic Assumptions**

**1. Quality:** A major difference between TQM and Lean in this aspect is the precision in defining waste. In Lean literature, waste is based on the seven forms, whereas TQM has a very general definition of poor-quality-costs, including everything that could be eliminated through improvement.

**2. Employees and the quality of their work:** The proponents of LP usually have a strong instrumental and managerial perspective, and discuss employees in terms of components in the production system.

**3. Organizations as systems:** Lean and TQM see the organization as a system but there is a slight difference in perspective between the two concepts. Whereas TQM has a strong focus on the internal structure and integration of departments within the organization, Lean stresses a supply chain perspective, and sees the internal production operations as a part of a value stream from the sub-suppliers to the end customer.

#### ❖ **Change Principles**

**1. Focus on processes:** TQM and Lean also share the conception that management should analyze and improve the processes and train the employees. Within the Lean concept the term “value stream” is usually preferred and in TQM the term “process” is used.

**2. Management by facts** TQM employs the analysis of variability through the use of statistical tools is a central concept, which is not seen as equally in the Lean.

**3. Learning and continuous improvement:** TQM is focused on stimulating creativity and individual efforts for improvement, whereas Lean places strong emphasis on the standardization of work and collective learning.

#### ❖ **Interventions**

**1. Analysis of customer requirements:** Customer focus is one of the hallmarks of TQM. The Lean concept emphasizes customer interests. Moreover, Lean is a discipline that focuses on process speed and efficiency, or the flow, in order to increase the customer value.

**2. Supplier partnerships:** The suppliers are seen as important in both Lean and TQM.

**3. Improvement teams:** Quality circles have a central role in much of the TQM literature. Although Lean team is very important to establish from, employees, managerial and leadership boards, the Lean literature are rarely discussed about the improvement teams.

**4. Scientific methods for performance measurement and improvement:** Both TQM and Lean employ various scientific methods for analysis and evaluation of performance. In TQM, measurements are done in order to identify problems and to document improvement,

whereas Lean thinking argues that measurements should be made for planning and synchronization purposes.

**5. Process management techniques:** In the Lean literature, different techniques are presented for both overall process level and individual activities. At an organizational level VSM can be used for highlighting several kinds of problems in the processes. In-control processes are more commonly associated between Lean and TQM programs.

LP usually requires, as TQM, a cultural change where the soft or intangible factors of management (the systemic factors) like leadership, people management and partnerships are changed, so that a new organizational culture is developed to support and improve the core processes [31]. To summarize the following paragraphs present the main points of the similarities and the differences between the two approaches [31]:

The aim of Lean and TQM is to improve quality, TQM reaches a certain point or stage at which no more improvements can be made. LP, however, focuses on taking quality improvement to the next level.

- The difference between the two is the approach they take. TQM views quality as a conformance to internal requirements, whereas LP focuses on reducing the number of defects. LP helps organizations reduce operational costs, cycle time, and cost savings. It tries to eliminate costs that are of no value to the customers such as costs incurred due to waste.

- In more general terms, LP and TQM requires the skills of trained professionals.

#### **II.4. Continuous Improvement/Kaizen Tools**

There are various techniques and statistical tools that have been used for decades or have been borrowed from other disciplines to support problem solving process in TQM. They form a methodological tool, which can be used to structure and visualize complex issues and which thus supports all the phases in the problem-solving process: plan-do-check-act (PDCA).

The PDCA method, shown in figure 2.7, is used to implement CI in the companies' working, and is also called the Deming Cycle or the Shewhart Cycle [13].

- ✓ **Plan:** Identify an opportunity and plan for change.
- ✓ **Do:** Implement the change on a small scale.
- ✓ **Check:** Use data to analyze the results of the change and determine whether it made a difference.
- ✓ **Act:** If the change was successful, implement it on a wider scale and continuously assess the results. If unsuccessful, begin the cycle again [14].

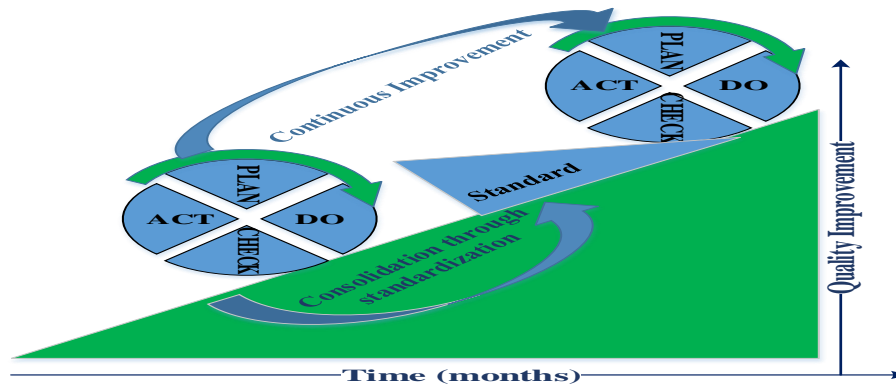


Figure 2.7 - PDCA model for continuous quality improvement (adapted from[37]).

They are particularly suitable when all of the data needed to solve the problems are available and have to be analyzed.

The figure 2.8 presents one possible approach, proposed by J. G. Pimblott, where Pareto and Cause and effect diagrams are common and essential in both processes of identification and analysis. The current approach presents seven quality control tools, according to EOQ (European Organization for Quality). The process of data acquisitions includes three tools (Check sheet, Histogram and Control chart), and the process of analysis another four tools (Pareto diagram, Cause and effect diagram, Scatter plot, and Flow chart) [13].

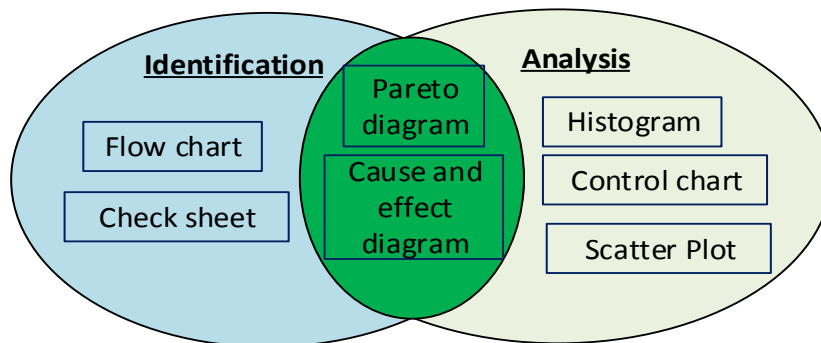


Figure 2.8 - Seven quality continuous tools in process identification and analysis (adapted from[13])

Those “improvement tools” can be used as “graphical problem-solving methods” and as general management tools in every process between design and delivery. However, they are also effective to implement the TQM internal and external objectives and continuously supervise/control them. The challenge for the manufacturing/production or commercialization industry is for: ‘Everyone to understand and use the improvements tools in their work’. Some of the seven tools can be used in process identification and/or process analysis [13]

#### II.4.1. Process Flowcharting

A Flowchart is a diagram that uses graphic symbols to depict the nature and flow of the steps in a process. Flowcharts graphically illustrate, through symbols and text, the information (data, responsibility, departments) process flow and the interaction between all the included

steps. The flowcharts make easier to understand the working mechanism of the company and highlight the responsibility of each departments/workers in the achievement of the company success and objectives. Flowchart is used to increase the process effectiveness and to organize, standardize and improve the working environments. A full description of the reasons behind using flowcharts is detailed below [35]:

✓ **Process Documentation / Training Materials:** Flowcharts are commonly used to create process documentation, although this reason overlaps with regulatory TQM requirements. This means standardizing and documenting the business processes at all the level of abstractions which play a paramount importance for the business continuous maintain and success. Flow chart offers the opportunity to be the core of the training materials which are often created to disseminate the knowledge and the informative or technical instructions to all the workers that they have different education levels and comes from various backgrounds. This methodology will help homogenize the working business environment and prepare it for some adjustments in order to continuously improve it.

✓ **Workflow Management and CI:** Flowcharts are used also to define the current state of the processes that allows analyzing processes for waste and inefficiency. After that, it is necessary to identify areas for process improvement, you can then craft new flowcharts to document the leaner processes. To ensure that the company is meeting the customers' needs, it needs to take control of your business processes.

✓ **Boosts programming:** Flowcharts support the procedural programming: to boost the effectiveness of the programming because complex program logic can be decomposed then effectively modeled to properly design the user interface.

✓ **Troubleshooting guide:** These are usually in the form of Decision Trees that progressively narrow the range of possible solutions based on a series of criteria. The effectiveness of these types of flowcharts depends on how accurately the range of problems and solutions can fit into a simple True/False diagnosis model. Troubleshooting flowchart can greatly speedup the problem solving time.

✓ **Regulatory and quality management requirements:** Many organizations may fall under certification requirements for quality management systems - such as ISO 9000, TS 16949, or one of the many others. In such environments, flowcharts are not only useful but in certain clauses they are actually mandatory. Similarly, the business processes may be subject to regulatory requirements which demand that the accounting procedures be clearly defined and documented. An easy way to do this is to create flowcharts for all the accounting processes.

#### II.4.2. **Fishbone Analysis: Cause and Effect Diagram**

The fishbone is a key tool for CI in TQM. It is a supporting tool for identifying the causes of the problems before they damage the organization. It is based on the observation of work environments and brainstorming ideas originated from the team work/group. It is a qualitative important tool that precedes the analysis of the business process and its effectiveness. It is also commonly referred as "Ishikawa Diagram" because it was developed by the Japanese quality control statistician Mr. Kaoru Ishikawa. It is defined as a fishbone because of its structural outlook and appearance that looks like a skeleton of a fish. Furthermore, this diagram typically

evaluates the causes and sub-causes of a particular problem and therefore assists to uncover and reveal the symptoms of a business problem (ASQ, 2005). For that particular reason it is also called “cause-effect diagram”. Therefore, this graphic description is a tool that can be used in order to explore and display the elements/causes analyses, to identify the roots of the specific quality problem, and to explore the relationship between them. The causes are classified under the categories of materials, methods, equipment, environment, and people [6] as shown in figure 2.9 that illustrates the entire process that can be easily interpreted. In fact, the cause and effect diagram is a simple chart which illustrates how the various factors associated to the process affect the process output [7]. The fishbone diagram has a variety of benefits: it helps teams understand that there are many causes that contribute to an effect. It graphically displays the relationship of the causes to the effect and to each other. It helps to identify areas for improvement. Then, the fishbone diagram is used to develop corrective and preventive actions that tackle the causes of a quality problem in order to avoid them in the future and improve the efficiency.

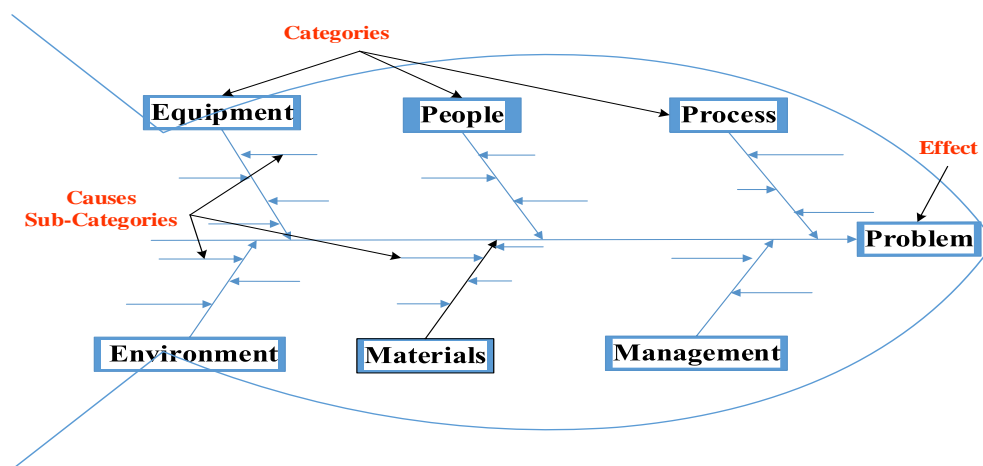


Figure 2.9 - General structure of fishbone or the cause-effect diagram [4].

Moreover, the fishbone diagram serves as an excellent reminder that the described items are the mistakes and malfunction’s causes which the company needs to pay attention and consider in order to continually improve their processes, which is an important context for the company to be competitive in the global market place. It is an easy technique to implement and to visually understand due to its structure. Even after the need has been addressed, the diagram shows areas of weakness that can be rectified before causing more sustained difficulties [6]. The next steps should be followed sequentially and applied iteratively in order to successfully draw the fishbone diagram:

- ✓ Step 1 - Properly identify the problem in hand from the analysis of the observations of the effect details. This is achieved by answering the questions: who are involved, what the problem is, when it occurs, and where it occurs.
- ✓ Step 2 - Add the major factors that contribute to the problem and identify all causes that apply to each factor: the people composing the brainstorming team are very important as they can look at the problem from different angles and identify different contributing factors and their respective causes.
- ✓ Step 3 - Diagram analysis

### II.4.3. Pareto Analysis

Engineers and managers are frequently faced with a number of problems or causes of faults that cannot be processed simultaneously. It makes sense to deal with the greatest, most important or most –cost-intensive problem first. Pareto Analysis (also known as ABC Analysis or Lorenz Distribution), which was devised in the early of 1950s by the quality expert Joseph Juran, and allows to visualize the rank order of the influencing variables of relevance to a particular issue. These are listed in order of the level of influence they exert and their numerical significance and cumulative percentage are shown accordingly (see figure 2.10. The Pareto analysis aims at identifying the causes of poor quality which contribute to the maximum problems and concentrates on these problems. It then allows to implement required modifications or actions to solve the problems [15].

The Pareto principle is also known as the “80/20 Rule” – which enable the manager to identify the 20% of the causes that create 80% of the effect allowing and to focus on those vital 20% is maximize the benefits rather than waste the resources tackling the other 80% of the causes for a minimal benefit. It highlights the vital few areas that needed to be target to tackle the bulk of the problems.

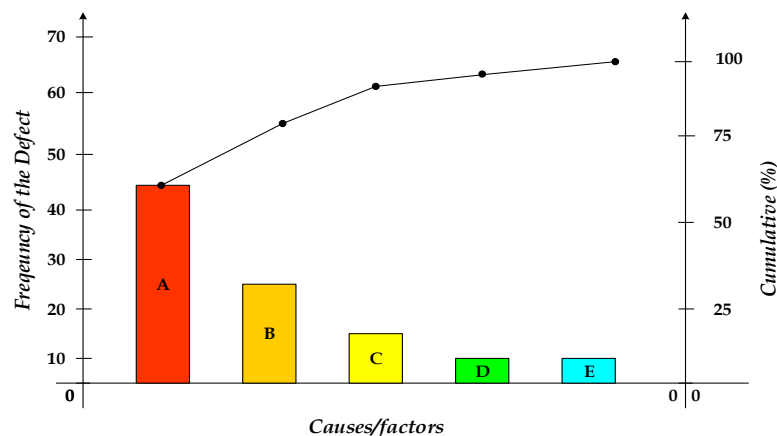


Figure 2. 10 - Pareto chart, continuous process improvement [4] .

Figure 2.10 highlights the most frequently occurring defects, the most common causes of defects, or the most frequent causes of customer complaints. Once the data is collected, it is necessary to sort the numbers in the descending sequence. The horizontal axis of the Pareto chart is labeled with the group names of the response variable (categories). The left-side vertical axis of the Pareto Chart represents the absolute frequency of the categories and the right-side vertical axis of the Pareto Chart is the cumulative percentage that corresponds to each category.

Thus, the Pareto chart and the 80:20 rule are powerful tools to help focus resources effectively for obtaining large benefits, being, at the same time, simple to use.

### II.4.4. Histogram

The Histogram is a TQM tool that shows graphically the frequency distribution of the data. It is as a summary statement of a data set and thus it enables seeing patterns that are



difficult to see in a simple table of numbers. The distribution pattern has three important points: central, width, and shape of the curve. The histogram displays the values that variables assume (e.g. temperature, materials, process, and environment) and that can be used to identify root causes and to verify the goals' achievement.

A histogram is a graph in which the continuous variable is clustered into categories and the value of each cluster is plotted to give a series of bars as shown in figure 2.11. In this figure, a skewed distribution of a set of a product measurements is shown, remaining, nevertheless, the product within the specified limits.

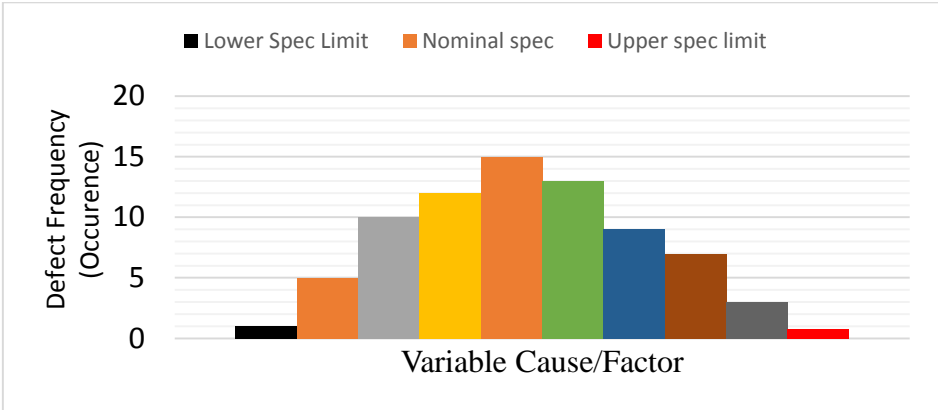


Figure 2.11. - Histogram graph for detecting the defect occurrence (adapted from [4])

Consequently, the histogram is a tool that helps in analyzing, recognizing or identifying many causes, and drawing conclusions about the dataset. It summarizes the central tendency of the distribution, as well as its variation and symmetry, among other information.

**II.4.5. Check Sheets and Lists**

A Check Sheet is a data recording form that has been designed to readily interpret results from the form itself. It is used for the collection of quantitative or qualitative repetitive data for results' interpretation. It is easy and quick to use.

A Checklist contains items that are important or relevant to a specific issue or situation. Checklists are used under operational conditions to ensure that all important steps or actions have been taken. Their primary purpose is to guide operations, not for collecting data. Generally it is used to check that all aspects of a situation have been taken into account before action or decision making.

**II.4.6. 5S's Tool**

The 5S's are a lean tool derived from the Japanese words: seiri (sort), seiton (set in order), seiso (shine or purity), seiketsu (standardize), and shitsuke (sustain) [19]. 5S is a five step methodology aimed at creating and maintaining an organized visual workplace as shown in figure 2.12.

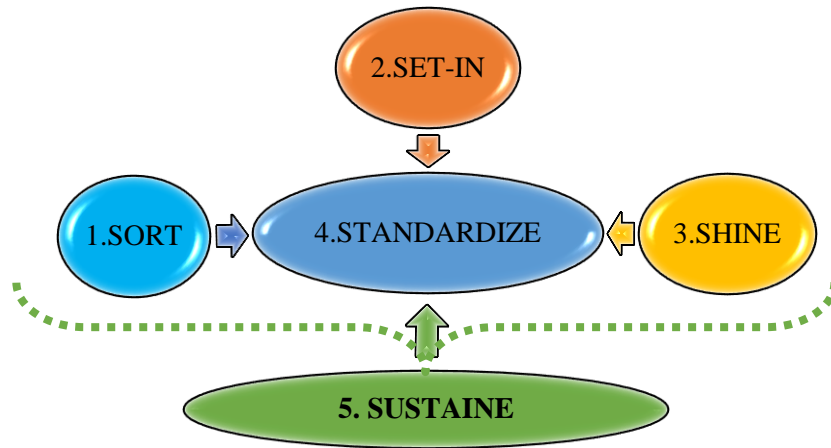


Figure 2.12. - Kaizen/Lean 5S framework for clean and healthy working environment (adapted from [18]).

✓ **Sort:** remove all but the necessary materials, equipment and supplies. Typically, the first step in a producer's implementation of 5S will be a tour of the target area marking with red tags those items that seem to be out of place or unnecessary. After reviewing each item, the item will either be put in its proper place or removed if it is unnecessary or redundant. The Sort process is essential to provide the organization of the workspace needed for LP [35].

✓ **Set in Order:** arrange product and equipment so it is easy to find and easy to use. Equipment and storage locations are labeled so equipment or tools will be easy to identify and put away when they are no longer in use (e.g., tool cutouts or outlines on a peg board or in a tool chest). The labeling of storage locations with tape on the floor or the work station facilitates visual management. A glance is sufficient to identify missing tools or tools not properly stored.

✓ **Shine:** keep everything swept and clean. Cleaning implies system maintenance and inspection. As a work area is cleaned, problems such as oil leaks or other maintenance issues become more apparent before they have a chance to affect performance.

✓ **Standardize:** Integrating the first three S's. Standardize ensures that the implementation of the Sort, Set in Order, and Shine doesn't deteriorate over time. It formalizes the procedures, schedules and practices that sustain the system and drive future improvements

✓ **Sustain:** discipline starts with the Leadership. The high level managers and responsible have to care about the consistency of their message and visions. They should pay attention while they are communicating the strategy, including the reasons for the employee actions, outside of the procurement function. The new employees have to be trained properly while providing them proper structure to support this strategy. No 5S process for supply management will be effective without vigilant leadership. Lean producers have used this process effectively, but consistent leadership over time is necessary to prevent system deterioration [35].

Consequently, the 5S is a simple tool for organizing the workplace in a clean, efficient and safe manner, enhancing the productivity and the visual management and introducing the standardized work. Most of the other definitions of 5S and descriptions concentrate heavily on the aesthetics and the efficiency gains achieved through implementing 5S and neglect the real aim of 5S; the need to introduce standard operational practices to ensure efficient, repeatable, safe ways of working.

In addition, the work standardization provides a stable foundation to build other improvements through implementing Lean tools and it provides a highly visual workplace. One of the most important benefits of 5S is that it makes problems obvious. Moreover, 5S is a team run process and should be conducted by the people who work within the area in which the principles of 5S are being applied; it is not a tool that can be applied by an outsider onto an area without the knowledge and cooperation of the people.

Finally, 5S Lean tool is very closely connected to TQM. As a matter of fact, Lean tools inherit some of TQM’s genetic materials, and Lean is often viewed as a concept overlapping with TQM. Furthermore, the 5S techniques along with TQM tools are fundamental to increase the efficiency and productivity of the employees while ensuring a pleasant organizational environment. These consequence will also have a direct impact on enhancing the company SC performance and therefore on satisfying the actual customer/clients’ needs and fulfilling their expectations.

**II.5. Total Quality Management and Lean in Supply Chain**

**II.5.1. Supply Chain Management**

A supply chain (SC) is made up of the interrelated organizations, resources, and processes that create and deliver products and services to end customers. The engineering tasks include planning and managing supplier and demand, acquiring materials, producing, and scheduling the product or service; warehousing; inventory control, and distribution; and delivery and customer service. Figure 2.13 illustrates these processes that provide the basic framework for the conversion and movement of raw materials into final products [21]. Traditionally there are three stages in SC which are procurement, production and distribution. Each one of these stages may be composed of several facilities in different locations around the world.

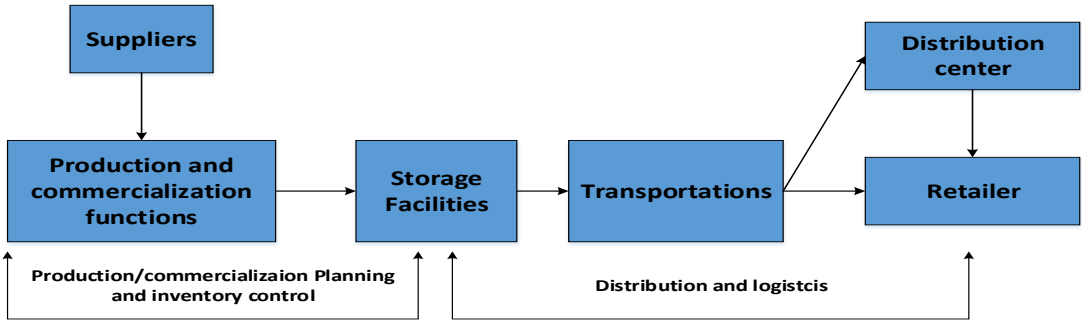


Figure 2.13 - Supply chain process [21].

SCM aims to coordinate all these activities so that customers can be provided with a prompt and reliable service of high-quality products at the least cost. Successful SCM can then provide the company with a competitive advantage and customer satisfaction [22]. SCM is a management of a global network which composed by the relationship between the supplier’s supplier and the customer’s end customer through the supply chain participants (Distributor/Wholesaler and Retailer) (Distributor/Wholesaler and Retailer) and used to deliver products and services from raw materials to end customers through an engineered flow of information, physical distribution, and cash.

## II.5.2. Integrated Total Quality and Supply Chain Management

The companies aim to produce value and optimize profitability of their supply chain. Therefore, the use of advanced management practices is necessary to attain this objective. In this context, the use of integrated approaches to TQM, logistics, and SCM becomes fundamental. Thus, it will be important to take advantage of TQM and SCM synergies in order to improve customer satisfaction, to increase employee's motivation and to promote performance of the organization [23].

Accordingly, the integration of SCM and TQM is a natural procedure, since traditionally the emphasis of supply chain was on specific features such as purchasing, manufacturing and shipping in order to support logistics operations, but due to the competitive environment, there is a need to improve the performance by controlling cost, increasing efficiency and high service levels, rapid response and high quality of products and services. This integration is known as the concept of supply chain quality management (SCQM) [23]. Moreover, the SCQM is the formal coordination and integration of business processes involving all partners' organization in the supply channel to measure, analyze and continually improve products, services, and processes in order to create value and achieve satisfaction of intermediate and final customers in the marketplace. The concept of how the areas of QM and SCM are related in a particular organization and their impact on organizational performance is still very limited [25].

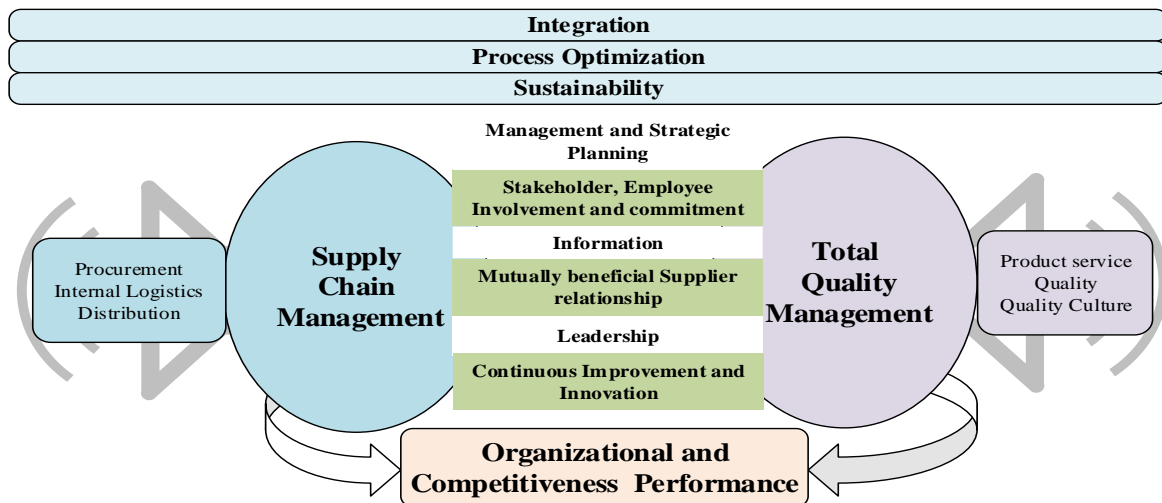


Figure 2.14 - Conceptual model of the integrated SCM and TQM methodologies (adapted from [24]).

Figure 2.14 illustrates the relationship between the two critical areas of the SCM and TQM. The ultimate goal of the TQM and SCM is improved competitiveness and customer service. Competitiveness can be achieved in many ways, e. g. by reducing costs, increasing operations flexibility with respect to market changes in customer demands or by providing excellent quality of products and services [23]-[27].

In addition, table 2.2 details the eight modern TQM principles of ISO9000 in SCQM, namely customer focus, leadership, involvement of people, process and system managements, continual improvement, factual approach to decision-making, and mutually beneficial supplier relationships [25].

The product quality at both manufacturing and commercialization processes has great effect on the quality of the final product of the company. This means that the emphasis of research and practice of TQM has transferred from company focus to supply chain focus. It is not only the high quality of products and services that are important but also the high level of quality control of the whole SC, ensuring the competition advance. Moreover, the essence of competition advantages is not simply pursuing the quality of the product and process, but also the performance of the whole SC. Therefore, the establishment of quality management system of SC based on the management ideas of ISO9000 will promote the involvement of all the members and facilitate the implementation of the quality control of the whole SC system [24].

Table 2.3 - Eight modern TQM principles of ISO9000 in SCQM [24]

Principles	In TQM	In SCM based in TQM
Customer focus	Customer = user	Customer = user + in-between users, such as suppliers, manufacturers, sellers, etc.
	Company pay attention to the needs and expectations of the user.	Company pay attention to the client's needs and expectations. Also, all the members of SC must satisfy the needs and expectations of their backward users.
	Satisfy the user.	The end users will be satisfied if all the member of supply chain can satisfy the needs of their backward users.
Leadership	Quality effort can get actual effect only with the recognition and support of the leadership.	The leaders should adequately consider the needs and expectation of the other members, establish a clear and consistent holistic target, and then lead to inspire the other members to strive jointly for the target.  At the same time, the core enterprise should foster more leaders of TQM in each layer of supply chain and make them take their responsibility zealously.
Involvement of people	The exertion of enthusiasm and creativity of all the employees is the precondition of the actual effect of quality management.	A work atmosphere should be established to inspire the enthusiasm and creativity of all the employees. Each employee should: <ul style="list-style-type: none"> <li>• Understand his role and responsibility in the SC.</li> <li>• solve the problems forwardly as mastership,</li> <li>• Learn the principles, skills and technologies of TQM and ISO9000.(foster the ethos of self-motion and self-knowledge in SC through 5S).</li> </ul>

Process management	It is the requirement of the quality management system of SO9004:2000 and the essential difference of modern and traditional quality view.	The processes and their mutual effects should be identified and managed to ensure the harmonious operation of supply chain. Then, the key processes can realize high quality, i.e. small variation, small waste, and more increment, through the CI and total quality control in all the SC nodes.
System management	TQM is a holistic approach that identifies and manages all the sub-systems respectively. Then, the coordinated effect and mutual promotion among the sub-systems will make the whole effect greater than the sum of the improvement of each sub-system and improve the validity and efficiency of the realization of final targets [8].	<ul style="list-style-type: none"> <li>•Enterprise should confirm the mutual dependence relationship among the processes in supply chain system.</li> <li>•Break the boundary among supply chain members.</li> <li>•Construct and integrate the processes in supply chain system.</li> </ul> <p>Then, many well operation sub-systems can be constructed to collocate the resources rationally among the sub-systems.</p> <p>The whole SC system: supply, transport, production, distribution, inventory, etc., can realize the target and policy of quality through the optimal operation.</p>
Continual improvement	In the quality of the product in order to reduce the cost and satisfy the customer.	<ul style="list-style-type: none"> <li>•Is pressing because the market competition is hard.</li> <li>•All the member of SC should improve their product and service respectively. Then, the continual, stable and harmonious quality assurance can be established.</li> <li>•The leaders and other members must find the ways and practices improving performance in or out of supply chain through benchmarking to make the CI speed fast than the one of rivals.</li> </ul>
Factual approach to decision making	Collecting data/ info <ul style="list-style-type: none"> <li>•Advanced information technology,EDI/ERP,Intra-net/Internet, are used in order to provide foundation for making decision.</li> </ul>	<ul style="list-style-type: none"> <li>•Collect data and information of the company and all the other members of SC to record and analyze the current operation situation of each member.</li> <li>•The potential problems in any step of SC can be found duly according to the results of data analysis.</li> </ul>
Mutually beneficial supplier	<ul style="list-style-type: none"> <li>•TQM organizations collaborate with their suppliers in some way to</li> </ul>	The core enterprise must realize the following activities:

relationships	<p>increase the quality of component parts.</p> <ul style="list-style-type: none"> <li>• the organization and its supplier are mutually dependent. Maintaining the mutually beneficial relationships between them can improve the ability of creating value both of them</li> </ul>	<ul style="list-style-type: none"> <li>• Identify and select the main suppliers, reduce the scale of SC, and realize small supply base management.</li> <li>• Investigate the requirements of customers and develop new product jointly with suppliers.</li> <li>• Share information, technology, and resource with suppliers.</li> <li>• Admit the improvement and achievement of suppliers.</li> <li>• Take joint improving activities with suppliers.</li> <li>• Ensure the conformity of quality system between core enterprise and the other members, including basic conformity (e.g. program files, technology specification, process interface) and advanced conformity (e.g. quality target, quality policy, and quality culture).</li> </ul>
---------------	---	--

### II.5.3. Lean Supply Chain

Continuous improvement in processes to focus on the elimination of waste or non-value activities stops across the chain is an important aspect of the Lean Supply Chain (LSC). It is supported by the reduction of set-up times to allow for the economic production of small quantities. In this way organizations can achieve the benefits of external responsiveness by responding to customer requirements with flexibility. The SC can provide higher profits and internal manufacturing efficiency when product demand is stable and can be forecasted accurately. Moreover, LSC focuses on responding to unpredictable market situation. It is used to achieve a quicker delivery and lead time flexibility. It deploys new technologies and methods, utilizes information systems/technologies and data interchange facilities and puts emphasis on organizational issues and people (knowledge and empowered employees).

The primary objective of a LSC is to get access from the communication data on inventories, capacities, and delivery plans and fluctuations, within the framework of just-in-time (JIT) principles. The objective of the LSC is one that produces just the right product at the right time with as little waste as possible. This, in turn, indicates that increasing customer value can be achieved from cost reduction on the supply side. Thus, it is necessary to reduce and eliminate waste or non-value added activities in the total SC flow [25].

In lean terms, SC and logistics areas are frequently viewed as a box (one activity, such as warehousing) or a line (transportation) on a value stream map. Value stream mapping separates value-added and non-value-added activities starting at the customer and working its way through the system back to the supplier [28]. Many concepts and tools in the lean practitioner's toolkit can be applied to the SC and logistic function. Some are relatively simple and easy to understand, such as 5S-Workplace Organization, Visual Workplace, and Layout. Others, such

as Batch Size Reduction, Quick Changeover, and Total Productive Maintenance (equipment-related waste), are more complex [28].

Toward Lean logistics, organizations need to implement leaner thinking and incorporate it into the SC in order to achieve better organization benefits and improve customer service, reduce environmental impact by decreasing waste and even improving overall corporate citizenship. Hence, Lean logistics management focus not only towards making the system operate but towards the continuous elimination of waste and continuous improvement of the system including on logistics and quality.

## **II.6. Summary**

This chapter has presented the principles and concepts of the TQM and Lean approaches for quality continuous improvement. The complementary continuous improvement (Kaizen) tools for defect analysis, identification, and corrections such as fishbone, Pareto, flowchart, etc. and for work environment organization and waste elimination such as Lean 5S's were presented. Moreover; this chapter has revealed that the TQM and Lean are two management approaches to improvement that have many concepts in common. However, based on Lean strategies, TQM can be a tool to support and build synergies for creating more competitive factors in the market place. Hence, Lean and TQM both aim to improve quality, where Lean boosts and renew the TQM strategy when it reaches a certain point or stage at which no more improvements can be made [33].

According to the review and study performed in this chapter, it can be concluded that some differences between Lean and TQM are worth to be mentioned. First, Lean focuses on improving entire value streams, whereas most of the other improvement methods tend to focus on individual processes. The second important difference is that most process improvement methods tend to focus on improving the productivity or efficiency of major value-adding processes, whereas Lean emphasizes reducing or eliminating non-value-adding activities (waste) and adding value. LP has become a popular trend among companies and especially among manufacturing companies. TQM is also a great tool mainly used in manufacturing, and service industries. In addition, TQM improves and sustains the quality of the products and processes in order to meet or value-added to customer expectations. Within Lean settings, TQM has been enriched by peculiar Lean practices geared at reducing manufacturing process variance. Finally, Lean is not just a box of tools; it is a system, philosophy and thinking and TQM is one of various tools and techniques to implement Lean principles in an industry.





### Chapter 3: Case Study: Lean and Total Quality Management in Logistics Processes

This chapter will be dedicated to the application of the integrated approach based on the TQM tools aligned with the 5S principles in order to install autonomous and stepwise CI (Kaizen) methods and tools in Pimelux company, in accordance with the theoretical background addressed in the previous chapter. The challenge arising from applying these tools and techniques within the 5S-Kaizen-TQM approach in the company organization will be also discussed.

Furthermore, the steps involved in the problem identification and analysis will be presented to cope with actual situation and then to efficiently implement the process of CI for the preparing orders, after sales process, warehouse organization, and eliminating wastes.

The results of the followed approach that combine waste elimination, work environment organization, and CI tools that target process standardization and quality excellence in order to satisfy customer’s need and their expectation will be presented.

#### III.1. Company Presentation

Primelux is a commercialization company of light-emitting diode (LED) lighting products and systems. It mainly imports their manufactured LED products and accessories from China. The company commercializes these products with a proprietary (i.e. Primelux) brand name mainly in the Portuguese market. Primelux is located in the center of Portugal, in the industrial zone of Oliveira de Bairro. It has been established in 2009. “SOANJO” is the fiscal name of the company. It is offering to the market a wide range of LED lighting products and solutions for lighting areas: domestic, industrial, road as well as related services.



Figure 3.1 - Primelux locals and warehouse.

Primelux is composed by administrative offices and a big warehouse with a reception desk where workers collaborate together to process the customers’ orders acquired directly at the reception or sent from the commercial team via informatics systems as shown in figure 3.1.

The accuracy and the efficiency of the prepared lots of LED products according to the customer's requirements and specifications is the high priority of the company. The main mission of the company is to satisfy the needs of their clients, guarantying the availability of the desired products and assuring the product warranty during 5 years, which is the warranty duration of LED products. The working persons/teams in the different workplaces and with different responsibilities have to meet the clients' specifications and expectations and serve them the best they can.

The flowchart depicted in figure 3.2 presents the general process starting from collecting the interest of the customer's order of the product till the accomplishment of the LED products/systems orders that go through various actors of the Primelux. Furthermore, the main activities, which are accomplished between four actors, the client, the seller, the warehouse employee, and the transport partner, usually involve two type of flows, physical and information flows.

Figure 3.2 highlights that the commercial employees represent the first interface that connect the customer to the company. They send the specification/interest/order expressed by the customer in order to start the preparation of the order process which will be performed in the company warehouse. The order expedition is completed by the transportation partners to the local client in Portugal. Primelux LED lighting products/systems are sold under 5 years warrantee. During this period the company undertakes to repair or replace the purchased LED goods if some defect appears in their sold product after installation by the end user. These tasks are performed by the personal of the after-sales process.

In order to make the information management flow easier, the company had implemented PHC, which is an ERP management software. It facilitates the day-to-day activities and simultaneously provides information to the manager for better decision making from the first contact of the end user to the after-sales service. The functions that can be executed by a well-trained person in this software are described as follows:

- Customers, invoicing and accounts
- Point of Sale Management (POS)
- Suppliers, orders and current accounts
- Inventory Management
- Construction Management lots
- Occupation management
- Connecting Portable Terminals
- Treasury and Banks
- Intrastat (method of collection of statistics)
- General and Analytical Accounting
- Fixed and Heritage
- Notes receivable and payable
- After-sales service and technical
- Sales force, telemarketing, Proposals
- Clinics and Medical Offices Management
- Mediating Real estate management

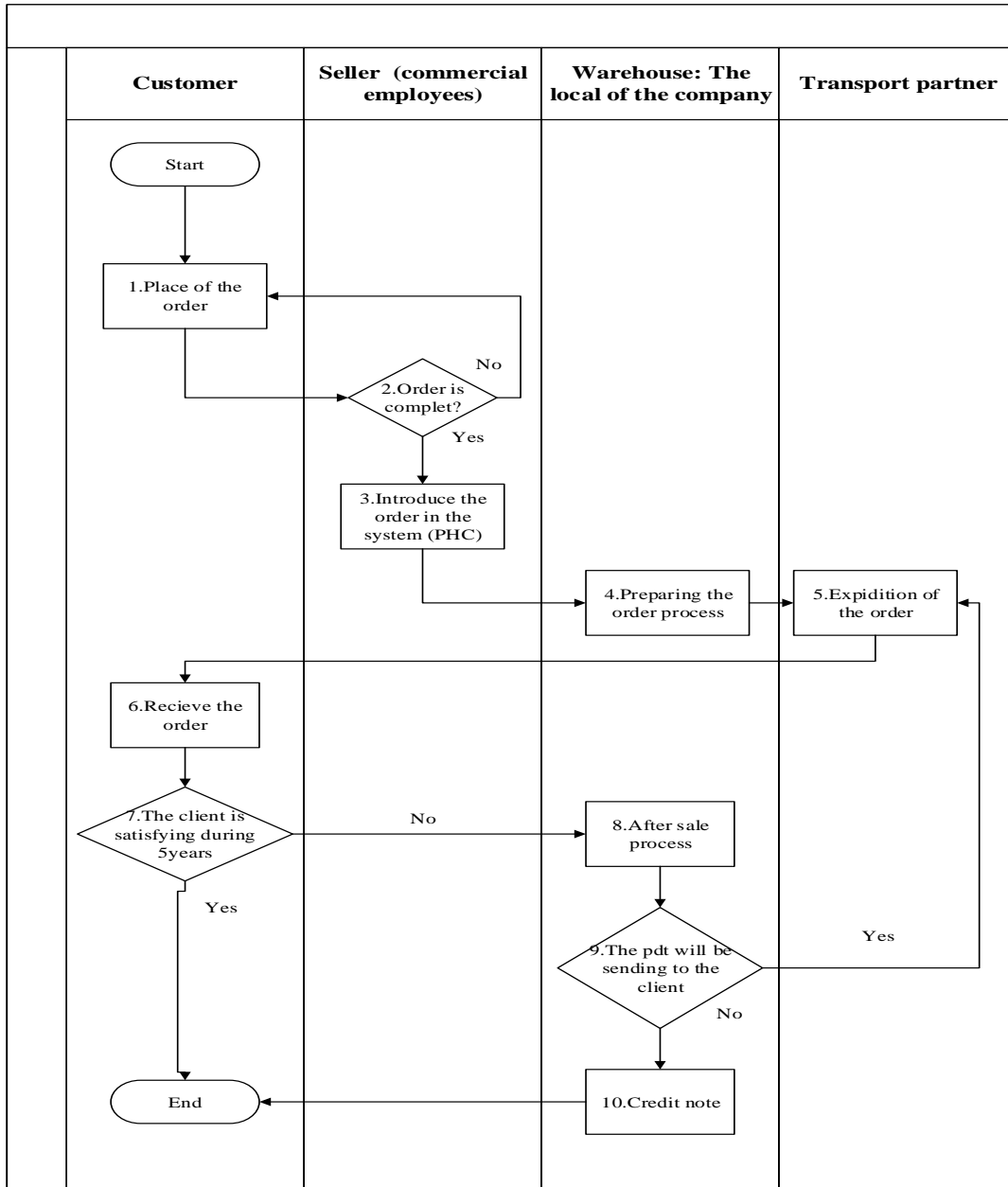


Figure 3.2 - General flowchart describing the Primelux's main functions.

### III.1.1. Human Resources and Market

Primelux currently has 10 employees distributed among the various sectors of the company: one manager, three commercials, and three logistic tasks' responsables, one for the accounting, one for the Human resources and development and one for the product development. Primelux offers to their employees training in order to improve their performance. The training can be internal or external and it is related with the different departments of the company, such as "sales and productivity techniques", "commercial attitude and customer relationship", "marketing digital", "closing of accounts 2014 and orçamento de estado (OE) for 2015". The focusing on continuous training of all human resources makes the company able to meet customer needs, market demands and get new clients.

Human resources are considered important to the company and are encouraged to receive the best training that is offered to them. On the other hand, it is expected the effort and commitment of all to meet the expectations of the company and the market service demands. Primelux commercializes its products in the national market, in Portugal, but there are some rarely cases where the products are also sold in international markets (Spain, Angola).

Figure.3.3 shows that the clients are almost uniformly distributed over Portugal. Accordingly, the area of commercialization is divided in three regions: North, Center and South. There is one commercial agent responsible for each of the regions. So the commercial people are responsible for satisfying their old clients' needs, to keep track of their expectations and to gain new ones.



Figure 3.3 - Primelux Customer's distribution in Portugal to date.

### III.1.2. Primelux LED Product









Primelux offers to the market a wide range of products and solutions for the following LED lighting areas: domestic, industrial, road and services. So their products' range answers to the replacement of the whole range of the traditional lighting. The company does not sale their products directly to individual persons/end-users. The LED lighting products of Primelux brand reconcile the reduction operating and maintenance costs with the reduction of CO<sub>2</sub> emissions while ensuring customer's significant economic and environmental benefits. Therefore, it is oriented to the contribution in the environmental sustainability. Among the advantages of using LED as a new and the efficient lighting solution the following are highlighted:

- Reduces energy costs: uses at least 75% less energy than incandescent, saving on operating expenses.
- Reduces maintenance costs: lasts 35 to 50 times longer than incandescent lighting and about 2 to 5 times longer than fluorescent lighting. No bulb-replacements, no ladders, no ongoing disposal program.
- Reduces cooling costs: LEDs produce very little heat.

- Offers convenient features: available with dimming on some indoor models and automatic daylight shut-off and motion sensors on some outdoor models.
- Is durable: won't break like a bulb.
- Is it under warranty: comes with a minimum three-year warranty which is far beyond the industry standard.

Furthermore, Primelux offers to their customers a 5 years product warranty in order to sustain the high quality of marketed products and promoting efficiency in the pre- and post-sale services. Primelux brand aims to be market leader in the LED lighting business. The company aim is to put forward to their customers several types of LED lighting products and solutions and especially to present innovative products in order to satisfy their needs. Some Primelux products are presented in table 3.1.

Table 3.1 - An Example of different types of LED products commercialized by Primelux.

			
Lamp RGB	Lamp	Prime 360°	Spot SMD
			
Prime down light aluminum branco	Prime down light aluminum	Panel house	Panel house
			
Tube lamp T5 SMD	Industrial Accessorios	Exterior Fita IP65	Prime deco
			
External lampe	Projector	Projector	Project with sensor

This large range of products needs to be codified in order to simplify the product identification and ease the control of the physical flux and also to have a standard codification and understanding with their internal people and customers. The specific codification of Primelux product will be described in Table 3.2 and an example illustrated in figure 3.4.

Table 3.2 - Primelux LED products' codification

X	Y	TT	BB	PPP	CC	SS
Armadura/Lamp	Product	Product type	Base	Power	Color	Sequence
Letters	Letters	Numbers	Numbers	Numbers	Letters	Numbers
L-Lamp A-Armadura	L- LED C- Accessories S-with nothing	01-Bulb 02-Spotlight 22-Downlight 16-Water 19-Garden 40-Drivers	20-gray aluminum 21-Aluminum silver gray 33-Black Stainless Steel 80-IP44 non-waterproof	001-1W 002-2W 200-200W	OR-red OB-Bleu WW-Warm white CW-Cool white NW-Natural white	01-Sequence 1 02-Sequence 2

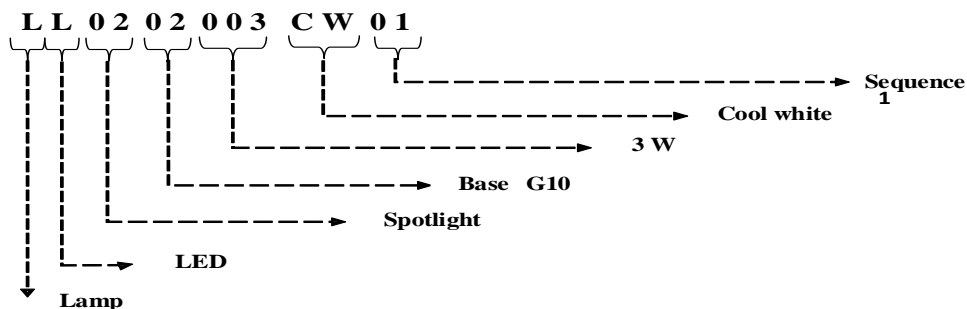


Figure 3.4. - Example of lamp, LED spotlight, and codification.

### III.1.3. Organization Chart

Primelux is managed by three associates and it is composed by six departments as can be seen from the organization chart in figure 3.5. The main activities of each of the departments are described bellow.

**Commercial department:** this department involves the following tasks:

- **Purchasing:** The purchasing of the Led lighting products and the hiring of the external services that the company needs to accomplish their activities. An essential part of this responsibility is to ensure the selection of the good suppliers/business partners, to provide to the market the needed products in the right moment with a competitive price, and to ensure that stocks are delivered on time and with good quality products.
- **Sales:** is responsible for the sales and distribution of the products to the different regions.
- **Marketing:** is responsible for market research and testing new products to make sure that they are suitable to be sold. Also responsible for deciding the type of promotion method for the products, the advertisements to be implemented and the advertising media to be used.
- **After sale product service:** it is included in the commercial department according to his importance in the detection of some information which has a big effect in the function of the three previous ones: the client's feedback about the quality product and installation.

**Logistic department:** Primelux, logistics department is responsible for the complete process involving managing and controlling the flow of goods and services, information, real-time data from the reception of the goods to the expedition of the products and dealing with after sales

service. The logistics process consists of the process of integration of several aspects such as material handling, warehousing, preparing the orders, assuring the circulation of information, packaging, and reception of the coming back material from the customers and dealing with it and also it is include the material inventory.

- **Dispatching and transport the purchased material**
- **Reception and storage:** it includes the reception of the material, ensuring the conformity of the received material, checking the product codification, and introducing the information of the product in the PHC system and storage the product in their one place.
- **Order preparation:** it is an important process which starts by receiving the customer order and finishes by preparing the transportation document and the expedition of the order.
- **Dealing and the repair of the after sale product:** this is the most important process of the logistic department. It includes reception and the products returned back, check the product state and also the repair of the broken products if possible.

**Resources department:**

The role of resource department is in charge of recruiting, training, and the dismissal of employees in the organization and is also responsible for the maintenance and control of the equipment and the vehicles of the company.

**Financial department:**

It is includes the preparation of the accounting, the insurance, the assets and the inventory. It is responsible for the suppliers and the employee’s payment.

**Quality department:** This department is responsible to ensure the total quality of the other departments. It is responsible for the implementation of quality improvement tools and the document standardization.

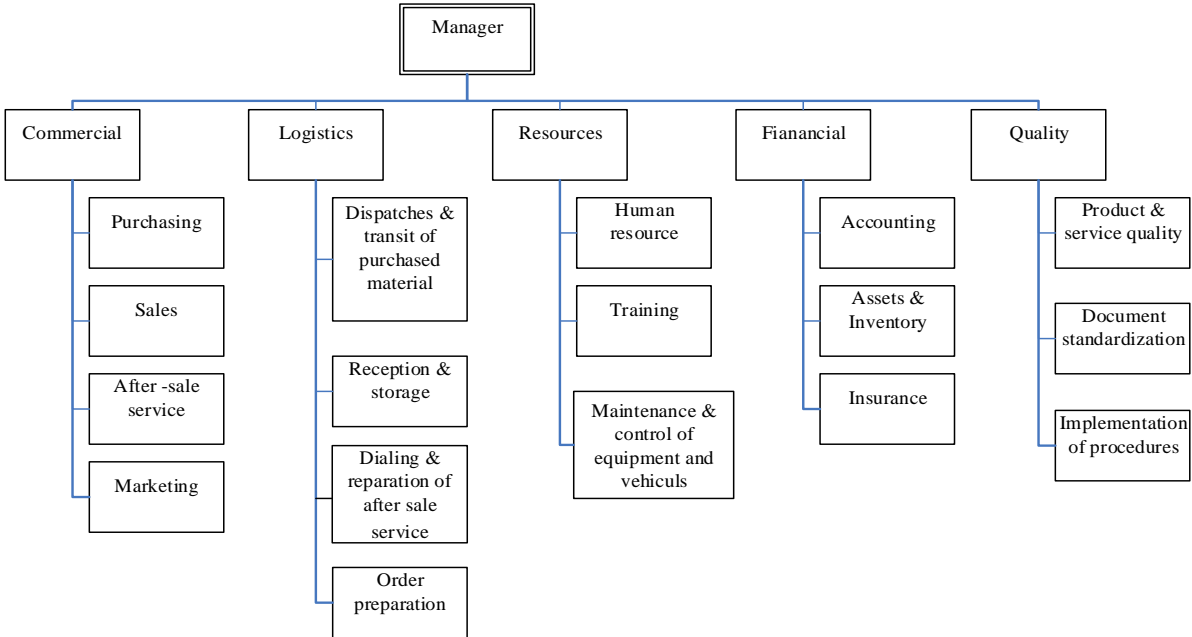


Figure 3.5 - Primelux organigram.



### III.2. Case Study Analysis

The Primelux SCM consists of product purchasing, tracking of the orders, preparing the orders, delivering, after sales service (repairing defective products), all processes required in the client satisfaction. The company aims to sustain the growth opportunities by implementing the CI working framework applied for their SCM in order to enable to satisfy the actual challenges arising from the internal and external customers in terms of the conformity of the orders, the delivery time, quality of the product, etc. and to cope with their expectations.

In this context, the company will focus its efforts on all the hierarchy levels to improve its logistic and quality processes (see figure 3.5) It is then necessary to analyze the company's situation to be able to detect and identify the improvement opportunities in order to take the appropriate corrective actions. The company was confronted with different types of problems: many customers complain about the "nonconformity" of the order, wrong articles' references, missing or excess of the quantity required, wrong client address. The returned products had also processing problems in the company warehouse. Therefore, this analysis revealed that they were undertaking an inefficient and faulty SCM and process operation that controls the customer satisfactions as detailed in table 3.3.

Table 3.3 - Different types of the errors and fails that impact the customer satisfaction and company organization, which are identified after 45 days.

Problem type	Description and examples
Nonconformities in the prepared order	<p>The non-conformity of the order can have several causes:</p> <ul style="list-style-type: none"> <li>• Missing or abundance of the quantity.</li> <li>• A wrong article reference (send to the client a different article from the desired one).</li> <li>• Switching of data between the clients: the address client, invoices...</li> </ul>
Product quality	<p>The product's quality problem can have different causes which are related to several sources:</p> <ul style="list-style-type: none"> <li>• Products in guaranty.</li> <li>• Products are totally broken.</li> <li>• Products have some defect in: the design, light color, functioning...</li> </ul>
Processing	<p>The process dysfunctions can produce the following types of problems:</p> <ul style="list-style-type: none"> <li>• The failure to consider all the receiving orders: some orders are forgotten, not seen...</li> <li>• The failure to satisfy the open orders, some orders are still open during 2 and 3 months.</li> </ul>

This section will describe the implementation of the TQM's identification and analysis tools which were detailed in chapter 2. Firstly, the fishbone (i.e. cause effect diagram) diagram will be applied to determine the different causes of insufficient Primelux's SCM. Secondly, Pareto

diagram will be applied to identify the contribution of the most important causes, especially those that affect the unconformity of the orders.

### **III.2.1. TQM Analysis: Cause-Effect Diagram**

A team brainstorming was considered as a first step in the construction of cause-effect diagram because it is suitable to help the team member to define the main effect (problem) and determine the causes and sub-causes of the dysfunction. Therefore a Brainstorming session was promoted in the company. As we can see from the diagram of figure 3.6, there were six principal causes that influence the efficiency of the SCM. Those six main causes will be detailed below:

**Faulty process:** Primelux had not defined an accurate description (flowcharting) of their processes that need to be followed neither for the key or the supporting activities. For instance, the employees performed their tasks in their proper/individual way when executing critical activities such as “preparing the orders” and “after sale process”. There was no defined and standardized documentation that clearly described the different steps for each process and even the responsibility of every employee.

**Misdirected people:** For instance, there was a lack of coordination between the employees which are responsible for the logistic. Moreover, it was mentioned that they did not have to follow any specified guidelines or rules for their job specifications. Consequently, there are some customers’ complains about the way of the employees answer their phone calls. The misallocation of the people made a big contribution in increasing the percentage of errors in “preparing order process”.

**Lack of proper equipment:** The company warehouse contained some tools of material handling, as an example stacker, chariot, handling trolley, manual truck-pallet, etc. Those tools are useful for the employees in handling the material, it was noted that the lack of IT facilities in the warehouse, especially the traceability equipment, presented an obstacle for the efficient execution of the realization of the preparing order process. The high cost of traceability equipment may be also considered as a reason of the absent of this kind of equipment in the warehouse. Also the lack of proper equipment of packaging increased the time of preparing the order, and as a consequence, decreased the number of satisfied clients per day. Also, there was insufficient use of the cleaning machine and lack of maintenance.

**Proper environment:** The warehouse environment was characterized by the protectionism and the resistance to change. As an example, the employees used to work in their one way and they don’t like to change their habits. In fact, it was found that the warehouse was disorganized, especially in the areas of the two work places “preparing the orders” and “after sales process”. As an example, in the first work place it was difficult to distinguish between the boxes of the orders that were already prepared and the boxes that were not. In addition, all the type of documents (the order, the invoice, the waybill,...) were in the same place since there was no identified specific place for each type of document.

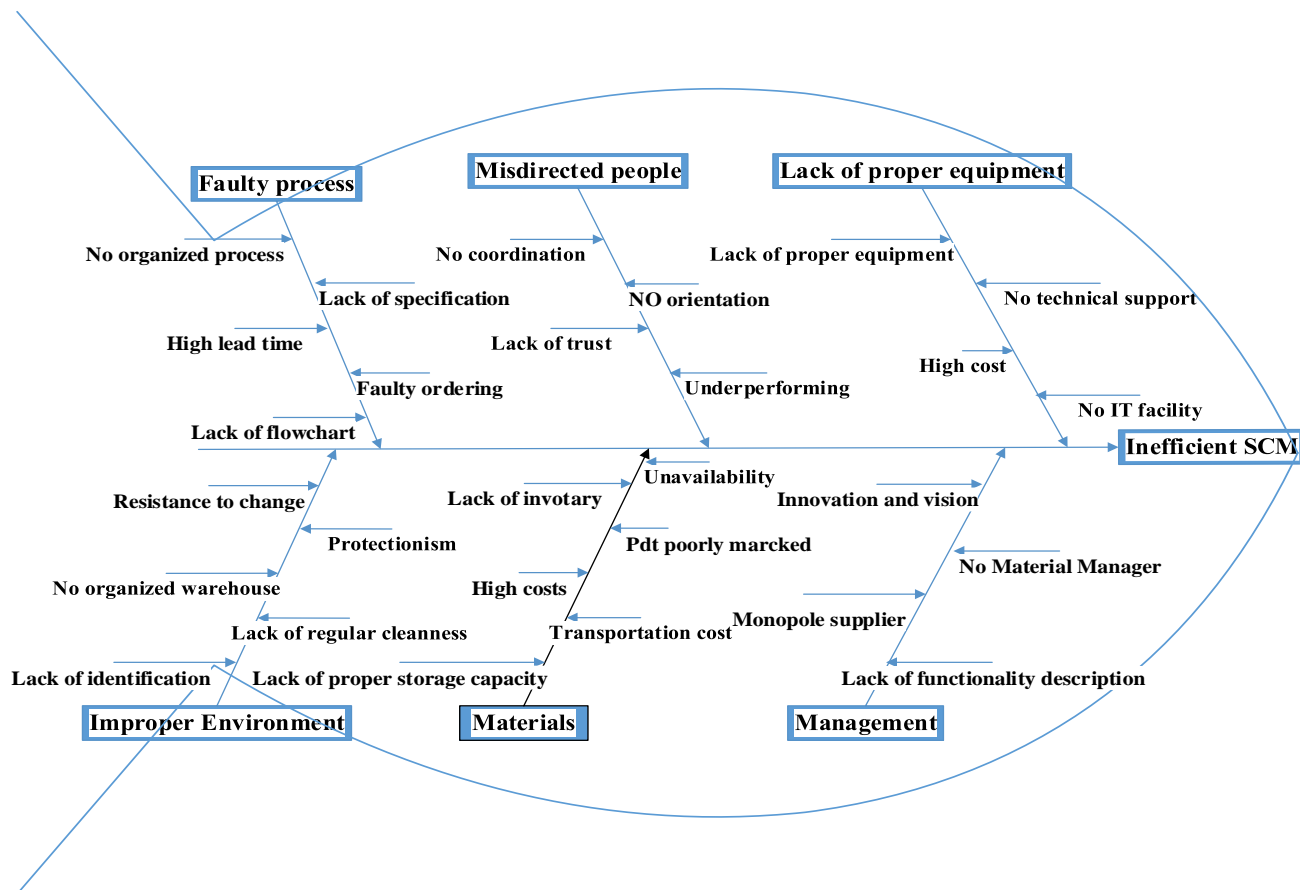


Figure 3.6 - Cause effect diagram applied in SCM of Primelux developed during the project.

- Material:** The LED product technology is considered a new product in the market with high cost and high level of innovation. Appropriately, the reason of poor materials management also rooted into few serious causes like high cost of the product, high cost of transportation, lack of proper storage capacity, and unavailability of all the items of the lighting product. Additionally, the poorly product tag and its wrong codification was one of the important causes of the poor material management.

- Management:** this outlines the strategies and a set of action plans for every product or service operation. They are virtually responsible for carrying out the business process as well as supply chain. The company management was inefficient and automatically led to an efficient SCM because there was no material manager, no clear description of employees' functions, lack of innovation and vision, etc. Also the monopole strategy of purchasing has some negative points which influenced the functionality of the supply chain management, as the operation of purchasing represent the first operation of the supply chain.

The diagram now has a comprehensive list of possible causes for the inefficient SCM, though the list may not be exhaustive or complete. However, the team has enough information to begin discussing the individual causes and to analyze their relevance to the problem. The team can use analytical, statistical, and graphical tools to assist in evaluating each of the causes. The Pareto principle will be explained in the next section in order to find the elements that cause major problems and to list them as major causes in the Fishbone diagram.

### III.2.2. TQM Analysis: Pareto Diagram

As a second step, the Pareto principle is applied to analyze the order conformity in attending the customer satisfaction. This step is performed in conjunction with the fishbone diagram for prioritizing possible changes that will improve the situation by identifying the problems that will be solved and continuously sustained. The steps followed in the elaboration of Pareto diagram were:

✓ **Identify and Problems List:** During an observation period, talking with the team member and analyzing the customer’s complain, it was detected that the “noncompliance” of the order was due to more than one cause. The most frequent problems which had a big necessity to be solved are listed below:

- The missing of the quantity.
- Wrong reference.
- Wrong color.
- Failure to consider the order.
- Exchange between the clients’ addresses.

✓ **Identify the root cause of each problem and their score:** for each problem, it was identified its fundamental cause using the cause effect diagram which is presented in Figure 3.6. The table 3.4 presents the different causes of each problem and the respective absolute frequency during last year. Those data had been collected from the observation of the waybill archive because the company has not an incidence register in their PHC system.

Table 3.4 - Identification of the root cause of each problem and their respective score.

Problem	Cause	Score
The missing of quantity	lack of traceability equipment	22
	Faulty process	
	Disorganized environment	
Wrong color	lack of traceability equipment	17
	Product wrongly marked	
Wrong reference	Lack of traceability equipment	35
	Disorganized environment	
	Faulty process	
Other	Disorganized environment	3
	Faulty process	

✓ **Group the causes and designing the cumulative chart:** As it can be seen in table 3.4, one problem has more than one cause, so the causes were grouped together. Table 3.5 presents the data stored in descending order, the score cumulative, and the cumulative percentage.

Figure 3.7 represents the Pareto diagram where it can be seen that the “lack of traceability equipment” is in the top, so it will have the highest priority, but also the “faulty of the process” and the “environment” present an important percentage and the three of them present 91% of causes of the considered dysfunctions.

Table 3.5 - Data sorted by the cumulative score and respective percentage

Causes	Score	Cumulative	Cumulative %
Lack of traceability equipment	74	74	35,07
Faulty process	60	134	63,51
Disorganized Environment	60	194	91,94
Product wrong marked	17	211	100

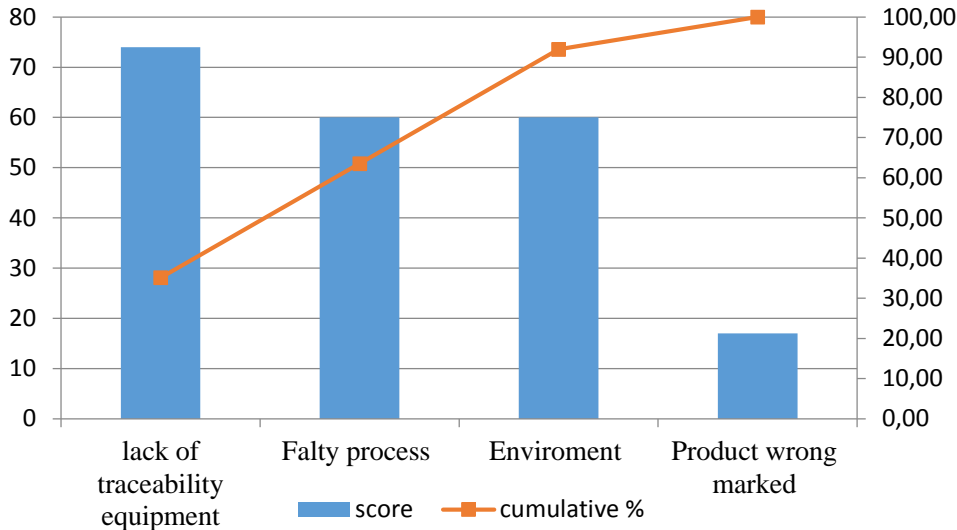


Figure 3.7 - Pareto Diagram of the nonconformity of the orders.

After brainstorming, observation, and the application of the cause-effect and the Pareto diagrams, the following sections will detail the considered actions for the TQM and 5S methodologies in order to improve the efficiency of the studied processes of the SCM in Primelux.

### III.3. Action Plan

This section draws some conclusions from the two previous sections analyzing tools in order to get an improvement plan with suitable corrective actions. As noticed in those sections, the faulty process, the missing of the traceability equipment and the confused environment are the main causes of the nonconformity of the orders. Accordingly, the corrective actions for each above-mentioned causes are the following:

✓ **Key processes flowcharting:** In order to tackle the issues related to the two critical processes in the supply chain (“Preparing the orders” and “after sales”), it is necessary to identify their flowchart diagrams, because those two have a great impact in the customers satisfaction. Flowcharting these processes help in the standardization of the process and in the detection of the dysfunction.

✓ **Availability of the adequate Equipment:** The inefficient use and the lack of proper equipment in the big warehouse contribute for the dysfunction of the SCM. Since there is a continuous increasing of the movement of the physical flux inside of the warehouse, the high number of the orders, the large quantity of the purchased material, and the product of after sales service, the presence of traceability equipment is highly required. For instance, a barcode reader

with the adequate updated database management software can be the solution to ensure the proper identification of the products and the logistic operations with a minimum of errors. Moreover, the availability of the technical equipment for packaging and handling in the warehouse can make easier, faster, and more efficient the logistic operations.

✓ **Environment organization and waste elimination (5S):** Involving and motivating the employees in creating and maintaining a work schedule and eliminate waste is the efficient solution to organize and solve the work environment problem. The focus was on the “preparing order” and “after sales process” work places. The 5S LM tool was applied in the warehouse to maintain it organized. to standardize the work, and to keep a human healthy, clean, and secure work environment. The establishment of 5S audit accompanied with daily cleaning checklist will help the employees to maintain the 5S lean tool. Therefore, employees will refrain from protectionism, resistance to change etc.

✓ **Inventory checklist:** It is recommended that the company change its philosophy in doing the inventory by establishing a more frequent routine for checking the LED product and the inventory of the entire product than doing it once per year, in order to control the movement of the stock and to detect the poorly marked items. By increasing the number of inventories and standardize it in one checklist, every week one employee of the company will be responsible for the inventory of one item, the error of poorly marked will be decreased. Also the actual storage capacity is not sufficient for Primelux which commercializes a large range of articles. This problem will be solved, as the company has already planned to build a second warehouse. Materials problems are also a key failure cause of the supply chain management which requires solutions as quick as possible.

✓ **SCM and Human Management:** Primelux should adopt a better approach to the purchasing process. Therefore, the purchasing department needs to change the actual strategy of purchasing, which is a monopole strategy, and look for other suppliers with competitive advantages. Also, to better manage the human resources there is a fundamental need to define the function of each employee. Primelux can hire more talents for bringing innovations and simultaneously train the existing ones.

✓ **Employee training:** Primelux should motivate its employees and illustrate the importance of appreciating the concept of team work and their impact in the organization. Furthermore, the detection of weaknesses of each employee and provide the suitable training, is a very important action in order to improve their communication and technical skills. The identification of the position and the responsibilities of every worker minimize confusions and help everyone to focus in their specific work.

### **III.3.1. Process Flowcharting**

The main logistic activities performed in the warehouse are mentioned in the following figure 3.8. It represents the type of the flow that circulates between the internal customer, (the sellers and the other department), the warehouse and the external customers (the clients, the suppliers and the service providers, etc.).

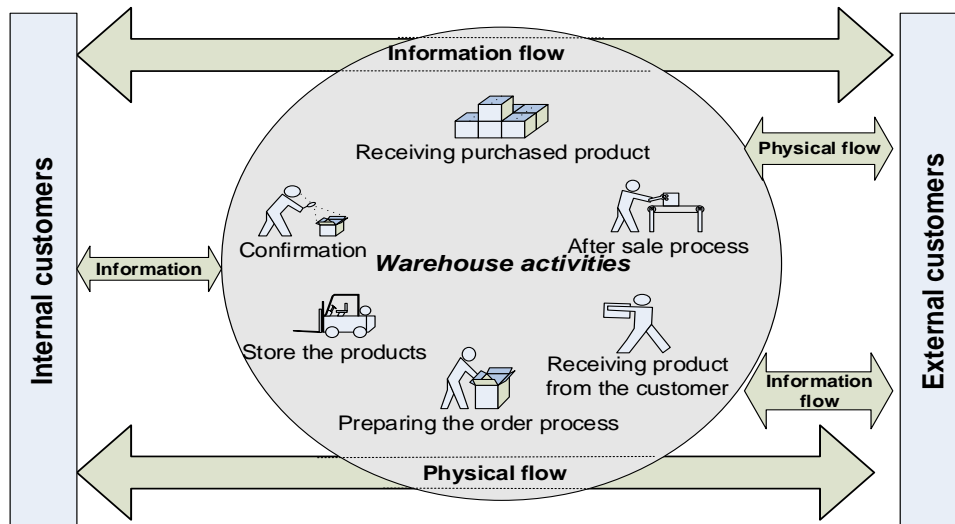


Figure 3.8 - The main activities of the warehouse and their relationship.

The activities that are considered as a direct service to the client - the preparing orders process and the after sales process - are going to be analyzed in order to standardize the processes.

### III.3.2. Preparing Order process

The order preparation or order picking operation is one of the most important for the success of the logistic warehouse's processes. It consists in taking and collecting articles in a specified quantity before shipment to satisfy customers' orders. It is a basic warehousing process and has an important influence on supply chain's productivity. This makes order picking one of the most controlled logistic processes.

Preparing order flowcharting is the first experience in order to standardize the work for the company. To get the final version of the flowchart, the company has performed several steps. Firstly, make the team members aware to the necessity to change the way of preparing the orders and to the importance of standardizing the process. Secondly, the process was observed during a period of time in order to better understand the logical and the different steps that need to be performed during the picking order process in order to prepare the first flowchart version. Before doing a group meeting to discuss the flowchart, it was discussed with two employees and some changes were incorporated on it. During the meeting with the group member, the updated version and how to minimize the Human error during the process were discussed. It was also proposed to buy a traceability equipment, having this proposal been supported by all team members. The most important actions that were performed during the meeting are listed below:

1. Improve the flowchart version.
2. Take the decision to buy traceability equipment: it has advantages that help in doing a better activity:
  - Eliminate the possibility of human error
  - Workers can instantly identify packages and products with a high precision.

- Keep manual data entry errors at a minimum, since workers often spend a considerable amount of time examining packages, reading identification information and correcting data.

- Maintain tight and accurate control over inventory. Warehouses, for example, can scan barcodes on packages as they enter and exit the facility to maintain a record of every package stored at the warehouse.

3. Implement an alert in each order introduced in the PHC from the sellers.

Finally, the preparation order process is standardized in the flowchart shown in table 3.6, where an explanation of the different steps is also provided.

Table 3.6. - Preparing order flowchart and their respective actions.

Flowchart	Action
<pre> graph TD     Start([Start]) --&gt; R1[1. Receiving order]     R1 --&gt; D2{2. verification of the order requirement}     D2 -- No --&gt; R3[3. Contact the client]     D2 -- Yes --&gt; R4[4. Introduce the order in the PHC]     R4 --&gt; R5[5. Print]     R5 --&gt; R6[6. Prepare the order]     R6 --&gt; D7{7. Is the order conform?}     D7 -- No --&gt; R8[8. correct the error]     D7 -- Yes --&gt; R9[9. Prepare the invoice / waybill]     R9 --&gt; R10[10. Prepare the carriage bill]     R10 --&gt; R11[11. Expedition of the order]     R11 --&gt; End([End])     </pre>	<ol style="list-style-type: none"> <li>Orders can be by telephone, in-person, mail, PDA.</li> <li>Confirm all the requirement of the order acceptance. (procedures INCLI),</li> <li>Contact the client to complete the requirement.</li> <li>Introduce the order in PHC system. Alert in the commercial email</li> <li>Print all the orders which will be ordered according to their receiving time.</li> <li>Preparing the orders.</li> <li>Control the orders they already</li> <li>Correct the error.</li> <li>Prepare the invoice.</li> <li>Prepare the transport document.</li> <li>Expedition of the order accompanied with the according document.</li> </ol>

### III.3.3. After Sales Process

Primelux clients benefit of this service during 5 years if their product fulfill the warranty conditions. To standardize this process, firstly it was necessary to discuss with the responsible employee about the different phases that the returned product can pass through (reparation, transformed to pieces, garbage, also it can be a good product but the client has not enough



experience in the installation ...). Secondly, a first version of the flowchart was prepared and discussed with the responsible. Again some modifications were introduced and the standardized process flowchart was obtained. Furthermore, a group meeting was scheduled to discuss the last version of the flowchart. As a result, the group member has discussed and agreed on the proposal flowchart and took the decision of adding a new register file to the PHC system for “after sales service”.

This process is long and has a lot of specifications but the standardization process is easier than the previous one. Therefore, as it is mentioned in figure 3.9, after sales process is divided in two parts: the first part is related to the relationship with the client and the second part is associated with dealing with material in Primelux warehouse. The different steps of the process, which are illustrated in the occurrence flowchart, are also detailed following.

### **The first part of the after sales process: The relationship with the client.**

- 1. Client complaint:** the clients of Primelux can complain by sending e-mail, phone-call or physically presence at the local of the company.
- 2. Is the product under the warranty?:** it is necessary to check if the client complaintfulfills the conditions of the warranty
  - Is the product under the warranty or not.
  - Does the product belong to the company or not.
- 3. Technical assistance:** If the complaint does not fulfill the conditions the process will be automatically open a new sub-process of “technical assistance”.
- 4. Open an after sale processes:** If the complaint fulfills the conditions, an occurrence process will be opened.
- 5. Is The product already in Primelux?:** This step is to check if the product is already in the company.
- 6. It is to be substitute immediately:** In this case if the product is not available yet in Primelux, is necessary to check with the client if it is an emergency case or not and to understand form the client the situation of the product. If the client needs this product in one or two days or he can wait until the reparation of the broken one.
- 7. Waiting for the product:** waiting until receiving the faulty product.
- 8. Prepare new product:** Prepare the new product in order to substitute the broken or malfunctioned one. This step involves more than one action. The employee prepares the desired client product and verifies whether it is in good quality conditions and if it has the required performance. Then, the product’s packaging tasks starts.
- 9. Prepare the document “waybill”:** Prepare the document that it will accompany the product.
- 10. Expedition:** Send the product to the client.
- 11. The client still interested in the product:** Check with the client his/her satisfaction and whether he/she is still interested in the Primelux product.
- 12. Credit note:** If the client is not interested in the product any more, a process of credit note will be started.
- 13. Return the product to the warehouse:** The Primelux client needs to send the complained product to the company at the same time as the occurrence is opened. In this step, the material is physically available in the warehouse (in the local of receiving the occurrence).

**14. The product is it broken:** Verify the situation of the product: Check whether the product is broken or has some dysfunctions.

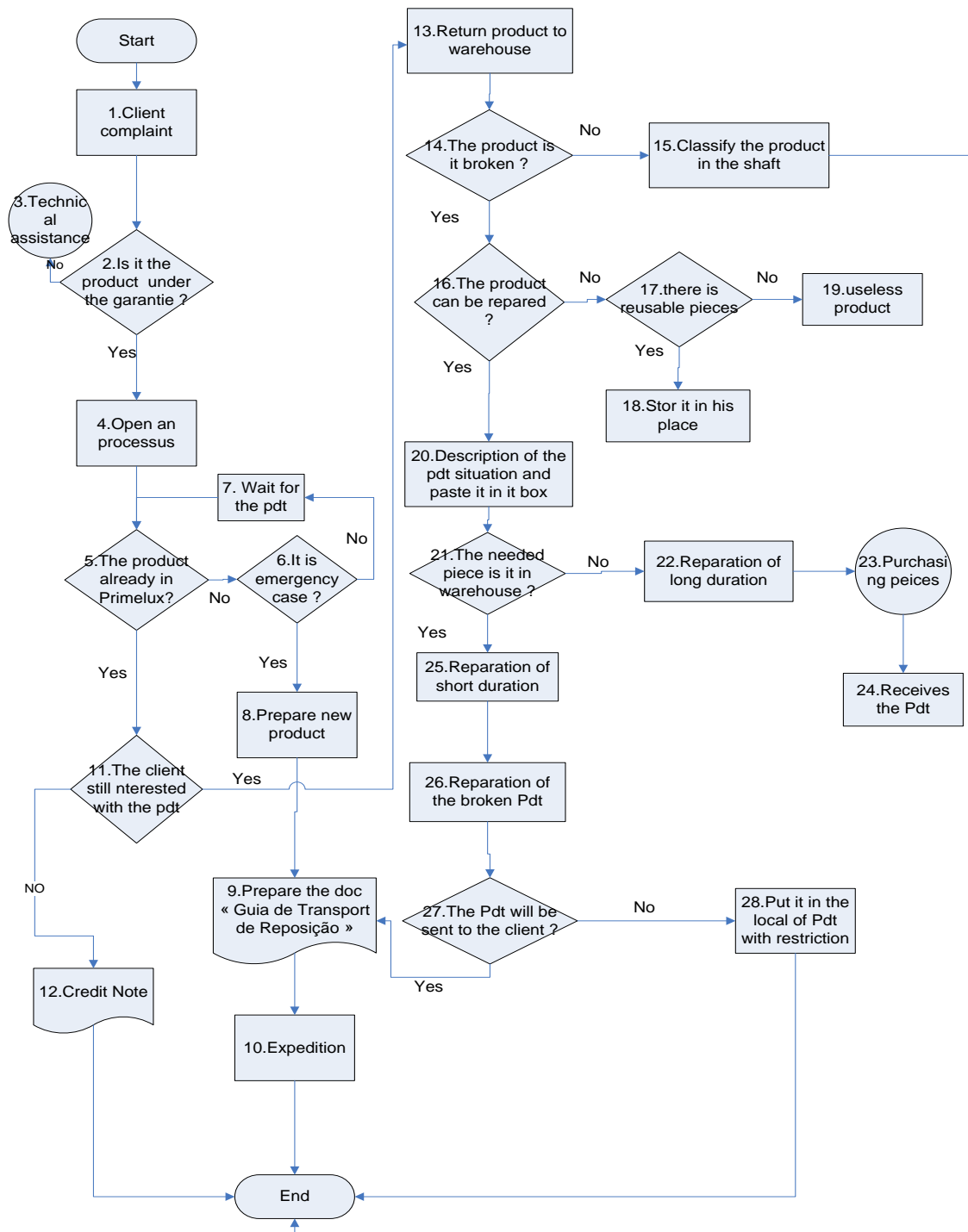


Figure 3.9 - Flowchart of the after sale process.

**The second part of the after sales process:** Dialing with the returned product in warehouse. In this part the complained product is already available in Primelux local.

**1. Classify the product in the shift:** The product is in good condition, so it will be classified in their shift.

2. **The product can be repaired?:** Do the diagnostic of the broken material .And verify if the material can be repaired or not
3. **There are reusable pieces?:** When the product cannot be repaired, the worker check if there are some reusable pieces.
4. **Store it in his place:** the worker stores the reusable pieces in its appropriate places.
5. **Useless product:** the useless product will be classified according to its item and is shifted to the useless products' place.
6. **Description of the product situation and stick it on the box of the product:** complete the form and describe the situation of the product.
7. **Are the needed pieces in the warehouse?:** Check if the needed pieces exists in the warehouse or not.
8. **Repair of long duration:** If there is a necessity to purchase the needed pieces the product will be classified as “reparation of long duration”.
9. **Purchasing pieces:** Start the sub-process of pieces purchasing.
10. **Receiving the pieces:** Receiving the purchased pieces.
11. **Repairing of short duration:** If the repairing piece is available in the warehouse the repair will be classified as “a repair of short duration”.
12. **Repair the broken product:** repair of the product.
13. **Will the product, be sent to the client?:** If is yes, it will be related to step number 7.
14. **Put the product in the local of product with restriction:** after satisfying the client all the repaired products will be classified as products with restrictions.

**End of the process: the process can be closed from different points, according to the situation. 12/10/15/28.**

**Technical assistance:**

The sub-process of the technical assistance is considered as a supporting activity of the after sales service. When the product is not under warranty or is not following the condition of a free after sale product, Primelux provides its customer a technical assistance service. The different steps of the sub-process are shown in figure 3.10.

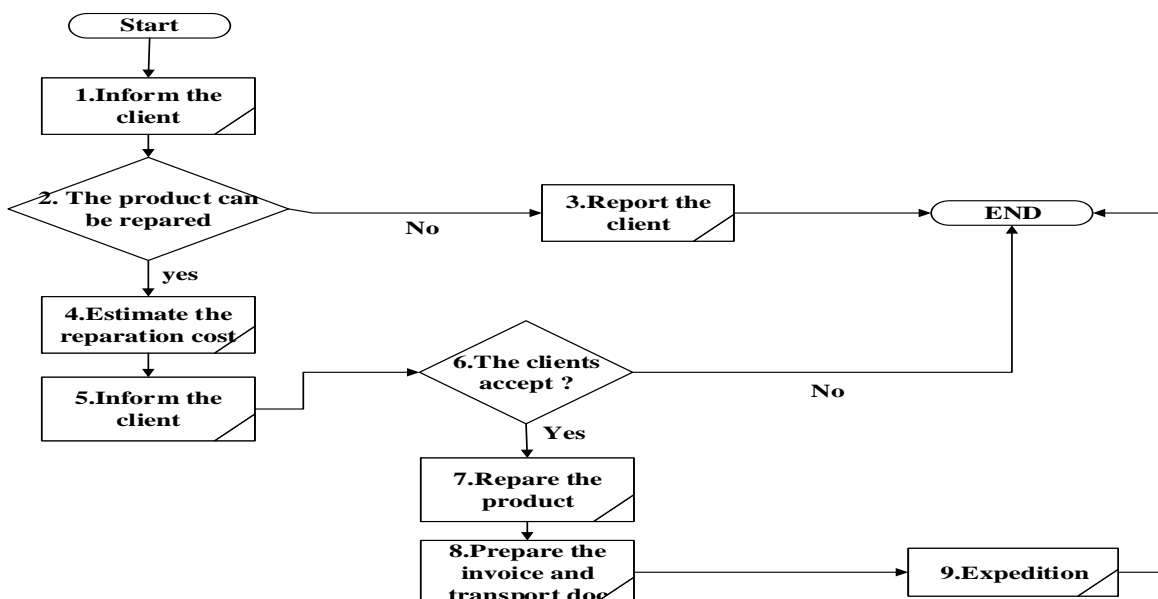


Figure 3.10. - Flowchart of the technical assistance.

- 1. Inform the client:** Inform the client that their product doesn't fulfill the warranty conditions.
- 2. The product can be repaired:** is to check the product situation, it can be repaired or not.
- 3. Report and inform the client** about the product situation and the process will be closed.
- 4. Estimate the repair cost, duration,** and inform the client.
- 5. The client accepts:** waiting for the client feedback, if he accepts or not.
- 7. Repair the product:** Repair the product.
- 8. Prepare the invoice and the transport document:**
- 9. Expedition:** Expedition of the goods accompanied with the according document.

This subsection has described the first action taken in the preparing orders and after sell process by means of flowcharting toward providing a clear explanation of different interdependent and iterative steps involved in the respective processes. These flowcharts were developed with the collaboration of the employees and the final version was communicated and shared with them. Consequently, the employees will have a clear appreciation of their responsibility in executing their tasks and highlighting the importance of their work in the success of the whole preparing orders and after sales processes with respect to the customer's satisfaction. Furthermore, both processes flowcharting will be the core pillars to progress with further improvements in the company regarding eliminating waste and organizing the working environments/area through 5S lean CI implementation that will be detailed in the next section.

#### **III.3.4. 5S application:**

This section presents the implementation of 5S tool in two different Primelux's workplaces. Firstly, the two workplaces will be illustrated before applying the 5S tool. Secondly, an identification of the different steps followed by the tool implementation will be described, and finally the new organization of the two workplaces will be presented. The 5S tool will be performed in:

**The first work place area:** preparing orders workplace includes all the steps starting by picking the product until the expedition.

**The second work place area:** After sale process work place, includes all the steps starting by receiving the returned material until the classification of the products.

For performing the 5S in the first step, several photos of the entire warehouse were taken with a digital camera. As it can be seen in figure 3.11, the second work place is messier and more disorganized than the first one. Nevertheless, the first work place contributes for the increase of the number of errors of the nonconformity of the orders. For this reason, the first workplace has priority in applying the 5S.

The 5S is considered as an important tool for the company and a new culture for the employees. However, the 5S implementation is not an easy task/job to do since the company's employees usually lack the 5S culture and this may cause an environment resistance to change their daily habits.

**The first working place**



Preparing order working area



Working table



Reusable packaging boxes



Returned product



The preparing order area



Stacker

**The second working**







Figure 3. 11. Illustration of the status of the two workplaces before applying the 5S tool.

### III.3.4.1 . 1st phase: Sort - Set in - Shine

The first three stages of 5S were performed together because they are the base of the tool and they are interdependent.

During the sorting stage, the needed materials (products, tools, and packages) were separated from the useless ones. Here some illustrative cases of employee bad habits will be cited:

- 1- There were no stored products on the working table.
- 2- Returned products existed in this working area.
- 3- The packaging boxes were mixed with garbage and rubbish of paperboard.
- 4- Useless documents existed on the working table.
- 5- The prepared orders were mixed with others which are in the phase of preparation.

So, all the garbage were threw out and the unnecessary products were **stored**. This step was repeated many times. After a period of time when the employees use to take out the unnecessary items from their working area, some team discussions, in the area of the first work place took place, in order to change the ideas of how this area could be reorganized in a new way. Finally, the different locations that compose the workplace were identified with explicit guidelines, which are cited bellow:

- The working table: it is used during the collecting of the order's products and place the product in their boxes. The under table space is used to store Primelux packaging boxes with different sizes.

- The verification location: it is a verification place of the orders.

- The packaging table: this table was a suggestion of one discussion. To hold the packaging roll and facilitate the packaging tasks. It is used for the tubular product packaging.

- The expedition place: after preparing the transport document of the orders and attach it in the boxes the prepared orders will be moved to the expedition place until the end of the day.

- The cleaning tool place in order to make it an organized way.

- Home locations for the different used tools: the stacker, the chariot and the manual truck-pallet. Also the exits and the access were identified in order to assure the safety of operations.

The cleaning phase was accompanied with the two previous ones. At the end of those three phases, and with collaboration of the team members, a cleaned area and organized environment which has identified places of all needed tools in this area were obtained. The places were also bordered the identified by adhesive tape for a better visual identification of the changes made.

The photos that can be seen in Figure 3.12 present the new set in order of the first work place organization. Most of those photos were taken after two or three weeks of the implementation of the three previous phases. In this period, some changes of the equipment location were done and also this time was important for the employees to be familiar with the new organization of work place.





Figure 3.12 - Illustration of the status of the 1st workplace after applying the 5S tool.

### The second work place: after sales process

This area is more difficult to organize than the first one, as it is larger and its process has more specifications as can be seen from the flow chart diagram.

The first phase was so hard to perform that it took about three weeks to accomplish. The following cases were found to need improvement:

1. Products don't belong to the company.
2. Products don't fulfill the warranty conditions.
3. A big quantity of products no treated from two years ago.
4. Products with restrictions mixed with other products and pieces.
5. Working tools are everywhere has and do not have a specific place.



During the sort phase almost 4 full palettes of useless material and garbage were taken out of the place.

In the **set in order phase**, several meetings took place in the area of the second work place in order to organize it and take the necessary actions and considering the sequence of the different steps of the after sales process. The different locations that were identified during the several steps performed in the after sales process are cited bellow:

- **Receiving returned products:** This place is where the returned products are kept until they will be processed and treated.

- **Working table:** It is for the diagnostic and the repairing of the product. The storing of the hand tools that are used daily by hanging them on a tool board was proposed: Firstly, the shapes of all the hand tools were design to be helpful in placing the tool in its due location making also easier to visualize the missing of any tool. Secondly, with the collaboration of an employee, the hanging tool was fixed and the board was attached in the wall of the working table. The under table space was used for the separation of the daily wastes.

- **Storing shelf:** This shelf is divided in three parts for storing the products and tools: waiting for decision, short duration repair, and tools not daily used.

- **Office table:** it is for doing the administrative tasks related to the after sales process, the registration of the process in the PHC system, contact with commercials and the clients.

- **Testing table:** the testing of the product can last for several hours or for one or two days, therefore it is necessary to identify a specific location just for testing. It is composed by a table to hold the product and a testing lighting board.

- **Rejected products:** this place is for the separation of the rejected products according to the product types (projectors, lamps and tubular, and the lighting tape).

- **Pieces shelves:** it is for storing the reusable pieces (disassembly from the returned products). It is classified according to the type of the pieces: Led, glass, drivers...

- **Product with restriction:** It is for the returned products that have small defects but they are working well.

- **Rejected product shelves:** the boxes of the rejected products that are daily separated, will be stored in those shelves until finishing the credit note process with the supplier because sometimes the supplier ask to send back the products to production. After closing the process with the supplier, this waste is sent to the recycling company. The space for receiving the returned products, the work table, the office table, and the place of holding the product garbage, shelves for the reusable pieces, shelves for storing the products with restriction and products waiting for pieces after the implementation of the 5Ss are shown in Figure 3.13.

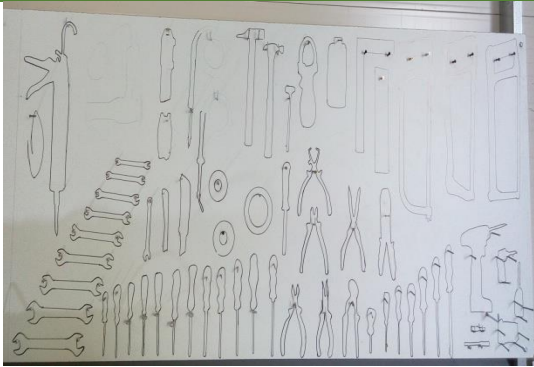
The second working place



Work table



Test table



Hand tool Board : the design of all the tools



Hand tool board



Storing shelf



Office table and the local of rejected product



Figure 3.13. - Illustration of the status of the 2<sup>nd</sup> workplace after applying the 5S tool.

The benefits of the three first steps of the 5S are to make it easy to reach the needed item and to move the other item of the way every time. Those steps firstly, increase the productivity by decreasing the time spent retrieving a tool. On the other hand, there are cost savings because "lost" tools do not need to be re-ordered. Finally, it is easier to clean up the workplace.

### III.3.4.2.5S 2nd phase application: training and presentation

Before moving to the 5Ss' two last phases, training to all the members of the company was organized, which was composed by a 5Ss presentation and two simple games. In the 5Ss presentation, the different steps of the tool were defined mentioning their importance and their effectiveness. Also a comparison between the old method and the actual one was presented in order to easily visualize the difference and valorize the tool. Furthermore, the two last steps of 5S tool were focused on and it was mentioned their importance in maintaining a successful implementation of the tool.

5Ss' games and simulation were used because it is believed that employees retain more information through doing things than being told about them. The two 5Ss' training games are quick and effective tools for persuading high management of the value of implementing a 5S program and demonstrating the benefits of the tool.

The 5S simulation was built using Lego pieces and a series of toolboxes (or tackle boxes). The aim was to build a simple model using the Lego pieces and a set of instructions. The first toolbox corresponded to the worst case scenario; all of the Lego blocks were mixed in the bottom of the toolbox along with additional parts that were not required, (pens, the cartoon waste, some small pieces...) and the instructions were in only text without no more guidelines. The second toolbox contains only the required Lego blocks, each located in a clearly labeled cell in the order that they were required for assembly. Instructions were very clearly annotated digital photographs as is illustrated in the figures shown in appendix I.

Finally, a discussion was performed to compare the two situations in order to realize the importance of the 5S and its effectiveness in the waste reduction, in the quality of the final product, in the lead time and in the productivity level. This type of training has a great impact in changing the employee culture and in motivating them to respect the rules of the 5Ss tool.

### III.3.4.3. 5S 3rd phase application: Standardize – Sustain

In the final phase, the two last steps of the 5S were applied: standardize and sustain. The standardize process ensures that the three stages of the 5S become standardized and also provides a standard method of working used by all the employees. Therefore, an evaluation board located in the warehouse as depicted in figure 3.14 has been established. It contains the cleaning checklist, illustrated in Appendix III, the responsible of the first work place has to print this list every week and to follow the daily and the weekly tasks. In checklist there is space for the signature of the auditory member to make the control easier. It also contains the result of the 5S's audit. The 5S audit is performed with a list of guidelines to make easier the tasks to the audit member. These guidelines are illustrated in the appendix VI.1 and VI.2. Furthermore, the figure 3.14 presents the lean thinking posters, which are fixed in working areas, in order to maintain the 5S tool and improve the 5S employee's culture.


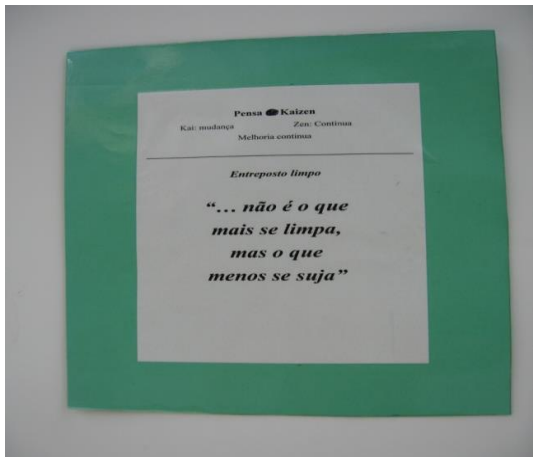
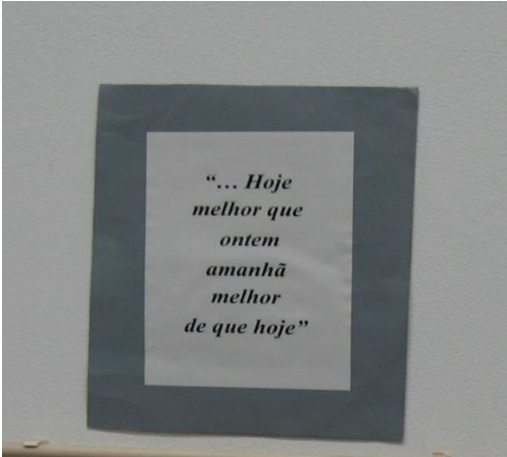
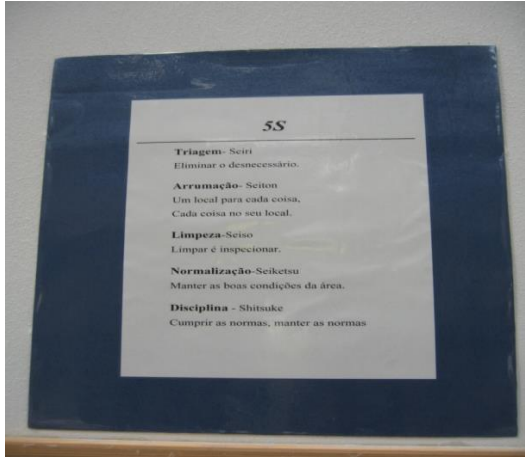
		
	Evaluation board of the warehouse	Kaizen poster
The second working place		
	5 S's poster	5S's poster

Figure 3.14. - Illustration of the Standardize – Sustain 5S application

The audit results are resumed in one radar chart and in a histogram, in order to control the state of the tool and easily detect the dysfunction. The radar chart and the histogram are fixed on an evaluating board in the working area with the objective of informing the employees about the level of their work

Every Monday, the team members analyze the result of the 5S audit for every week day, using the radar chart and the histogram , to sustain the previous improvement and continuously improve their work areas.

Figures 3.15 and 3.16 show an example of the use of the two graphic representations just mentioned.

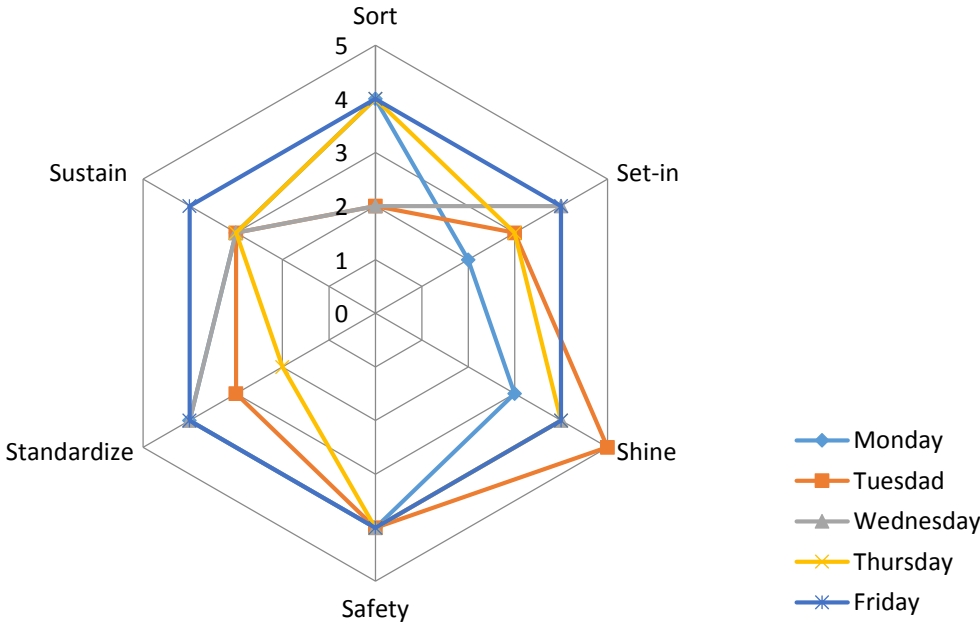


Figure 3.15. - 5S’s Evaluation by means of radar chart.

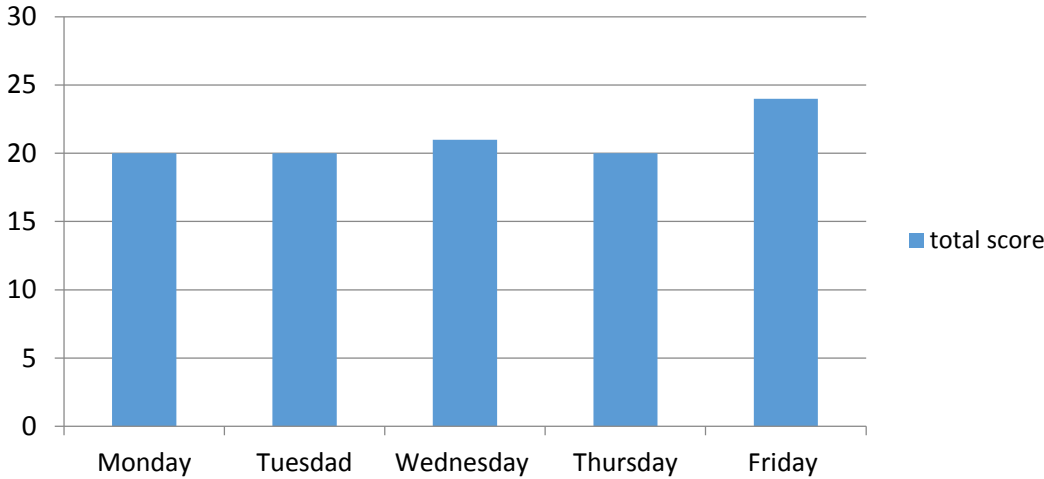


Figure 3. 16. -: 5S assessment through histogram.

The several document referring to the phases of standardizing and sustaining of the 5S tool are presented in Appendix VI.



Table 3. 7. - Audit Responsible list

Weeks	17	18	19	20	21	22
<b>Days</b>	22/04-24/04	27/04-30/04	04/05-08/05	11/05-15/05	18/05-22/05	25/05-29/05
<b>Responsible</b>	<b>Malek</b>	<b>Ana Claudia</b>	<b>Idalia</b>	<b>João</b>	<b>Eg. Soares</b>	<b>Ana Claudia</b>

### III.4. Additional Improvement Actions

Beyond the proposed action plan, some additional improvement actions were proposed and discussed. Among these actions, it is possible to refer:

✓ **The permanent/continuous inventory:** as mentioned in the Pareto diagram, the cause of the wrong marked products has an effect on the no-conformity error number. To control this fact, during the purchasing product confirmation, the employees should pay attention to the box code and the product identification. Furthermore, to better detect the wrong marked product in the warehouse, a permanent product inventory was established. It was proposed that one employee should be responsible for doing an inventory during two hours per week. This method helps the identification of the wrong marked products and the correction of the stock quantity. Furthermore, it maintains the warehouse organization and the identification of the visual product defects. A schedule table was established to identify the employees' distribution of the permanent inventory. During the first two weeks of the permanent inventory, there were two cases of wrong product marked and three other cases of stock correction.

✓ **The inspection of purchased products:** in order to control the purchased product quality, it was proposed to do an inspection for the product before the storing process. The idea was to perform a product sampling, according to the boxes size and product type, and to test its functionalities during a period of time. the product which has the highest occurrence level of problems was chosen and several products from different boxes were tested. A visual test for the physical aspect of the product was done and a connection of the product to an electrical source during 24 hours was performed. As a result, it was confirmed that all the tested products worked properly at least from visual inspections.

Nevertheless, the LED lighting technology has different aspects when comparing with the traditional lighting, which makes the inspection rally rigorous before sending to the clients. Some of these aspects are described below.

1. LED product is very reliable.
2. LEDs usually do not fail abruptly like traditional light sources; instead their light output slowly diminishes over time.
3. LED light output and useful life are highly dependent on electrical and thermal conditions that are determined by the luminaire and system design. Lifetime claimed by LED luminaire manufacturers should take into account the whole system composed and structured by various LEDs products.

4. The LED products' defects usually happen in the installation due to technical mistakes from the technician or the electrical implementation. Probably, installation instructions and product properties data is missing, that should be mentioned in the product packaging.

Unlike conventional lighting systems, LED systems are not necessarily lamp based; commercially available LED products include fully integrated luminaires, integral-driver lamps (with conventional bases), lamps with external drivers, and modules (with newly developed interfaces to other components), among others. Regardless of product type, LED system performance is typically affected by interactions between system components; for example, LED package lifetime is highly dependent on thermal management, and LED lamp performance can be dependent on the luminaire in which it is installed. Establishing a rated lifetime for a complete LED system is further complicated by the cost and impracticality of traditional life testing, especially because the continued development and improvement of LED technology can render results obsolete before testing is finished. Consequently, the typical approach to characterizing lifetime is no longer viable for LED systems.

✓ **Functionality description:** The identification of the different warehouse **workstation** and the description of their functionalities is an important action in order to define the responsibilities of each employee, maintain a good employee's relationship and minimize the probability in making identification error and unusual mistakes. Therefore every employee will focus in his tasks while cooperating and collaborating with others and their superiors. Three main functions were defined in the warehouse:

**1. Administrative workstation functions:**

- Telephone attending.
- Email management.
- Introduction of the orders in PHC.
- Shipping documentation Treatment.
- Verification of non-satisfied orders.
- Billing / Credit Notes.
- Treatment of returns.
- Administrative treatment of after sale process.
- Reception.
- General Imprint (Expediente geral).
- Archives treatment.
- Monitoring and management of transport Guides.
- Treatment and order preparation.
- Contact with external service providers.

**2. Technical workstation functions:**

- Telephone attending.
- After Sales Service.

- Repairs and technical assistance.
- Treatment and order preparation and shipping.
- Treatment of failures and non-compliance and preparation of primary reports.
- Reception and conference of the material.
- Responsible for equipment' maintenance.

### 3. Warehouse Responsible workstation functions

- Reception and verification of the material.
- Material identification.
- Material confirmation.
- Preparation of orders.
- Organization and warehouse cleanness.
- Responsible for quality documentation.
- Responsible for control equipment maintenance.
- Preparation of permanent inventory.
- Monitoring and CI.
- Eliminating setup times and orders, as they become responsible for the unwanted increase of the ordered volumes.

The workstation distribution was made considering the employee skills and experience.

## III.5. Results and Discussion

Table 3.8 presents the score of the order's failure during three different periods. The first period, from the January to June of 2014, is considered as the reference period to compare with the next two periods. The second period, from the July to December 2014, is a period of observation and analysis. The three lasts months of this period, are considering as a transition period. The situation has been analyzed and the process flowcharting was created in order to correct the process dysfunction and standardize the process. Furthermore, it was decided to buy the traceability equipment and planned for the next corrective step. In the final period, the 5S tool was applied, based in the process flowchart and make available the adequate tools (e.g. code bar reader) to efficiently perform the work tasks.

Table 3.8. - Number of defects variation.

Number no conformity order	The score	% of Defect
<b>Jan-2014 to Jun-2014</b>	46	100
<b>Jul-2014 to Dec-2014</b>	31	67,39
<b>Jan-2015 to May- 2015</b>	11	23,91



As can be seen in table 3.8, the score of the order's failure has decreased from 46, before applying any corrective tools, to 11 in the last 5 months during the application of the corrective actions of the 5S-Kaizen-TQM approach applied to the all the iterative and interdependent steps of the preparing order process. The following histogram presents the drop of the non-conformity orders percentage during the transition and applying the corrective action period.

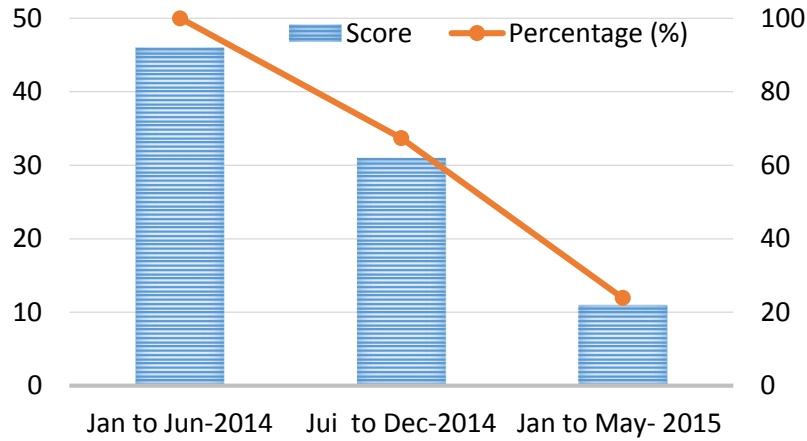


Figure 3.17. - Illustration of the number of defects variation for three different periods of observation.

The analysis of the numerical results of figure 3.17 shows that the percentage of the failures has dropped by almost 76% after the implementation of the TQM and lean tools and the availability of the traceability equipment. This promising results were a positive feedback that encouraged Primelux's workers and managers to believe more in the followed approach and to install a CI philosophy in the company, by adaptively adjusting the TQM and Lean tools to their reality..

In addition, the length of time for all the steps involved in preparing order was measured after the standardization of the process using the flowchart and the organization of the workplace area using the 5S methodology. These measurements were recorded by involving all the team member that contribute to give the time spent for running their preparing order's task.

Table 3.9. - Preparing order measurements

Order Number	Item number	Preparation	Verification	Document	Expedition
1	1	02 min :00 s	00 min:20 s	01 min:10 s	00 min:50 s
2	5	03 min:50 s	04 min:00 s	01 min:02 s	00 min:53 s
3	1	05 min:00 s	00 min:40 s	01 min:02 s	00 min:47 s
4	15	23 min:00 s	05 min:00 s	01 min:05 s	01 min:00 s
5	3	04 min:00 s	00 min:50 s	02 min:00 s	00 min:50 s
6	8	08 min:00 s	02 min:00v	01 min:00 s	01 min:30 s

Table 3.9 presents the time measurement of the different steps of preparation order. As mentioned, the time of each step depends on the item number and also on the product location. Those measurements were taken after the process standardization and the implementation of the two first phases of the 5S, because in the beginning it was difficult to take some measurement for one specific order. Furthermore, the introduction of the traceability equipment in the process has had a great impact in decreasing the time of all the process by eliminating the verification step.

### **III.6. Summary**

This chapter has presented the LED lighting commercialization company in which in the training was carried out. The studied and the investigated CI tools in the TQM supervised by Lean Thinking was applied and tailored to detect/identify, analyze and propose the action plans the defect and malfunctions of the Primelux logistic processes which are the preparing order and after-sale. Furthermore, the Lean 5S's tool was applied in conjunction with TQM tools to eliminate waste and to install an adequate working environment which enables the reduction of the number of human errors and mistakes.

Primelux employees were totally involved in this project and they have been entirely committed to successfully implementing the CI tools. Their involvement was encouraged firstly by the continuously communication of the results of the analysis step and the proposed actions' plan. Secondly, the adequate training have been provided in order to promote collaborating, cooperation and team working.

The qualitative and quantitative analysis and results have confirmed that the TQM tools in conjunction with Lean 5s tool and thinking approach can work in parallel to provide a fast and tangible results for the logistic processes of the company. This will make easier the establishment of a healthy collaborative working environment between teams/employees and make faster quality improvements of their commercialization activities enabling better satisfaction of the customer's needs and expectations.



## **Chapter 4: Conclusions and Future Work**

### **IV.1. Conclusions**

This Master report has reviewed the theoretical framework that details separately the TQM along with 5S and CI (Kaizen) tools. Then the integrated approach 5S-Kaizen-TQM was presented which was supervised by the lean thinking philosophy. The proposed integration targeted the CI of preparing the orders, after-sales, and organizing the warehouse in order to ensure CI (Kaizen) of the quality and reduce the costs/wastes of the SC at Primelux.

These tools can be summarized as qualitative and descriptive tools as flowcharting, cause-effect diagram, and check analysis. Also a quantitative analysis was presented on the Pareto diagram and the histograms to provide a scientific based metric that can enable better decision making. Preventive and corrective actions were proposed. The qualitative and quantitative tools for analysis and implementation such as flowcharting, cause-effect diagram, Pareto diagram, and check analysis were evaluated, validated and compared. The intermediate results of the implemented approach was continuously communicated to all the workers at all the hierarchy level in Primelux to adjust and correct the objective in order to provide a final result that match the company needs.

The proposed action plan was applied to the preparing orders and after-selling process by means of flowcharting towards providing a clear explanation of different interdependent and iterative steps involved in the respective processes. The flowcharts and 5S and Kaizen implementation were developed with the collaboration of the employees and the final version was communicated and shared with them. Furthermore, processes flowcharting, waste minimization, and environment organization were the core pillars to progress with more continuous and autonomous improvement in the company. Consequently, the employees had a clear appreciation of their responsibility in executing their tasks and highlighting the importance of the accuracy (i.e. precision, strength) and the timing of their efforts in the success of the whole preparing order and after processes with respect to the customer's satisfactions.

Finally, this report reflects that good engineering and management from professional and academic areas show that an integrated approach stepwise 5S-Kaisen-TQM should be followed for optimizing and improve the services of a small medium enterprise without huge amount of investment.

### **IV.2. Future Work**

Many aspects are important to get an efficient LED SCM in the LED lighting product commercialization: the high innovation speed, product life cycle, product variety, and demand predictability. Furthermore, some of the current issues are raised which concerns mainly related to the measurement and reporting of lifetime and reliability.

On the one hand, it is necessary to focus a continuous effort in the market survey in order to study customer behavior and needs for selecting the LED lighting product and systems and recognize the competitors' advantages. Furthermore, maintain a good quality, product inspection with the necessary instruments and keep tracking the innovation speed are necessary actions to assure good demand predictability and minimize the stock level.

On the other hand, although LEDs have the potential to be best than other technologies in terms of longevity, it is worth to investigate more the reliability of the LED products and systems because the selection of the right product requires some understanding of expected failure mechanisms, lifetime, reliability, and serviceability, as well as asking the right application-specific questions. In fact, for most LED light sources, the lamp fails before significant lumen depreciation occurs. Because LEDs can continue to operate at very low light levels, LED life is usually defined as lumen depreciation to a particular point, such as 70% of initial lumens. Therefore, innovative luminaire designs and control strategies—such as variable drive products that maintain lumen output—will further complicate the measurement and reporting of lifetime.

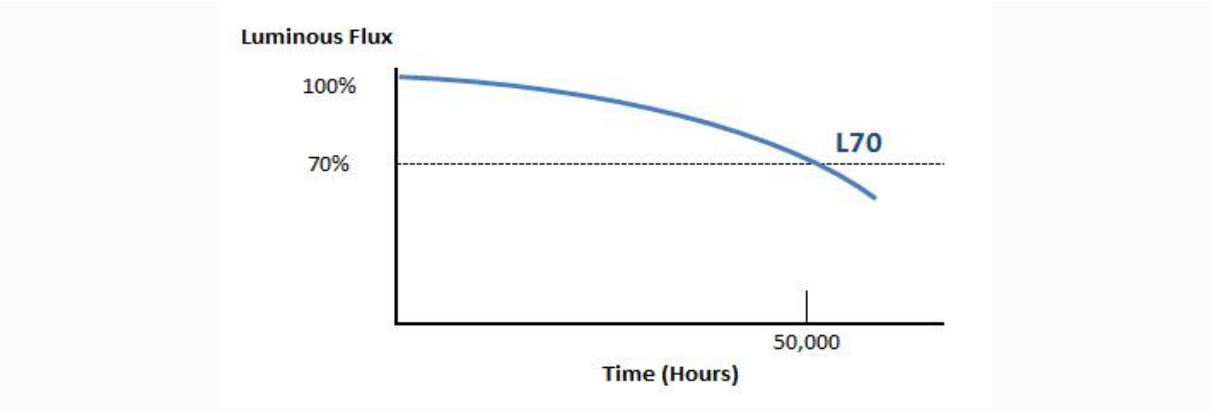


Figure 4.1. - Lumen depreciation to 70% of initial lumen output (L<sub>70</sub>).

In this context, it would be valuable to have a technical team that understands the Lumen maintenance, the lifetime, the reliability, the reliability graph and the mean time between failures (MTBF), in order to provide the right decision in supplier selection and give guidance to the LED system installation along with the required test/inspection instrument for lumen LED measurement.

Finally, it is strongly advised to extend the proposed approach to the total productive maintenance as other complementary methods, if the company would like to extend their functions to manufacturing or system packaging and installation, for maintaining and improving the integrity of production and quality systems through the machines, equipment, processes, and employees that add business value to the company.

## References

- [1] Beecroft, G. (2001), “*Cost of quality and quality planning affect the bottom line*”, *The Quality Management Forum*, Vol. 27 No. 1, pp. 1-7.
- [2] John S. Oakland, Amrik S. Sohal, *Total quality management*, 1996.
- [3] Cooper and Fisher, (2002) *Software Acquisition Capability Maturity Model (SA-CMM)*, Software Engineering Institute, Pittsburgh.
- [4] David L. Goetsch, Stanley B. Davis,( 2006) “*Quality management: introduction to total quality management for production, processing ,and services*” Fifth edition.
- [5] R. Chandrupatla Tirupathi, (2009), “*Quality and Reliability in Engineering*”, Cambridge University Press, p.326.
- [6] S.B.Mallur, introduction-Definition, Basic Approach, TQM framework, Historical Review, Benefits of TQM. Available in: <http://pt.slideshare.net/MALLURSB/unit-1-quality-total-quality-tqm>.
- [7] Bayazit, O. (2003), “*Total quality management (TQM), practices in Turkish manufacturing organizations*”, *The TQM Magazine*, Vol. 15 No. 5, pp. 345-50.
- [8] Alejandro Muñoz Casas (2011), *Total Quality Management, Quality Culture, Leadership and Motivation*, Master Thesis, Politecnico Di Milano, Corso di Laurea Magistrale in Ingegneria Gestionale Dipartimento d’Ingegneria Gestionale, 2011
- [9] Ghobadian, A. and Gallear, D. (2001), “*TQM implementation: an empirical examination and proposed generic model*”, *Omega*, Vol. 29 No. 4, pp. 343-59.
- [10] Muhammad Saeed, (2012), “*Lean thinking in the supply chain operations and its integration with customer order decoupling point and bottlenecks*”, Master Thesis Department of Management and Engineering Division of Production Economics Linköping Institute of Technology.
- [11] N. Bhuiyan and A. Baghel, “*An overview of continuous improvement: from the past to the present*”, *Management Decision* Vol. 43 No. 5, 2005 pp. 761-771.
- [12] M. Aurel Titu, C. Oprean, and D. Grecu, (2010), “*Applying the Kaizen Method and the 5S Technique in the Activity of Post-Sale Services in the Knowledge-Based Organization*”, *Proceedings of the International MultiConference of Engineers and Computer Scientists 2010 Vol III*. Hong Kong.
- [13] Mirko Sokovic., Jelena Jovanovic., Zdravko Krivokapic., Aleksandar Vujovic., *Basic Quality Tools in Continuous Improvement Process*, *Journal of Mechanical Engineering* (2009).
- [14] W. Edwards Deming, (2008) “*Quality Control And Continuous Improvement*”, chapter seven.
- [15] Mohiuddin Ahmed, Nafis Ahmad, “*An Application of Pareto Analysis and Cause-and-Effect Diagram (CED) for Minimizing Rejection of Raw Materials in Lamp Production Process*”, *S Canada, Management Science and Engineering* Vol. 5, No. 3, 2011, pp.87-95 DOI:10.3968/j.mse.1913035X20110503.320
- [16] Dahlgaard, J.J. and Dahlgaard-Park, S.M. (2006), “*Lean production, six sigma quality, TQM and company culture*”, *The TQM Magazine*, Vol. 18 No. 3, pp. 263-81.

- [17] Dahlgaard, J.J., Petersen, J., & Dahlgaard-Park, S.M. (2011). Quality and lean health care: A system for assessing and improving the health care organisations. *Total Quality Management and Business Excellence*, 22(6), 673–689.
- [18] Japan International Cooperation Agency (JICA), “ Step-wise approach for 5S-KAIZEN-TQM” available at <http://www.jica.go.jp>.
- [19] Ramunė Čiarnienė, Milita Vienažindienė (2012), “Lean Manufacturing: Theory And Practice”, proceeding in *Economics And Management*: vol 17 no. 2.
- [20] Spear, S.J. (2004). Learning to Lead at Toyota. *Harvard Business Review*, 82(5), 78-86.
- [21] Beamon, B.M., 1998, “Supply chain design and analysis: Models and methods”, *International Journal of Production Economics*, Vol. 55, No. 3, pp. 281-294.
- [22] H. Stadtler, (2005), “Supply chain management and advanced planning-basics, overview and challenges”, *Eur. J. Oper. Res.*, vol. 163, no. 3, pp.575 -588 2005.
- [23] Lin, L. and Gibson, P., (2011) Implementing Supply Chain Quality Management in Subcontracting System for Construction, *Quality Journal of System and Management Sciences*, vol. 1, no. 1, pp. 46-58, 2011.
- [24] C. Fernandes, P. Sampaio, and M. S. Carvalho, (2014) “Quality management and supply chain management Integration: A conceptual model”, proc on International conference on Industrial Engineering and Operation Management. Jan 2014.
- [25] Chang, G. (2009). Total Quality Management in Supply Chain. *International Business Research*, 2(2), 82-85
- [26] Flynn, B.B. and Flynn, E.J. (2005), “Synergies between supply chain management and quality management: emerging implications”, *International Journal of Production Research*, Vol. 43 No. 16, pp. 3421-36.
- [27] Tutuncu, O. and Kucukusta, D. (2008), “The role of supply chain management integration in quality management system for hospitals”, *International Journal of Management Perspectives*, Vol. 1 No. 1, pp. 31-9.
- [28] P.A. Myerson, “The Journey to Continuous Supply Chain Improvement”, *The Lean Supply Chain*, April 2012, available at <http://www.inboundlogistics.com/cms/article/the-journey-to-continuous-supply-chain-improvement/>
- [29] Womack, J.P. and Jones, D.T., 1996, *Lean Thinking: Banish Waste and Create Wealth in Your Corporation* (Simon & Schuster, New York, USA).
- [30] T. Melton, (2005) “The Benefits Of Lean Manufacturing What Lean Thinking has to Offer the Process Industries”, *Chemical Engineering Research and Design*, 83(A6): 662–673
- [31] A. Anvari, R. Moghimi, “The Strategic Approach to Exploration Review on TQM and Lean Production”, *Journal of Contemporary Management*, October 2011.
- [32] NIST.(2000) *Principles of Lean Manufacturing with Live Simulation*. Manufacturing Extension Partnership, National Institute of Standards and Technology, Gaithersburg, MD.
- [33] A. Anvari, Y. Ismail, S. Mohammad Hossein Hojjati, “A Study on Total Quality Management and Lean Manufacturing: Through Lean Thinking Approach”, *World Applied Sciences Journal*, 2011.
- [34] P. Hines, M. Holweg and N. Rich, “Learning to evolve A review of contemporary lean thinking”, *International Journal of Operations & Production Management*, 2004.

[35] Nicholas Hebb, "The Top 5 Reasons for Using Flowcharts to Document Your Business Processes", FlowBreeze Software, available at: <http://www.breezetre.com/articles/top-reasons-to-flowchart.htm>

[36] Kimball E. Bullington "5S Supply Base Maintenance: A Program for Lean Supply Base Management", Middle Tennessee State University, US, 2002, Available at <http://raptor1.bizlab.mtsu.edu/SDrive/KBULLINGTON/Mgmt3750/5S%20Lean%20Supply.pdf>

[37] Quality Management in the World of Scrum and Agile IT System Development, TechWell Contributor March 9, 2009 available at <http://www.agileconnection.com/article/quality-management-world-scrum-and-agile-it-system-development>





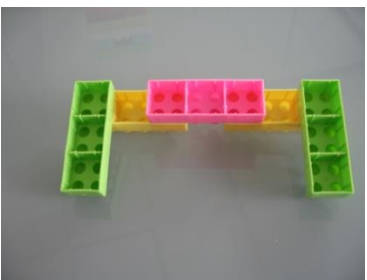
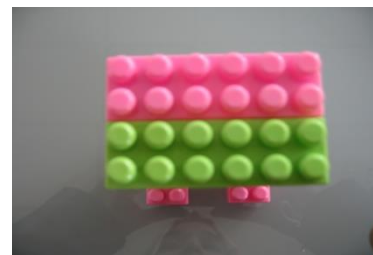
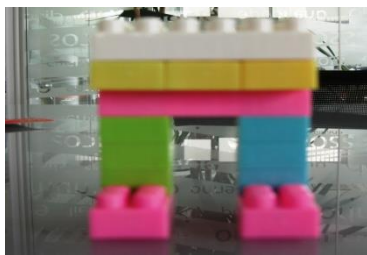
## Appendix I.1 First Training Activity



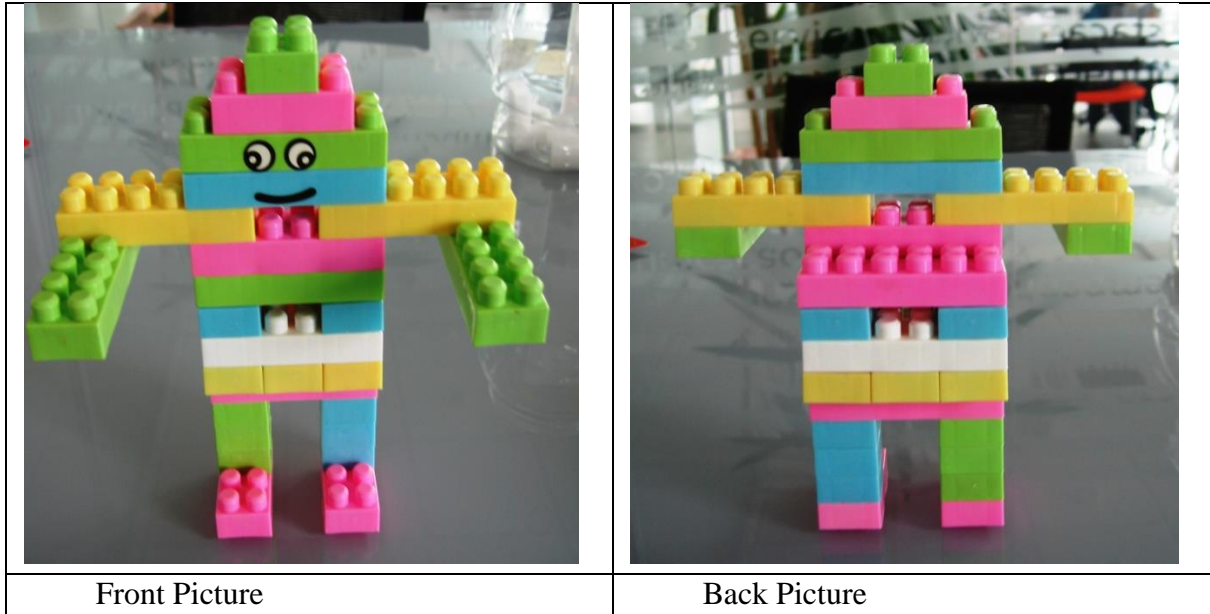
### Activity description:

Build the following man taking on consideration the two points below :

- The box ,which contain the pieces , is divided in 9 parts, every cellule contain a limit number of pieces ,please keep this separation and construct the man following the numbering of cellules .
- The following photos mention the different steps of the construction process.



## Appendix I.2 Second Training Activity



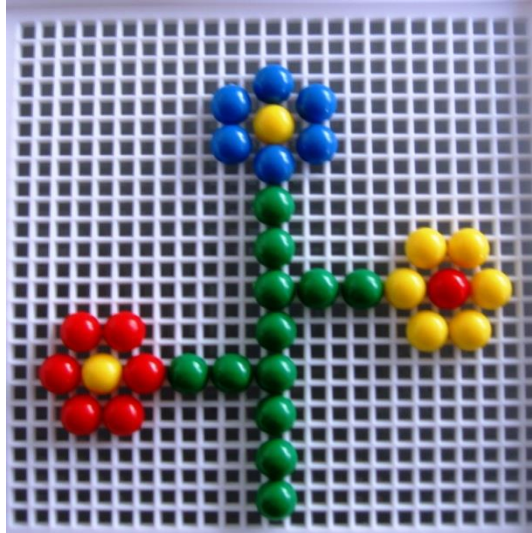
The idea of the game is to construct the previous main. Attached the two photos one front view and the second one is back view. In the building of the game it is necessary to take on consideration the following remarks by respecting:

- The colors of the picture in your contraction.
- The size of pieces.
- The number of pieces 27P.
- Don't forget to put the eyes and the smile.

## Appendix II.1 First Training Activity

### Activity description:

The idea of the game is to construct one example similar to the previous flower. Construct the flower take en consideration the colors and the number of pieces.

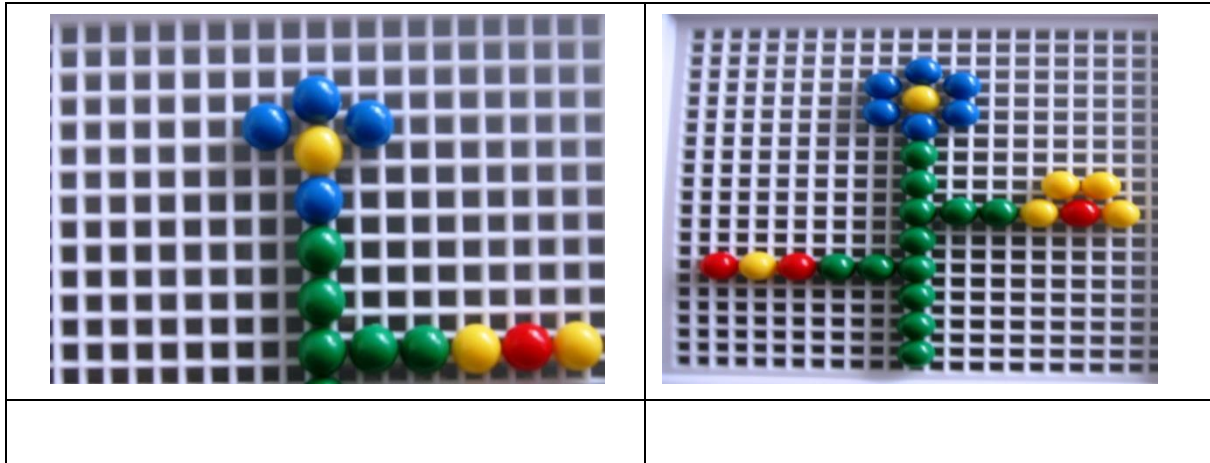


Example of the Flower to construct

## Appendix II.2 Second Training Activity

	<p><b><u>Activity description:</u></b></p> <p>Construct the flower following the different steps that are illustrated by the photos bellow.</p> <p>Please take on consideration the colors and the number of pieces.</p>
<p>8 pieces in the trunc, 2 peices in every arm</p>	





**Appendix III. Cleaning list for 5S standardization and sustain.**

<b>Verification cleaning list</b>										
Area					Date					
Responsible of the area					Audit membre					
<b>Daily tasks</b>										
Date										
Employee signature										
	1		2		3		4		5	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Working table										
The floor of the working area										
Expedition table										
Expedition area										
Audiit member signatuer										

**Weekly tasks**

	Date	Yes	No	Signature	responsable
Take the garbage			-	-	-
Cleaning the floor of the warehouse			-	-	-

Employee comments
-------------------

Audit member comments
-----------------------

**Appendix VI.1 Lean Audit Checklist**

<b>5S-Lean Audit Checklist</b>											
Area Audited		<input checked="" type="checkbox"/> Daily Audit <input checked="" type="checkbox"/> Monthly Audit <input checked="" type="checkbox"/> Team Self Audit	Overall Score								
Area Supervisor											
Employee Interviewed:											
Audit Team Members						<b>Score</b>					
Date Performed:						0	1	2	3	4	5
<b>1</b>	<b>Sort:</b> Are there any un-needed items in the area?										
	<i>Comments on # 1:</i>										
<b>2</b>	<b>Straighten:</b> Do the items that are needed have a conveniently located, visually designated homes? When not in use, are they returned to their home?										
	<i>Comments on # 2:</i>										



**Audit Team:** Refer to details below for explanation of each question. If further clarification or examples are needed ask supervisors or lean coordinator. The audit is a tool for improvement so include clear comments and conduct employee interviews to understand what has been done and why.

**Comments:** Include specific gaps, exceptional and below standard examples as well as ideas for improvement.

**Employee Interview (EI):** Interview an employee or two from the area to better understand how Lean & 5S are working in the area. (You do not need to ask all questions, just when you need to get a better understanding of where they are.)

**Audited Team:** Corrective Action should be taken for scores of 0 or 1. Consider all suggestions and ideas.

1. Sort		2. Straighten		3. Shine	
<p>Are there any un-needed items in the area (Tools, parts, drawings, paperwork, tables, fixtures, etc)? Pick any object in the area and question a team member. Specially in the work-table, verified table, in the area of holding the orders no verified... . Employee Interview (<b>EI</b>): <i>What is it for? How often do you use it? Where is it's home? Need to be Red-tagged?</i></p>		<p>Do items in the area have a designated home? Are they visually (labeled, color coded, shadow boards, etc) and conveniently organized? Can you tell what goes where? <b>EI:</b> <i>What part, tool or paperwork do you spend the most time looking for or walking to while doing your job? Is there a way to decrease that time?</i></p>		<p>Is the entire area clean? Are machines and workstations clean, properly maintained, and have all safety features in place? Do employees understand their role in 5S and TPM (autonomous maintenance)? <b>EI:</b> <i>When is the last time you cleaned: (pick an item or area)? How did you know it was time to clean it?</i></p>	
4. Safety		5. Standardize		6. Sustain	
<p>Are aisle ways, exits, electrical panels fire extinguishers, MSDS, First Aid, etc clearly marked, free from obstructions and</p>		<p>Has the team established and documented procedures for: 5S Checklists, Sort Criteria, Straighten Criteria, Red Tag System, Team Meetings, and</p>		<p>Are team members continuously improving their area or at least sustaining previous improvements? Were</p>	



<p>trip hazards. <b>EI:</b>  <i>Emergency procedures known (Tornado Shelters, Fire Procedures, etc), MSDS?</i></p>	<p>Peer audits? Are they following the documented procedures? Are the 5S Checklists, Team Binder and visuals organized and up to date? <b>EI:</b> <i>Where is your <u>(name a document)</u> &amp; how do you use it?</i></p>	<p>corrective actions taken on low scores from previous audits? <b>EI:</b> <i>Can you point out an improvement made by your team in the last month? How did it come about? How has it helped? Could it be improved?</i></p>			

