Application of the Philosophy of Quality in the Digital Electronic Matter.

Authors:

Inmaculada Plaza, E.U. P.T., Universidad de Zaragoza, Área de Tecnología Electrónica, Teruel, iplaza@unizar.es
Mariano Ubé, E.U. P.T., Universidad de Zaragoza, Área de Organización de Empresas, Teruel, mube@unizar.es
Carlos Medrano, E.U. P.T., Universidad de Zaragoza, Área de Tecnología Electrónica, Teruel, ctmedra@unizar.es
Alfonso Blesa, E.U. P.T., Universidad de Zaragoza, Área de Tecnología Electrónica, Teruel, ablesa@unizar.es

Abstract — *This paper shows a specific experience about the integration of the philosophy of quality in the Digital Electronic matter, which is introduced at the first cycle of Telecommunication Engineering (Electronic Systems speciality). This course is given at the Polytechnic School of Teruel (University of Zaragoza, Spain).*
In the first section, the authors consider the increasing relationship between the universities and the philosophy of quality. Starting with the analysis of the relation between the enterprise and the university, they explore the university like an organization with a common culture for all its members that must be managed.
All these ideas must be specified in the classroom. The second section shows the application of the philosophy of quality in the academic work, which was developed in a technical subject: the laboratory practices of Digital Electronics.
The objective was to provide the students with a methodology to analyse all kind of technological problems, to detect their causes and to make decisions in order to overcome these difficulties.
Following the method completed during the scholar year 01/02, the students were trained in the use of several of the Seven Classical Tools of Quality. The results obtained were very positive. In this way, it was possible to apply the conclusions during the next academic year, in order to improve different aspects of the educational methodology.
This situation encouraged the teachers to continue the previous experience, and they decided to extend it during the academic year 02/03 with the purpose of involving every student in a Continuous Improvement Process of the Digital Electronic matter.
The last section of this paper, describes the phases that have been developed in the current academic year, the different documents generated, the new tools showed to the students about decision-making and a useful technique that helps them generate new ideas.
We try to make the students feel as the ones who play the leading role in this Continuous Improvement Process.

Index Terms — *Learning from failures, Methodology, Quality, Teaching Innovation.*

INTRODUCTION

Spanish universities have changed deeply in last decades, due to the new society needs. The recent Organic Law of Universities states that the new environment and challenges require new ways to manage them. This law tries to provide the university system whit a legal frame that encourages the dynamism of the university community, and intends to reach a modern University, improving its quality, and serving as a welfare generator in every society areas [1].

In addition, the quality search has a relevant role in this law, as one of its main goals is to improve the quality of the whole university system and in every aspect of this concept [1].

The increasing relation between universities and the philosophy of quality in Spain is not a particular case. This trend is common to all European countries. Specifically, the Sorbonne declaration (1998), where the concept of Higher education Area appears for the first time, highlights the strong determination to promote an Europe of Knowledge in agreement with the trends of the socially more advanced countries, where the extension and the quality of the higher education are critical factors in the increasing of the life quality of the citizens [2].

In this way, university education has to be considered as an efficient tool to reach a quality improvement and a full adaptation to the knowledge society's demands. The society will need flexible organizations in the higher education field, which encourage a wide social access to knowledge and personal abilities to interpret the information and to generate the knowledge itself [2].

These challenges must be assumed by every university, as organizations with a common culture for all its members that must be managed [3].

Specifically, the University of Zaragoza should be an organization of quality, dedicated to the Aragon progress, to the education of cultured, critical and implicated people, which must be highly qualified professionals, able to respond to the social and working needs, and ready to adapt, anticipate and lead the process of change
(http://www.unizar.es/plan_estrategico.inicio.htm).

This goal can only be reached if all the workers assume the philosophy of quality, introducing it into their every day work. Particularly, teachers have to be able to specify all this ideas in their main work place: the classroom.

This paper shows a specific experience about the integration of the philosophy of quality in a subject of Telecommunication Engineering (Electronic Systems speciality), given at the Polytechnic School of Teruel (University of Zaragoza, Spain).

FRAMEWORK

As we mention above, this work was performed at the first cycle of Telecommunication Engineering (Electronic Systems speciality) [4], [5]. This course is given at the Polytechnic School of Teruel (University of Zaragoza, Spain). More information can be found in the web page: http://eupt.unizar.es (at this moment only in Spanish, English version is under construction).

The course plan of these studies determine that the goals of the educational process must be driven to make the students get the following attitudes and capacities:

- To detect and analyse technological problems.
- To design and develop projects to solve those problems.
- To adapt to variable technological and professional environment.
- Creativity.
- Communication ability, information analysis and decision-making.

We conclude that the educational process used by the teachers should foment the student's analysis and decision-making abilities. In this way, they could adapt and solve the technological problems they will face in their professional future, characterised by a continuous evolution.

Several needs can be deduced from the above arguments:

- Engineers must know a work methodology in order to allow them to develop the above abilities.
- This methodology will be the base of a work style characterised by its rigour and quality.
- The student will have to learn how to apply the methodology to different situations, as those they will meet in their professional future.

OBJECTIVES

The present work intends to cover the needs we exposed in the previous paragraph. That is, the main objective is: to provide the students with a methodology to manage all kind of technological problems in a systematic, clear and rigorous way; the methodology should be adapted to the team work and to a professional application.

Up to now, this work has been performed in two steps: scholar year 01/02 and the current scholar year, 02/03. We will explain them below.

SCHOLAR YEAR 01/02: METHODOLOGY, DEVELOPMENT AND RESULTS

The method we propose is the student training in the use of the Tools of Quality. Among the seven classical Tools of Quality (Check list, Histogram, Pareto Chart, Cause and Effect Diagram, Stratification and Scatter Diagram) [6] we have chosen two: Pareto Chart [7] and the Cause and Effect Diagram [8]. The reason is that these two tools are easy to use, simple and versatile [9].

As the ideas of quality use to be explained in the matters related to management or statistics, the present work has applied them in the laboratory practices of Digital Electronics. In this way, we try to surprise the students with this interdisciplinary approach, which will lead them to mix the knowledge of two different areas (while the students usually think they are isolated). We induce the student to think about the method as a global work style.

The process of application has been carried out in the following steps:

1. Explanation to the students:

As a starting point, the objectives of the approach were explained to the students, paying attention to the usefulness of the method in their professional future. We proposed that the conclusions obtained will be the base for the next year students, starting in this way a process of continuous improvement in the matter. Thus, the students can be more involved in the

educational process. Of course, the student effort must have a reward: the work performed contributed a 10% of the final mark (1 point).

The process includes the following steps: data collection by the students, whole data set collection and drawing of the conclusions by the teachers and final talk to the students. All of them were previously explained to the students as well as the method to apply the two Tools of Quality we have chosen.

2. Data collection and analysis of the results made by the students.

The practices were performed by 67 students, divided into 4 groups. The students were free to work alone or in two people teams. Only five of them chose to work alone. At the end of every session, they should write down a list of all the mistakes they made and any difficulty they met during the development of the practices. Close to every mistake, they had to write down the number of times it happened. 455 observations were reported, being divided into 40 kinds of troubles.

The teachers put together all the data in order to make a statistical treatment. The data could be divided into five blocks that were given to the students in a random way. They proceeded to analyse them and to make decisions. They also had to write a report, as if they were engineers in a private company, where they could be in charge of a people team and the people team met and collect these troubles. From the analysis, they should give to the company managers (the teachers) a set of actions to avoid the problems.

3. Data treatment and teacher summary.

From the last step, the teachers had 35 reports. The teachers graded them from 0 to 1. The best reports (1 or 0.9 points, 14 reports) were chosen to make the following analysis.

The students grouped the kinds of mistakes into families. Then, they represented each family by means of Pareto Chart. It allowed them to show up the most relevant families following the 80-20 rule (a 80% of the effects are produced by a 20% of the causes).

In the most relevant families, a more deep study was performed by means of the Cause and Effect Diagram in order to analyse the relation between the causes.

Even though five different types of data were given to the students, the main results are similar for all of them.

In Figure 1 we show the Cause and Effect Diagram obtained as a summary of the classifications made by the students. We started from the simplest classification (two branches: human and external). Then, we added sub-branches up to the most complex classification (eight groups).

Each branch has a variable number of observations associated depending on the kind of classification. But all the Pareto Charts made by the students show the same main mistake causes:

- Human errors: The majority (62 %) of the mistakes belong to this family.
- Instrumentation /material: A 32 % of the mistakes were related to instrumentation and material.

The *solutions* proposed by the students to solve these kinds of problems are represented in Table 1. The third column shows the solutions involving the students, and the fourth column shows the solutions involving teacher or centre actions.

4. Conclusions. Talk to the students.

The summary of the solutions has allowed the teachers to determine several activities in order to start a process of continuous improvement. These conclusions and the compendium of the reports were left in the internal network of the centre, where the students and the teachers can access them. In addition, the final conclusions were explained to the students in the lecture room.

5. Student valuation.

An anonymous opinion poll was performed between the students of Digital Electronics in order to know their opinion about the application of the Tools of Quality in the development of the practices. They could evaluate several items and give some suggestions. The results are very clear:

- A 97.5% of the students made a good valuation the application of the Tools of Quality in the practical laboratory work (Figure 2). Specifically, they point out its usefulness and its application in the professional world. They consider it a good method to prepare them for their future activities.

- They realized (a surprise for them) that the human errors represent the highest number of mistakes. Their first thought after a circuit error was to attribute it to devices and instruments. Thus, a new way of thinking and facing the problems is promoted between the students.

- A 57 % of the teams get conclusions to apply in their own work, analysing their mistakes and comparing to those of the rest of the class.

- A 90% think that the results should be given to the student next year, in order to start a process of continuous improvement. The opinion of the rest (10 %) is that the new students should meet the same difficulty level.

- The majority find suitable the difficulty level of the work and the reward they can obtain.

- About the use of the methodology in other subjects, an 8 % thinks that one time is enough to know the work methodology (see Figure 3). The 67,5 % of the students would like to apply it to other matters but they specify that the method should be restricted to the practices and that the effort should have some influence on the mark.

New contributions:

- Some teams extended the analysis to the time evolution of the mistakes.
- We found also that some teams learned more about the Tools of Quality because these students were motivated by the subject.
- Some students proposed a control of the quality of the materials used in the practices.

SCHOLAR YEAR 02/03: CONTINUOUS IMPROVEMENT PROCESS.

This situation encouraged the teachers to continue the previous experience, and they decided to extend it during the academic year 02/03 with the purpose of involving every student in a Continuous Improvement Process of the Digital Electronic matter.

The phases that have been developed in the current academic year are explained above, but some improvements were made. Among them we can state:

- A Check List has been elaborated based on the mistakes we have obtained the previous year. Thus data collection is easier and at the same time the students know a tool very useful in the industry.
- Some instructions have been given to the students with the solutions showed in table 1. In this way, the new students can learn from the oldest students.
- The revision of the material used in the laboratory is performed more often, once a week instead of fortnightly.
- The use of new Quality Tools has been proposed:

- Braimstorming: a lively technique that helps a group to generate as many ideas as possible in a short time period.
- FMEA (Failure Mode and Effects Analysis): it is an easy to use and yet powerful pro-active engineering quality method that helps to identify and counter weak points in the early conception phase of products and processes. (http://www.fmeainfocentre.com/).

FINAL CONCLUSIONS

The use of the Philosophy of Quality in the Digital Electronics practices has been shown to be an innovative approach allowing to detect the problems and to continuously improve the educational method.

We try to make the students feel as the ones who play the leading role in this Continuous Improvement Process.

ACKNOWLEDGEMENT

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FIGURES AND TABLES

FIGURE. 1
CAUSE AND EFFECT DIAGRAM.

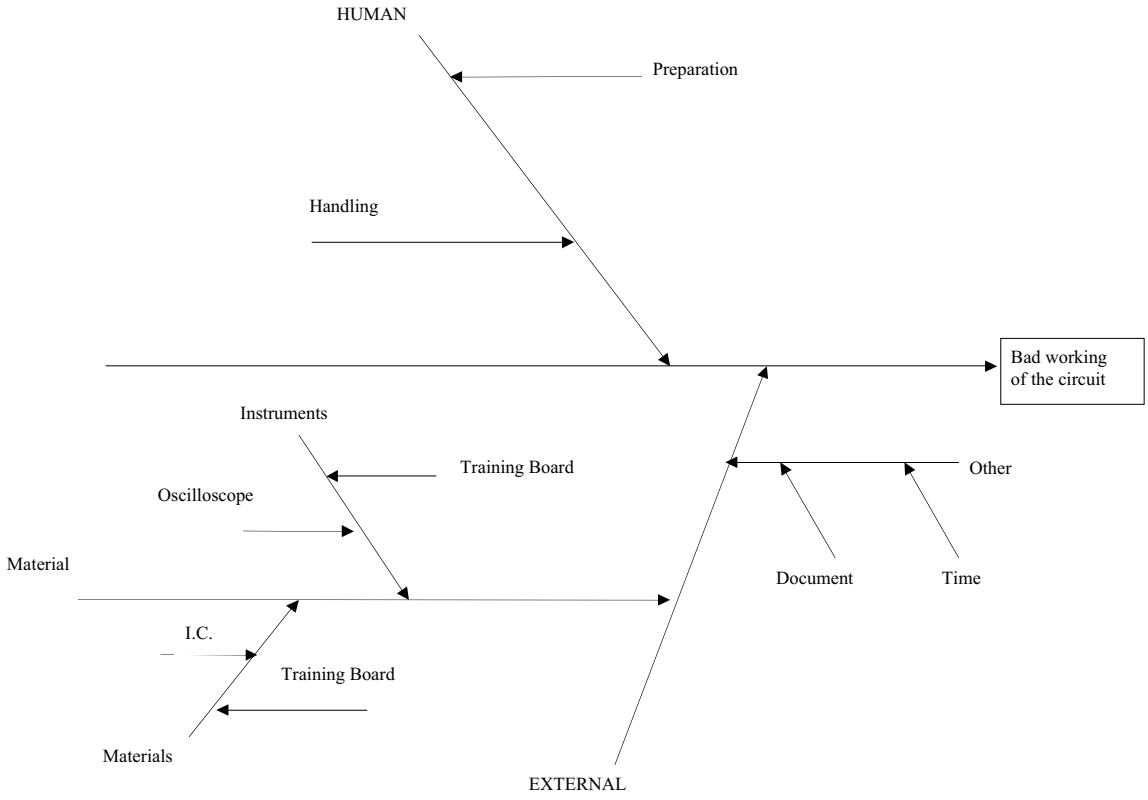

TABLE I
SOLUTIONS PROPOSED BY THE STUDENTS FOR THE MOST RELEVANT PROBLEMS

Kind of mistake	Factor	Student	Teacher / Centre
Human	Lack of previous preparation	- The matter should be studied more continuously.	- To control with periodical exams.
		- Previous preparation as homework.	- To ask for a previous report.
		- Ask the teacher in the lecture room, laboratory or tutorials.	- To explain before the practice. Voluntary attendance.
	Assembly errors	- Pay attention when reading the data sheets and ask for the unclear points.	- Translation from English. - To explain the datasheets in detail. Voluntary attendance. - To allow the access to the laboratory at any time.
		- Ask the teacher in the lecture room, laboratory or tutorials	
		- To get some assembly practices: order and clean assembly.	
		- To revise the guidelines of instrument use before the practice.	- Brief revision before the session. User's guide available.
	Lack of attention	- To check all the devices and connections.	- To recall the checking of all connections and pins. - To motivate. To point out the importance of the matter.

Kind of mistake	Factor	Student	Teacher / Centre
Material // Instrument	Training Board, I.C.	- To tell the teacher or the laboratory technician about the faults met. - To through away the material (cable, I.C.) broken during the practices. - To take care of the laboratory material.	- To increase the periodic revision of the material. - To through away all the devices and materials that can not be repaired. - To make the students aware of the right use of the laboratory.

FIGURE. 2
VALUATION OF THE METHOD.

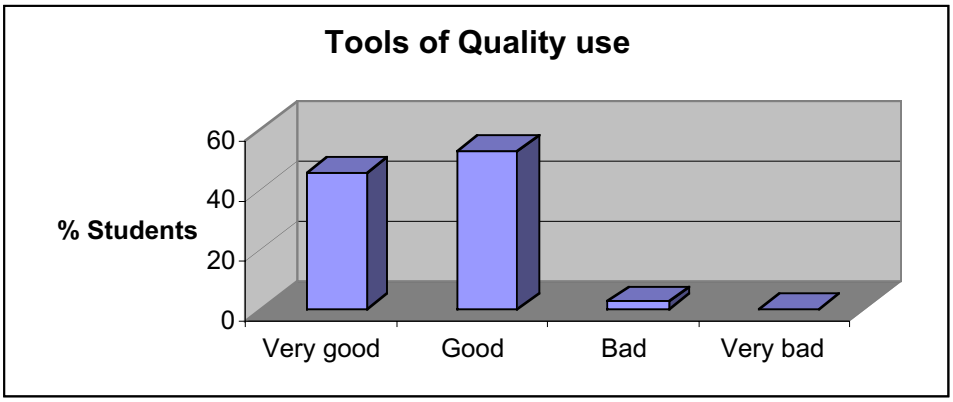

FIGURE. 3
OPINION ABOUT THE APPLICATION OF THE METHOD TO OTHER SUBJECTS.