SIX SIGMA AS A QUALITY IMPROVEMENT TOOL FOR ACADEMIC PROGRAMS

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Abstract

In this work, we present a methodology for the design and improvement of academic programs based on Six Sigma. Six Sigma is a methodology for quality improvement [ISO 13053-1] well known in industrial environments that is being more and more used in services and administration areas. The proposed methodology is applied to the Internal Systems Quality Assurance (ISQA) in Information Technology and Communications (ITC) Schools, but it is easily generalizable to other schools and faculties. The Spanish National Agency for Quality Assessment and Accreditation (ANECA for its Spanish acronym) sets the guidelines for improving the ISQAs, but ANECA does not indicate how to implement them. Currently, there is a lack of methodologies to create and/or improve quality control systems for teaching and associated services. It is therefore necessary to explore other ways.

As a first contribution, we are using successful quality improvement methodologies at the business level for academic purposes. Even though there are various methods for improving the quality of processes (EFQM, Kaizen, etc.), Six Sigma has proven to be among the best ones. Indeed, Six Sigma successfully adapted the scientific method in order to be straightforwardly applied to process improvement within organisations.

Our second contribution, probably the most important one, is the development of a typology catalogue gathering the developed procedures structure. Such catalogue allows to systematically detect types of procedures and structures, representing by itself a novel tool.

The remaining contributions are explicit descriptions of procedures for a particular ITC School. These descriptions showcase a comprehensive practical application of the proposed methodology. The integrated system developed in this work organises the procedures into three areas: strategic, operational and cross-cutting.

Keywords: Six Sigma, Quality Management Systems, Quality Assurance, Higher Education.

1 INTRODUCTION

In this paper we propose a model for the design and improvement of an Internal System Quality Assurance (ISQA), fulfilling the guidelines of the Spanish National Agency for Quality Assessment and Accreditation (ANECA for its Spanish acronym) based on the Six Sigma methodology. The main contributions of this work are the following:

- As a first contribution, we extend and adapt an industrial quality improvement methodology to the academic environment. Although there are various methods for process quality improvement (e.g. EFQM, Kaizen, etc.), Six Sigma has proven to be one of the most successful. Six Sigma adapts the scientific method, in a simple manner, so that it can be applied to process improvement within almost organization. In this context we define a process as “a group of interrelated actions that seek to achieve the same goal.”
- Our second contribution is the development of a typologies catalogue, containing the different types of structure that a procedure may have. This catalogue allows to detect in a systematic way the types of procedures and structures within the ISQA, constituting itself a new tool. For more detailed information, see [1].

2 SIX SIGMA FOR ACADEMIC PROGRAMS

The quality concept has evolved over the years. During this evolution, many specific methodologies for Quality Management have been proposed [2], being one of them Six Sigma [3, 4, 5, 6, 8, 9]. In particular, Six Sigma is a process improvement methodology that uses one of the most powerful tools

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developed by humankind: the scientific method. The Six Sigma methodology is based on the DMAIC cycle, consisting of five phases: Definition, Measure, Analysis, Improvement and Control. In this section, we give an overview of Six Sigma, including a basic description of how the different elements of the methodology interact with each other.

2.1 Six Sigma and the DMAIC cycle

Six Sigma should be always applied on well-defined processes. Once the project or process has been selected, the strategy to solve it must follow the DMAIC cycle mentioned above. It is important to remark that a team should be established in order to achieve the improvement of a process. In the following, we give a brief description of each of the phases of the cycle.

2.1.1 Define Phase

We begin with the definition phase. First, we must determine whether the Six Sigma methodology is suitable for solving the problem. The key to this phase of the DMAIC cycle is the Project Charter. A project charter is a statement of the scope, objectives and participants in a project. It contains the roles and responsibilities, describes the objectives of the project. The project main stakeholders are identified, and the authority of the project is defined. An important aspect of the project charter is the business case, i.e., a brief description of the business problem. Other aspects that should be included are: the problem statement, the statement of purpose, and the scope of the project. In addition, in the definition phase the team develops a list of Quality critical characteristics (CTQ, Critical To Quality). It is a crucial phase, as the result of improvement projects depends on having a good definition of what we want to improve. At this stage, it is advisable to employ techniques for fault system detection as FMECA (Failure Mode Effects and Criticality Analysis) [10], since they help to find the system's CTQs.

2.1.2 Measure Phase

The second phase in the DMAIC cycle is the measure phase. The objective of this phase is to acquire all possible information about the process in its current state. This information will precisely determine how the process is working. All processes involved in the project will be measured. For this task, all the variables to be measured are identified, and the measurement system is validated for these variables, i.e., it will be determined how precise and accurate the measurement system used is [11]. Furthermore, data will be collected and the process capability determined, i.e., how adequate (capable) is the process to meet specifications.

2.1.3 Analyze Phase

In the analysis phase of the DMAIC cycle, the team aims to identify the main causes of the problem under study. Unlike with other simpler strategies, within Six Sigma the main causes must be validated by the data, resulting in so-called "fact-based decisions". The process map, the data collected, and any other knowledge acquired during the phases of definition and measurement should be used to determine the causes of the problem under study. The power of the analysis phase is provided by the statistical analyses that are to be performed. This high level of analysis used by the Six Sigma methodology makes a difference with regard to any other problem-solving type of methodology. Statistical techniques commonly used to check the possible causes of the problem under study include, for example, analysis of variance (ANOVA), correlation analysis, scatter plots, or Chi-square analysis, among others. The specific techniques to be used depend on the complexity of the improvement project at hand.

2.1.4 Improve Phase

The aim of the improvement phase is to find a solution to the problem under study. Brainstorming is a technique commonly used to generate a set of possible solutions. In order to find a solution, it is really important to count on people who work regularly with the process, since their contributions can be very valuable. In many cases, these people are those that provide the best ideas to solve the problem, as they are those with knowledge about the process. That is, the combination of experience and scientific analysis is what will guarantee success. And we must not forget that the term "best" is not the same for everyone. Thus, a team should strive to get the best solution of all, and for all. A list of solution criteria can be a good tool to find the best solution. Before starting to implement the solution, the team must ensure that the proposed solution is able to be carried out. Some of the possibilities to be explored at this point are pilots, simulations, or partial implementation programs. Systems that do not allow errors such as Poka Yoke [12] can be introduced, thereby effectively preventing making mistakes on the system. The team should also create a map of the future state of the process as part of the improvement phase (map “to be”). This must be done so that the process can be carried out as many times as necessary in order to ensure that the implementation of the solution has been correctly achieved.

2.1.5 Control Phase

The last phase is the control phase, and its goal, in a nutshell, is to maintain the achievements that have been obtained as a result of the improvement phase. It should develop a plan detailing the steps to be followed during the control phase, and studying all new ideas. The idea of control in Six Sigma differs from traditional operations. The way to ensure that a CTQ characteristic is by means of controlling the input variables, which differs from the traditional process final inspection, which usually does not add value to the process. Therefore, the Six Sigma methodology tries to anticipate errors instead of focusing on correcting them. Once success is achieved, it must be celebrated. Even though the celebration intensity depends on each company, in order to create an environment of sustainable improvement, it should be, at least, a public recognition of the efforts.

2.1.6 The DMAIC cycle into perspective

Let us finish this brief overview of the DMAIC strategy showing the connection with the scientific method [13]. The analogy between both worlds can be seen in Table 1. Figure 1 shows the interactions between the different phases within the DMAIC cycle.

Table 1. The DMAIC cycle and the scientific method.

<table>
<tr><th colspan="2">DMAIC</th><th>Scientific method</th></tr>
<tr><td rowspan="2">Define</td><td></td><td>Research Question</td></tr>
<tr><td>Measure</td><td>Background research</td></tr>
<tr><td rowspan="2">Analyze</td><td></td><td>Make a hypothesis</td></tr>
<tr><td rowspan="2">Improve</td><td>Experiment and test the hypothesis</td></tr>
<tr><td rowspan="2">Control</td><td>Draw conclusions based on data</td></tr>
<tr><td></td><td>Spread results</td></tr>
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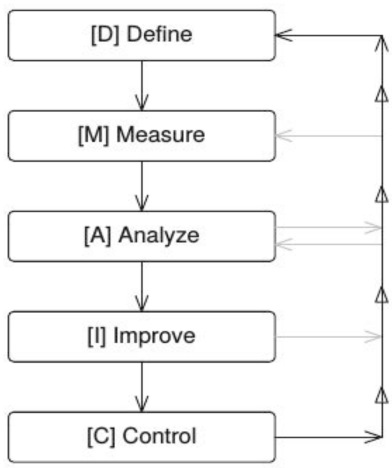

Figure 1. DMAIC phases interactions.

2.2 Quality within academic programs

Currently, there are methodologies to create and/or improve quality control systems, [2, 3, 4, 5, 6, 7 14], but it is difficult to find practical applications of these methodologies for quality management at higher education centers and their related services. Due to the changes stemmed from the homogenization and implementation of new university degrees in Europe [15], the need to establish quality controls that ensure the fulfilment of the stated objectives has arisen. European agencies such as the European Association for Quality Assurance in Higher Education (ENQA [16]) and national agencies such as the National Agency for Quality Assessment and Accreditation (ANECA [17]) have set the guidelines to be met at European and national level, both internally and externally, by means of assessments and/or audits [18, 19, 20] they must pass. As mentioned above, Six Sigma anticipates problems. Thus, errors can be detected and corrected in the output before they occur. Six Sigma is capable of transforming threats (detected errors) into opportunities, obtaining a product of high quality. Some of the threats an ICT center faces and the opportunities in which such threats should be transformed can be seen in Table 2.

Table 2. Threats and opportunities at an ICT center.

THREATS	OPPORTUNITIES
The training of graduate students is not what businesses expect.	Provide a job market oriented training. Continuously revising and updating training plans.
Students feel they are not taken into account.	Create agile lines of communication and participation between students and the school management.
The teachers and researchers with best scientific record prefer to work in other centers.	Encourage staff, allowing teaching in cutting-edge research lines.
Teachers and researchers do not feel their work is valued enough.	Recognize the teaching career as a research career is valued.
Budgets are increasingly tight.	Strengthen contacts with companies to get sponsorships and collaboration agreements in order to achieve an extra way of funding

3 GENERAL FRAMEWORK

In our design, we distinguish three broad areas of work, defining the various processes that we will develop: strategic, operational and crosswise.

- Strategic procedures are those whose importance is crucial for the development of the ISQA. Among others, this group should include those procedures defining the quality policy of the center. The responsibility of the definition and design of these procedures belongs to the center management. This is so because these procedures include a set of statements and commitments that once established, must followed by all the members of the ICT center.
- Operational procedures are those defining the lines for the optimal performance of ICT center. This group of procedures describes how to act within the different areas involved in the management of the center. Most procedures belong to this group, in particular, those related to teaching management, planning of study programs, students affairs, international relations, infrastructures and other activities.
- Crosswise procedures are those that affect to all the processes defined in the ISQA and, therefore, essential to achieve the quality objectives of the center.

In this work we will focus on the structure of the main strategic procedures and operational procedures, see Table 3.

Table 3. Strategic and operational procedures.

AREA	PROCEDURES
Strategic	Definition of the quality and complaints policy
	Definition of directives for academic staff
	Definition of directives for administrative staff
	Definition of directives for students
Operational	Design of the educational offer
	Admission requirements and recruitment
	Selection, admission and registration of students
	Students guidance
	Planning and development of study programs
	Learning evaluation
	Management of internships
	Management of job placements
	Training of academic staff
	Evaluation, promotion and acknowledgement for academic staff
	Training of administrative staff
	Evaluation, promotion and acknowledgement for administrative staff

4 SOME PRACTICAL APPLICATIONS

In [14] a catalog of eighteen different types of procedures within the Six Sigma methodology is presented. In this work, being focused exclusively on strategic and operational procedures, the catalog has been reduced to two main types. Next we show the generic diagrams for these two typologies:

- Cyclical without flow control procedures. In this type of procedures there is no well-defined end, that is, a procedure that fits into this type of structure will continue its operation from one step to the next, regardless the number of steps (see Figure 2).
- Linear without flow control procedures. In these procedures there is a well-defined beginning and end, being the easiest type to detect (see Figure 3).

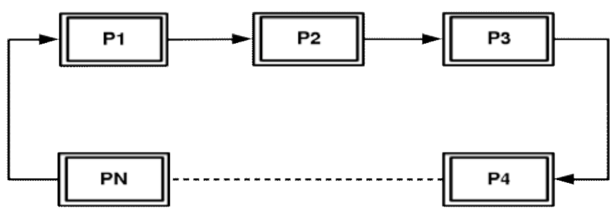

Figure 2. Cyclical procedures.

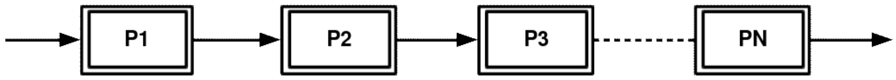

Figure 3. Linear procedures.

4.1 Example 1: Definition of the quality and complaints policy

Most strategic procedures are cyclical without flow control. An example of this typology is the procedure known as “Definition of the quality policy and complains”. This procedure is the basis for the implementation of the ISQA. It defines the general guidelines for the ISQA planning and guides the organization towards customer satisfaction.

The flow diagram corresponding to this procedure is represented in Figure 4, and consists of four basic steps: collection of information (legal and socio-cultural indicators); comprehensive analysis of this information; settlement of feasible quality policies; and dissemination and implementation of the quality policies.

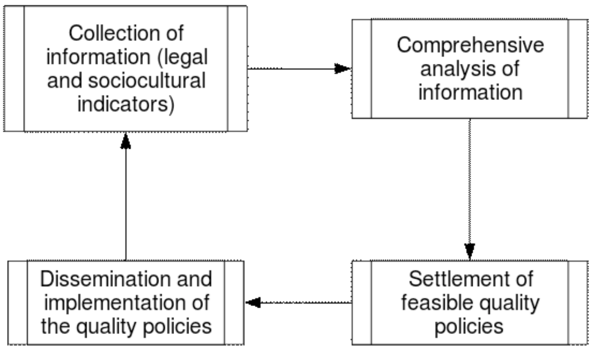

Figure 4. Flow diagram for the “Definition of the quality and complaints policy” procedure.

During the definition phase, the flow diagram in Figure 4 is established. This flow diagram leads to three main processes, P1, P2 and P3 (see Figure 5). In the first step, P1, the procedure collects the information necessary to establish and/or modify the quality policies of the ICT center. In this step the opinions of the members of the local and international ICT communities are collected. Also a study of the different laws that may change over time is performed. In the second step, P2, all the information will be analyzed and actions to achieve the desired quality standards will be designed. Finally, in step P3, the ICT center runs these improvements, and controls how these actions affect to the center performance. In order to implement this procedure properly, the center management should apply itself the designed policy quality guidelines and disseminate the developed rules to the entire ICT community.

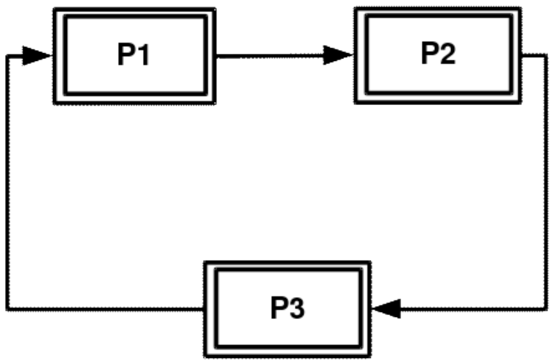

Figure 5. Main processes in the “Definition of the quality and complaints policy” procedure.

4.2 Example 2: Selection, admission and registration of students

Most operational procedures belong to one of the two typologies described in this work: cyclical without flow control or linear without flow control. We show in this section an example of procedure linear without flow control. The selected procedure is the one known as “Selection, admission and registration of students”.

The goal of this procedure is to establish the way in which the ICT center organizes the selection, admission and enrollment of students. We will focus on the organization of the selection tests and the manner in which the center will manage the registration of new students.

Figure 6 shows the flow diagram corresponding to this procedure. It includes the following six steps: 1. Establish a committee of experts; 2. Planning of the schedule and contents of the selection tests; 3. Dissemination of information; 4. Accomplishment of selection tests and process selection; 5. Information about registration process for new students; 6. Registration period. During the registration period the center must guarantee that all questions from new students regarding the registration process are solved.

During the definition phase, the flow diagram in Figure 6 is settled. This flow diagram leads to three main processes, P1, P2 and P3 (see Figure 7). In the first step, P1, the center establishes the committee of experts, planning of the schedule and dissemination of information such as dates and contents. In the second step, P2, the selection tests take place and then selection of students is accomplished according to their results in the test and any other criteria established (for instance, personal interviews). Finally, in the third step, P3, the center informs to new students about the registration process.

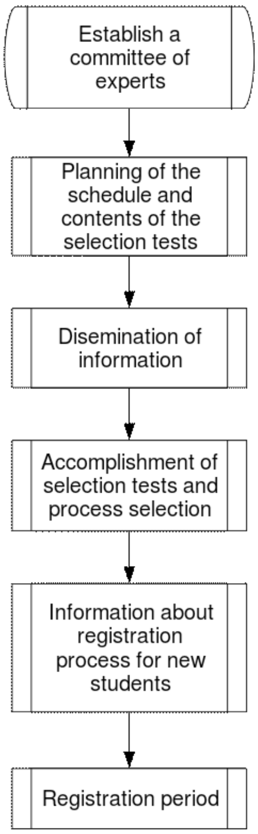

Figure 6. Flow diagram for the “Selection, admission and registration of students” procedure.

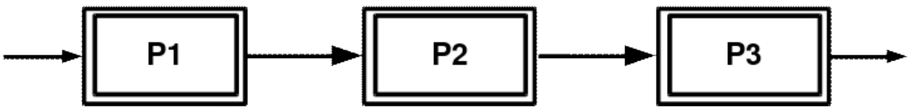

Figure 7. Main processes in the “Definition of the quality and complaints policy” procedure.

5 CONCLUSIONS

The Six Sigma methodology has been applied throughout the development of the ISQA. During this application it has been possible to identify the sources of variation within the procedures. In addition, it is important to remark that the procedures are not closed as they should be constantly evolving and being improved.

Although in this work we only present two typologies, the culmination of this work is the creation of a catalogue listing a whole set of structures. This contribution is extremely valuable as it allows determining the type and structure of procedures in a systematic manner. Given a new procedure, it can be associated to one of the typologies in the catalogue, thereby facilitating the development of its complete description.

Finally, it is important to take into account that the catalogue is open, i.e., new typologies may arise. This new typologies should be incorporated applying the described methodology to develop their structure.

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